



Military and Department of Defense Response to Climate Change and Emerging Environmental Issues

Adaptation Roadmap

Security Challenge

Global Warming Military Implications

Future Naval Operations

**Military and Department of Defense Response to Climate Change and Emerging Environmental Issues,
Adaptation Roadmap, Security Challenge, Global Warming Military Implications, Future Naval Operations**

* * * * *

U.S. Government, U.S. Military, Department of Defense (DoD)

* * * * *

Progressive Management

Questions? Suggestions? Comments? Concerns? Please contact the publisher directly at

bookcustomerservice@gmail.com

Remember, the book retailer can't answer your questions, but we can!

* * * * *

This is a privately authored news service and educational publication of Progressive Management. Our publications synthesize official government information with original material - they are not produced by the federal government. They are designed to provide a convenient user-friendly reference work to uniformly present authoritative knowledge that can be rapidly read, reviewed or searched. Vast archives of important data that might otherwise remain inaccessible are available for instant review no matter where you are. This e-book format makes a great reference work and educational tool. There is no other reference book that is as convenient, comprehensive, thoroughly researched, and portable - everything you need to know, from renowned experts you trust. For over a quarter of a century, our news, educational, technical, scientific, and medical publications have made unique and valuable references accessible to all people. Our e-books put knowledge at your fingertips, and an expert in your pocket!



* * * * *

CONTENTS

* * * * *

[Worldwide Emerging Environmental Issues Affecting the U.S. Military](#)

[How Should the Department of Defense Approach Environmental Security Implications of Climate Change](#)
[Report of the Defense Science Board Task Force on Trends and Implications of Climate Change for National and International Security](#)

[The Department of Defense and Climate Change: Initiating the Dialogue](#)

[Climate Change Implications to the Global Security Environment, U.S. Interests, and Future Naval Operations](#)

[Department of Defense 2014 Climate Change Adaptation Roadmap](#)

[Taking Up The Security Challenge of Climate Change](#)

[Military Implications of Global Warming](#)

* * * * *

[2015 Worldwide Threat Assessment](#)

[DIA Director Worldwide Threat Assessment](#)

[White House National Security Strategy February 2015](#)

* * * * *

Worldwide Emerging Environmental Issues Affecting the U.S. Military

* * * * *

The Millennium Project for the U.S. Army Environmental Policy Institute

January 31, 2011

SUBCONTRACT NO: 1048

LMI TASK NO: MAN0B.04

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

Summarizing Environmental Security Monthly Scanning

July 2010 - January 2011

Introduction.

1. Environmental Security Monthly Scanning Items

- A Preventing or repairing military damage to the environment
- B Preventing or responding to environmentally caused conflicts
- C Protecting the environment due to the moral value of the environment itself

2. Military Implications and Sources

Acknowledgments

This work was supported by the U.S. Army Environmental Policy Institute, with the supervision of John Fittipaldi, under the Subcontract No: 1048, LMI Task No: MAN0B.04

Introduction

The purpose of this study is to assess worldwide environment-related issues in order to identify and analyze events that might have environmental security implications, and/or trigger future international environmental treaties or modifications to the existing ones, with potential implications for the military.

The Millennium Project defines environmental security as environmental viability for life support, with three sub-elements:

- preventing or repairing military damage to the environment
- preventing or responding to environmentally caused conflicts
- protecting the environment due to its inherent moral value.

This report presents a summary of recent events and emerging environmental security-related issues organized around this definition. About 200 items have been identified since July 2010, and over 2,000 items since this work began in August 2002. For a complete version of the reports organized by months, see the Army Environmental Policy Institute web page <http://www.aepi.army.mil/reports/>.

* * *

Key environmental and resource constraints, including health risks, climate change, water scarcity and increasing energy needs will further shape the future security environment in areas of concern to NATO and have the potential to significantly affect NATO planning and operations.

- Active Engagement, Modern Defence. Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation adopted by Heads of State and Government in Lisbon. 19 Nov. 2010

While climate change alone does not cause conflict, it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world.

- 2010 Quadrennial Defense Review

United States Department of Defense

1. Environmental Security Monthly Scanning Items

A. Preventing or repairing military damage to the environment

Environmental Security Rises on the International Political Agenda

NATO's New Strategic Concept Includes Environmental Security

NATO Continues to Develop Cyber Defense Policies

Germany to Propose Adding Climate Change to UN Security Council Agenda

Environmental Aspects Should Be Factored More Into Conventional Security Concerns

UN Official Calls to "Securitize the Ground" as part of Human Security

International Consortium Created to Curb Environmental Crime

Environment-related Issues Dominate the UN General Assembly Debate

The UN and African Union to Increase Cooperation for Peace and Security

An Emerging Nordic-Baltic Alliance Might Have Security Implications

Pacific Region Programs for Addressing Environmental Security

Project on National Security Reform (PNSR) Vision Working Group Report

Comprehensive Assessment of Environmental Security

International Treaties Related To Environmental Security and Military Actions

Updates of the Rome Statute Include Amendments on the Crime of Aggression and Expansion of Criminalizing the Use of Certain Weapons in Non-international Conflicts

UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

UN Human Rights Council Affirms Right to Water as Legally-Binding

International Biosecurity Initiative

Synthetic Biology Guidelines to Reduce Bioweapon Threats

Conflict and Post-Conflict Environmental Security Issues

High cancer rates in Fallujah, Iraq; New Study Raises Questions on Environmental Damage from Bombardments

Measuring Progress in Conflict Environments: A Metrics Framework

Economic Argument for Peace-building in Sudan

Artillery Training Charges Pose Environmental Asbestos Threat

National and Regional Initiatives Affecting Military Activities

Latin American Initiatives for Environmental Security

First U.S.-Russian Environmental Protection Park

CEC's Five-year Strategic Plan Increases North-American Environmental Integration

EU to Set Resource Efficiency Targets

Islamic Conference of Environmental Ministers Approves Detailed Program

Evolution of Environmental Management Philosophy in China

Technological Advances with Environmental Security Implications

Computer Technology and Robotics

New Detection and Cleanup Techniques

Counter Bioterrorism or Pandemic Technologies

Promising Environment-friendly Technologies

Increasing Energy Efficiency Technologies

Technologies for New Generations of Cars

Space Technology

Technologies that Could Trigger New Forms of Arms Race

B. Preventing or Responding to Environmentally-Caused Conflicts

Security Implications of Environmental Aspects

New Website Addresses Conflict-sensitive Conservation

Extinction Threatening 21% of Africa's Freshwater Species Could Have Security Implications

Possible Conflicts over National/Regional Geoengineering Projects

Indigenous People Demanding Regulations for Addressing Climate Change and Mining

Race for Natural Resources

Natural Resources Fuel Violence in Eastern D.R. Congo

Protests in Peru over Dam Irrigation and Hydroelectric Project Part of a Regional Picture

The Battle for Rare Earth Elements Continues Chinese Rare Earth Restrictions

China Applies for Seabed Mining Permit in Search for New Mineral Resources

Arctic and South China Sea Resource Issues Causing U.S. to Review Law of the Sea

Arctic Debate

Natural Disasters and Scientific Evidence

Scientific Evidence and Potential Consequences of Climate Change

Migration Triggered by Environmental Causes

Climate Refugees Trends

Renewed Protection for Refugees in Latin America

Melting Sea Ice and Glaciers

Regional Evidence and Trends

Food and Freshwater

Food Security Issues Freshwater Security Issues

Health

Potential Impacts of Climate Change

UNEP Study on Inter-Linkages of Climate Change, POPs, and Human Health

Energy Security

Scientists Create 20-Year Roadmap for Nuclear Energy

World Energy Outlook 2010

China is Now the Largest Energy Consumer in the World

Nordic Countries to Support Mekong Energy and Environment Partnership

Coal-fired Power Plants under Fire

Prevention and Adaptation

Policy recommendations and Actions for Adaptation to Climate Change

Reports on Sustainability and Climate Change

FAO Launches Global Fire Information Management System

Climate Modeling and Scenarios

Climate Projection Models

Scenarios

C. Protecting the Environment Due to Its Inherent Moral Value

Environmental Security-Related International Regulations That Have Been or Are Close To Coming into Force since July 2010

Broad Environmental Aspects

Progress on International Environmental Governance

The Protocol on Strategic Environmental Assessment to the UNECE Espoo Convention Entered into Force on July 11, 2010

Repository of Multilateral Environmental Agreements

Biodiversity

New International Mechanisms Adopted for Protection of Biodiversity

Chemicals and other Hazardous Compounds

Stockholm Convention Updates

EU Parliament Adopts Restrictions on Nanoproducts

Germany publishes criteria for substances of very high concern

New Technologies

Synthetic Biology Guidelines to Reduce Bioweapon Threats

The EU Strengthens Legislation to Counter Cybercrime

Pollution

New EU Directive on Industrial Pollution

Water

UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

UN Human Rights Council Affirms Right to Water as Legally-Binding European Parliament Resolution on Jordan River Water Management Reform

Marine Environment

IMO MEPC Revises MARPOL, Addresses Emissions from Ships

Chile Establishes 150,000 KM2 Protected Marine Reserve in Pacific

Ecuador to Join the UN Convention on the Law of the Sea

Waste Management

Kenya to Implement E-Waste Management Program

Proposed Treaties and/or Changes to Existing Ones

Biodiversity

Prosecution of Pillage of Natural Resources as War Crime

World's Humid Tropical Forests to Suffer Considerable Biodiversity Change by 2100

Biosafety Regulations Reviewed in Context of Worrying Forecasts

New Protected Areas Proposed in the Pacific

Chemical and Biological Safety

International Biosecurity Initiative

Synthetic Biology Guidelines to Reduce Bioweapon Threats

New Regulations for Chemicals in California

Greenhouse Gas Emissions

Post-Kyoto Protocol Negotiations

Cancun UN Climate Change Conference Consolidates Progress

International Civil Aviation Pact Cuts Climate Emissions from Aircraft

More Aggressive Action Needed to Curb Ozone Depletions

New Technologies

Reports Assessing Several Nations' S&T Advances

Nanotechnology

Biotechnology

Space

India Urges Strengthening Outer Space Treaty

Improved Enforcement of Environmental Regulations

"Public Interest" Environmental Suits Increasing

International Consortium Created to Curb Environmental Crime

The ICC to Establish an Independent Oversight Mechanism

Strategic Plan for Biodiversity to Connect UN Conventions and UN Bodies

UN Review of Sustainable Development in Preparation for Rio+20 in 2012

International Atomic Fuel Banks to Reduce Nuclear Proliferation

Prosecution of Pillage of Natural Resources as War Crime

Regional Cooperation in Africa to Counter Wildlife Trafficking

Hazardous E-waste Grows as Major Environmental Problem

Shipping Efficiency Database to Reduce Emissions from Maritime Transportation

New Standards with Environmental Security Implications

Revised Standards Proposed for Corporate Greenhouse Gas Reporting

Comments Invited on EPA/DOT Proposed Heavy Truck Mileage/Emission Standards

ISO Publishes Methodology for Nanomaterials Classification

Fuel Efficiency Standards Are Changing around the World

International Air Cargo Screening Cooperation Requested

Miscellaneous Safety Issues

New Earth-Approaching Asteroid Discovered

Hungary Industrial Plant Spill Might Trigger Tougher Environmental Regulations

Study Indicts Swimming Pool Disinfectants for Toxic Effects from Byproducts

Artificial Grass May Pose Threat of Lead Poisoning to Children

China to Expand Weather Control Program

Nanotechnology--Potential Environmental and Health Implications

1. Environmental security monthly scanning items

A. Preventing or repairing military damage to the environment

Environmental Security Rises on the International Political Agenda

NATO's New Strategic Concept Includes Environmental Security

"Key environmental and resource constraints, including health risks, climate change, water scarcity and increasing energy needs will further shape the future security environment in areas of concern to NATO and have the potential to significantly affect NATO planning and operations", reads NATO's new Strategic Concept for the next decade, adopted at the alliance's Summit meeting in Lisbon, November 2010. The new roadmap was updated considering modern threats such as energy security, cyber attacks, and the security impacts of emerging technologies, along with and in the context of the spread of terrorism and extremist groups. It stipulates that, "A number of significant technology-related trends - including the development of laser weapons, electronic warfare and technologies that impede access to space - appear poised to have major global effects that will impact on NATO military planning and operations." In the spirit of enhancing EU-NATO cooperation, an EU-US Working Group on Cyber-security and Cybercrime was established to address specific priority areas, and an agreement on the Terrorist Finance Tracking Program was negotiated. [November 2010. Military Implications, Sources 1]

NATO Continues to Develop Cyber Defense Policies

NATO nations' Senior National Policy Advisors held a meeting in Brussels, January 25, 2011, assessing ways of using NATO assets and capabilities for further developing the Alliance's cyber defense policy and common defense system against cyber threats. "There simply can be no true security without cyber security," noted NATO Secretary General, Anders Fogh Rasmussen, highlighting that this meeting is an "important part of getting ahead of the cyber curve." Cyber security is also identified as an increasing challenge in NATO's New Strategic Concept. [January 2011. Military Implications, Source] 2

Germany to Propose Adding Climate Change to UN Security Council Agenda

Germany will join the UN Security Council for two years beginning in January as one of ten non-permanent members. During this time it is expected to urge this UN body to begin addressing climate change as a global security threat. This view is shared by many other UN members, as evidence of the security implications of climate change mount, and environmental security is becoming part of the security agenda of states and international security organizations. The UN General Assembly December 15, 2010 session focused on improving the coordination of efforts in case of disasters, including those associated with natural hazards. [Related items: UK Initiates UN Security Council Debate on Climate Change and Security in April 2007, and UN General Assembly Stressed Environment-related Issues in September 2008 environmental security reports.] [December 2010. Military Implications, Sources]

Environmental Aspects Should Be Factored More Into Conventional Security Concerns

In a Capitol Hill briefing, defense experts underlined that environmental degradation and the fight for natural resources threaten U.S. security in the 21st century, as depletion of resources exacerbates political instability and conflict in the developing world, increasing the number of failed states. Therefore, integrating environmental problems into security policy is essential and should be on a par with conventional security aspects. For many defense officials in developing countries, security is seen in terms of food, water, and environmental security, and natural disasters. Along the same lines, an article on Pakistan questions the justification of funds allocated to conventional security compared to those for human or environmental security. In 2010, Pakistan's

defense budget will rise 17%, to \$5.2 billion, while the week of flooding has by far surpassed the devastation of anything the Taliban could accomplish. The article notes that this is a dilemma of much of the developing world, mostly affecting those vulnerable to climate change and disasters. "Without neglecting the very real challenges posed by insurgency, civil war, or external invasion, the time has come to begin shifting resources toward human and environmental security," says the article. [September 2010. Military Implications, Sources4]

UN Official Calls to "Securitize the Ground" as part of Human Security

At the Third Annual Caux Forum for Human Security, held July 9-16, 2010, in Caux, Switzerland, Luc Gnacadja, the Executive Secretary of the UN Convention to Combat Desertification (UNCCD), underlining the links between climate change and conflict, called for a "decisive policy change in the way we perceive the drylands and address the issues of its people in order to avoid environmentally induced conflicts." To this end, he suggested the "securitize the ground" concept, in order to create a wider global political awareness of the social, environmental, and economic consequences of desertification, land degradation, and drought. Securitizing the ground is defined in the reference. [July 2010. Military Implications, Source5]

International Consortium Created to Curb Environmental Crime

The International Consortium on Combating Wildlife Crime (ICCWC) came into effect, by the signing of a Letter of Understanding by the heads of five organizations: INTERPOL, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the UN Office on Drugs and Crime (UNODC), the World Bank, and the World Customs Organization. In the same spirit, the resolution adopted by INTERPOL's 79th General Assembly, attended by 650 delegates from 141 countries, underlines that environmental crime is "multi-disciplinary in nature due to the complexity and diversity of crime types." Since it is "not restricted by borders and involves organized crime networks...", a global response is needed, with INTERPOL and the National Central Bureaus playing a leading role. The resolution also stipulates that environmental crime impacts the global economy and security, and recommends that INTERPOL form the Environmental Crime Committee. [November 2010. Military Implications, Sources6]

Environment-related Issues Dominate the UN General Assembly Debate

The need for increased and coordinated efforts from all countries to address climate change, vulnerability to natural disasters, and threats to biodiversity was the most frequent theme of the speeches of heads of state and governments addressing the UN General Assembly held 23-25 and 27-30 September 2010, and will probably top the 65th session's agenda. [September 2010. Military Implications, Sources] 7

The UN and African Union to Increase Cooperation for Peace and Security

The UN and the African Union (AU) launched a Joint Task Force on peace and security for improving conflict prevention, peacekeeping, and peacebuilding across the continent (expanding their present efforts in Sudan, Guinea, and Somalia.) The task force will meet twice a year at the senior level to review immediate and long-term strategic issues, and its program of work will be set in coordination with the UN Office to the AU and the AU's Permanent Observer Mission to the UN. The first high-level meeting of the Africa-European Union Energy Partnership was held September 14-15, 2010, in Vienna, Austria, addressing cooperation on energy security and renewable energy issues. The over 300 participants, including ministers and high-level representatives from 24 European and 33 African countries, also agreed upon concrete targets and objectives. [September 2010. Military Implications, Sources]

An Emerging Nordic-Baltic Alliance Might Have Security Implications

The first Nordic-Baltic Summit was held in London, January 19-20, 2011 to establish a regional "alliance" for addressing issues of common interest. The Summit was attended by the leaders of Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden, and the host, the UK Prime Minister, David Cameron. Reportedly, one of the outcomes is building an energy "supergrid" to link suppliers of renewable energy. A follow-up summit is planned for Sweden in 2012. Although the Summit's focus was on economic and social issues, speculations are that

the alliance will be expanded to security issues. In the meantime, Nordic foreign ministers will hold an April meeting in Helsinki to discuss prospects for a "NATO-type" defense pact to address Arctic-related security issues. Since there are conflicting national jurisdictions over the Arctic, and global warming is expected to open shipping and access to large gas and oil resources, new agreements seem necessary to prevent future conflicts. [January 2011. Military Implications, Sources9]

Pacific Region Programs for Addressing Environmental Security

The Pacific Regional Environment Programme (PREP) adopted the Strategic Plan for 2011-2015 at its 21st meeting held in Madang, Papua New Guinea, September 6-10, 2010. It creates a framework for regional environmental cooperation on climate change; biodiversity and ecosystem management; waste management and pollution prevention; and environmental monitoring and governance. The Asian Development Bank's paper, Focused Action: Priorities for Addressing Climate Change in Asia and the Pacific, outlines similar priorities for the its work on clean energy, sustainable urban development, land use and forest management for carbon sequestration, climate-resilient development promotion, and strengthening of related policies and institutions. [September 2010. Military Implications, Sources] 10

Project on National Security Reform (PNSR) Vision Working Group Report

The "Project on National Security Reform Vision Working Group" is a 3-year study with over 300 national security experts. It assesses the U.S. national security system, recommending a comprehensive reform agenda to prepare the system to meet the challenges of the 21st century. A central recommendation was to introduce foresight into the Executive Branch and into the National Security System via the establishment of a Center for Strategic Analysis and Assessment within the Executive Office of the President. [August 2010. Military Implications, Sources] 11

Comprehensive Assessment of Environmental Security

Environmental Security: A Guide to the Issues by Elizabeth L. Chalecki is a comprehensive overview of environmental security issues and discourse. It addresses the security implications of shortages and abundance of natural resources, the international ramifications of food security, the social impacts of changes of the global ecosystem due to climate change, and the effects of war and preparation for war on the natural environment. The book also, ".explores how nations can, and must, cooperate with each other to confront and manage these threats." [January 2011. Military Implications, Source] 12

International Treaties Related To Environmental Security and Military Actions

Updates of the Rome Statute Include Amendments on the Crime of Aggression and Expansion of Criminalizing the Use of Certain Weapons in Non-international Conflicts

The first Review Conference on the Rome Statute of the International Criminal Court (ICC) took place in Kampala, Uganda, May 31 June 11, 2010. The Conference reached agreement on the definition of the crime of aggression and the framework for the Court's jurisdiction over this type of crime. In principle, a crime of aggression is committed by a leader who plans or executes an "act of aggression" that constitutes "by its character, gravity and scale" a "manifest violation of the Charter of the United Nations," while an "act of aggression" is the use of armed force in a manner inconsistent with the U.N. Charter, including any of the acts stipulated in UN General Assembly Resolution 3314, which are listed in new Article 8 bis. The activation of the Court's jurisdiction is pending agreement of two-thirds of States Parties, which cannot be taken before January 1, 2017 and one year after the ratification or acceptance of the amendments by 30 states parties, whichever is later.

The criminalization of the use of certain weapons in non-international conflicts is added under Article 8, paragraph 2, e) and includes: poison, poisoned weapons, asphyxiating, poisonous or other gases and all analogous liquids, materials or devices, as well as the use of bullets that expand or flatten in the body. The amendment will enter into force for each State Party one year after depositing the instruments of ratification or acceptance of the

amendment. [Related item: Changes to War Crimes Proposed for the International Criminal Court in November 2009 environmental security report.]

The Conference also adopted the Kampala Declaration, reaffirming states' commitment to the Rome Statute and its full implementation, as well as its universality and integrity. [July 2010. Military Implications, Sources14]

UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

The UN General Assembly adopted a resolution recognizing access to clean water and sanitation as a human right, a move that might be a step forward towards a future treaty. The non-binding resolution received 122 votes in favor, no votes against, while 41 countries abstained—including Australia, Britain, Canada, and the U.S. Introducing the resolution, Bolivia's representative pointed out that more children are killed annually by lack of access to water than by AIDS, malaria and measles combined, while lack of sanitation affects 40% of the world's population. [August 2010. Military Implications, Sources15]

UN Human Rights Council Affirms Right to Water as Legally-Binding

Water tables are falling on all continents; more than 40% of humanity gets its water from watersheds controlled by two or more countries. About 900 million people lack clean water and 2.6 billion lack adequate sanitation. The UN Human Rights Council adopted a resolution affirming that rights to safe drinking water and sanitation are basic human rights contained in existing human rights treaties, and therefore legally binding. The International Covenant on Economic, Social and Cultural Rights (ICESCR), the UN Convention on the Rights of the Child (CRC), the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), and the Convention on the Rights of Persons with Disabilities (CRPD) give rise to obligations for States parties in relation to access to safe drinking water and sanitation. This action addresses previous objections by those nations who abstained from supporting this right in the UN General Assembly in July this year. The UN Human Rights Council calls upon all States to create the legal and procedural frameworks for assuring the implementation, monitoring and enforcement mechanisms "to achieve progressively the full realization of human rights obligations related to access to safe drinking water and sanitation, including in currently unserved and underserved areas." [October 2010. Military Implications, Sources16]

International Biosecurity Initiative

U.S. Rep. Brad Sherman (D-Calif.), chair of the House Foreign Affairs Subcommittee on Terrorism, Nonproliferation, and Trade introduced the International Biosecurity Act of 2010 (HR 6297) to pursue efforts to establish international cooperation to counter both natural and man-made biological risks and assess the establishment of a global legal regime for biosecurity. The bill might be included in the proposed WMD Prevention and Preparedness Act of 2010 (HR 5498), which is awaiting a House floor vote. [Related items: BWC Meeting Improves International Resilience Systems to Address Infectious Disease and BioWeapons in August 2009, New Technologies Need New Regulations Systems in March 2009, and other items in previous environmental security reports.] [October 2010. Military Implications, Sources] 17

Synthetic Biology Guidelines to Reduce Bioweapon Threats

Synthetic biological voluntary guidelines released October 13, 2010 by the U.S. Dept. of Health and Human Services call for sellers of synthetic double-stranded DNA products to know their buyers and their intended use. These guidelines will be reviewed and updated on a regular basis. Since synthetic biology could one day be misused to create bioweapons and potentially even weapons of mass destruction, international agreements to regulate this new technology seem both likely and warranted. The scale and scope of the expected future biological revolutions may one day require an international regulatory agency similar to the International Atomic Energy Agency. [October 2010. Military Implications, Source] 18

Conflict and Post-Conflict Environmental Security Issues

High cancer rates in Fallujah, Iraq; New Study Raises Questions on Environmental Damage from Bombardments

A paper by visiting professor Dr Chris Busby at the University of Ulster and colleagues reports a four-fold increase in all cancers and a 12-fold increase in childhood cancer in under-14s from a survey in Fallujah, Iraq which was heavily bombarded in 2004. The study showed that infant mortality in the city is more than four times higher than in Jordan and eight times higher than in Kuwait. There is a 38-fold increase in leukemia, and a ten-fold increase in female breast cancer. The changes cannot be ascribed to any specific cause, but the authors raise the possibility of uranium-tainted weapons being involved. [Related item: New Legal Proceeding over Allegations of Use of Illegal Weapons in Iraq in May 2010 environmental security report.] [July 2010. Military Implications, Sources] 19]

Measuring Progress in Conflict Environments: A Metrics Framework

Measuring Progress in Conflict Environments (MPICE): A Metrics Framework is "a hierarchical metrics system of outcome-based goals, indicators, and measures, useful to indications of trends toward the achievement of stabilization goals over time". The approach shows a different way to measure conflict, based on outcomes in terms of success or failure results of strategies and projects aimed to strengthen stability and build a self-sustaining peace, instead of assessing traditional output such as the number of schools built, miles of roads paved, or numbers of police trained. MPICE provides a "system of metrics that can assist in formulating policy and implementing strategic and operational plans to transform conflict and bring stability to war-torn societies" by establishing "realistic goals, bringing adequate resources and authorities to bear". The framework is aimed at analyzing the peace progress during stabilization and reconstruction in order to measure the drivers of violent conflict that prevent indigenous institutions from exiting the conflict peacefully. The MPICE system was tested in Afghanistan and Sudan, and it is currently being applied to crisis cases and will be applied to future ones, in order to improve the approach. It was developed by a consortium of organizations working in development, security, and policy. [July 2010. Military Implications, Source] 20

Economic Argument for Peace-building in Sudan

A recent publication by Frontier Economics suggests that the January 2011 Southern Sudanese referendum on independence could cost Sudan, regional neighbors, and international agencies more than \$100 billion over 10 years (and over \$800 billion in 25 years), if the vote results in civil war. The study looks at different conflict scenarios within varying baseline contexts; assessing economic outcomes of impacts on infrastructure, oil production, peacekeeping, and humanitarian aid. [November 2010. Military Implications, Sources] 21

Artillery Training Charges Pose Environmental Asbestos Threat

The Australian Department of Defence has launched an investigation into the possible exposure of troops to white chrysotile asbestos from a broken dummy charge bag used in a kit for 105mm howitzer training, imported from the U.S. [July 2010. Military Implications, Source] 22

National and Regional Initiatives Affecting Military Activities

Latin American Initiatives for Environmental Security

UNDP and Ecuador have signed an agreement establishing a trust fund to partially compensate the nation for not exploiting an estimated 846 million barrels of crude oil lying under the Yasuni National Park, designated a World Biosphere Reserve in 1989. Costa Rica is also promoting several programs for sustainable energy generation and reforestation aiming to achieve "carbon neutrality" by 2021. Brazil and the U.S. arranged a debt for stewardship arrangement whereby \$21 million in debt will be forgiven in exchange for Brazil protecting non-Amazonian tropical forests. A summary of the consultations across the region are presented in the UNDP LAC Regional Biodiversity Initiative Bulletin, Vol. 1 No. 7, of August 27, 2010. [Related item: UN and Governments of Latin America and the Caribbean Met to Improve Disaster Anticipation and Response System in September 2008,

and EU, Latin American and Caribbean Countries Environment Cooperation in March 2008 environmental security reports.] [August 2010. Military Implications, Sources] 23

First U.S.-Russian Environmental Protection Park

The first U.S. Russian joint environmental protection project is creating the Beringia international conservation park, which will stretch over millions of hectares of Chukotka and Alaska (the Russian side alone might be about 1.8 million hectares.) [August 2010. Military Implications, Source] 24

CEC's Five-year Strategic Plan Increases North-American Environmental Integration

The annual meeting of the Council of the Commission for Environmental Cooperation (CEC), and consultation with the Joint Public Advisory Committee (JPAC) and the public, held in Guanajuato, presented the CEC's proposed Strategic Plan for 2010-2015. The strategy refocuses the CEC towards a results-centered collaboration between Canada, Mexico and the U.S. on three environmental priorities: 1) healthy communities and ecosystems (which includes management of chemicals of concern); 2) climate change - low-carbon economy (focusing on improving the comparability of data on greenhouse gas emissions, as well as sharing climate change information and adaptation strategies among the three countries); and 3) greening the economy in North America (that includes e-wastes movement within North America and beyond.) The Council also decided to establish the North American Partnership for Environmental Community Action (NAPECA) as a 5-year grant program supporting partnership-building to improve environmental conditions at the community, local and regional levels. [Related item: Canada, Mexico, and the USA Met to Strengthen Regional Environmental Regulations in June 2009 environmental security report.]

In the meantime, Health Canada published the Report on Human Biomonitoring of Environmental Chemicals in Canada, an assessment of the levels of 91 chemicals in Canadians. The report presents the results of Cycle 1 of the Canadian Health Measures Survey—a monitoring and research effort assessing chemical exposure. Cycle 2 (2009-2011) is currently being implemented, and planning already began for Cycle 3 (2012-2014). On another related issue, beginning in 2011, the USEPA will require operators of large carbon-emitting operations to submit annual emissions reports for GHGs. General standards are needed for data gathering and monitoring at federal as well as continental level to fulfill CEC's program. [August 2010. Military Implications, Sources] 25

EU to Set Resource Efficiency Targets

The European Commission is preparing a "roadmap" in the form of a set of resource efficiency targets to be published at mid-2011. It is expected that member states will be required to limit their consumption of fuels, minerals, and water, among other resources, potentially linked to the "European Semester" system for monitoring member state budgets. [Related item: European Climate and Energy Package Formally Adopted in April 2009 environmental security report.] [January 2011. Military Implications, Source26]

Islamic Conference of Environmental Ministers Approves Detailed Program

Participants to the 4th Islamic Conference of Environment Ministers (ISESCO) adopted a comprehensive Islamic Environmental Programme and endorsed the broader implementation of the program by all Islamic countries. Programs were also adopted for development and implementation of renewable energy, environmental protection, water resources, and sustainable development, as well as for reinforcing member states' capacities to develop national strategies and emergency plans to cope with natural disasters. [October 2010. Military Implications, Sources27]

Evolution of Environmental Management Philosophy in China

The paper The Evolution of Environmental Management Philosophy Under Rapid Economic Development in China published in AMBIO: A Journal of the Human Environment, seems to be a comprehensive assessment of China's approach to environmental matters, mainly from an energy needs point of view. [January 2011. Military Implications, Source28]

Technological Advances with Environmental Security Implications

Computer Technology and Robotics

Nanowire Semiconductors for Nano-sensors and Nano-robotics

New Super-efficient Undersea Marine Research Robot

Cost-Effective Real-Time Electronic Monitoring for Coastal Ecosystems

Nanowire Semiconductors for Nano-sensors and Nano-robotics

Zinc oxide has been used to create a transistor utilizing the piezoelectric effect (mechanical motion inducing voltage) that can process logic operations through its interface with the ambient environment. No external electric signal is required to operate the nanotech processor gate. George Institute of Technology scientists who developed it claim that the technology can be joined with sensors and energy-drawing components to create, "self-sustainable, all-nanowire-based, multifunctional self-powered autonomous intelligent nanoscale systems." [August 2010. Military Implications, Sources30]

New Super-efficient Undersea Marine Research Robot

Engineers at the Monterey Bay Aquarium Research Institute in Moss Landing CA have announced a highly efficient autonomous underwater vehicle that is fast, capable of carrying instruments and also designed for long-term expeditions. The LRAUV (long-range AUV) runs on batteries and incorporates power-saving and internal control software allowing it to monitor its own energy use and make intelligent choices about how to pursue its mission. The robot is claimed to be flexible enough for inclusion in most scientific excursions and is designed to work as a member of a group. The next phase of MBARI experimentation will monitor marine ecology using two units. [November 2010. Military Implications, Source31]

Cost-Effective Real-Time Electronic Monitoring for Coastal Ecosystems

Researchers from North Carolina State University led by Prof. Alex Dean report developing a "cost-effective electronic monitoring system that will enable researchers to advance ... understanding of critical coastal ecosystems by allowing users to track water-quality data .. .in real time." The system uses inexpensive, wireless sensors that can be anchored to the seabed, moored to buoys, or towed behind vessels to collect data, which is then transmitted to a central server. This project is "open source" and should enable other institutions concerned with coastal environments to develop their own efforts more efficiently. [November 2010. Military Implications, Source32]

New Detection and Cleanup Techniques

Novel Micro-enabling Technology Potentials to Improve Detection Efficiency

DNA Backbone Provides Foundation for Sensitive New Multi-material Sensor

U.S.-China Ozone Microbubbles Provide Widely Applicable Cleanup Technique

Laser Detector Offers Fast Gas Analysis

New Colorimetric Sensor Uniquely Detects Vapor from TATP Explosive

Spectrometer Provides Accurate Beta/Gamma Detection in 15 Minutes

Molecular Imprinted Polymers Provide Basis for Sensors of Multiple Compounds

Russian Enterprise to Mass Produce Low Cost Detectors for More than 40 Substances

Flexible Supercapacitor Could Power Wearable Environmental Sensors

Marine Bacteria Which Can Metabolize Steel Discovered

Improved Method to Remove Pollutants from Gas and Liquids

Nano-based Olfactory Sensor Offers Diversity, Extreme Miniaturization

New Index Aids Characterization of Biological Reaction to Nanomaterials

Autonomous Network of Sea Skimmers Could Speed Oil Spill Cleanup

New Technique Provides Simple, Sensitive Analysis of Aerosols

Photocatalytic Pavement Removes Nitrogen Oxides from City Air

New Water Testing and Purification Technologies

Electrified Nanotube-Fabric Filter Offers Cheap, Fast Water Purification

Graphene-based Composite Removes Arsenic from Drinking Water

New Catalyst Enables Water Decontamination by Visible Light

Adding Flocculation Agents to Runoff Filter Socks Improves Performance

Novel Micro-enabling Technology Potentials to Improve Detection Efficiency

Sphere Fluidics, a University of Cambridge spin-out company, states that the use of, "...an integrated microfluidics and picodroplets system for rapid analysis, isolation and discovery of single (and small populations of) cells and molecules...", offers efficiency, control and automation advantages to existing systems of analysis and detection. Applications to energy, health, and chemical investigation are anticipated and in progress. [Related item: New Substrate Preparations Make for Inexpensive "Labs on a Chip" in October 2008 environmental security report.] [November 2010. Military Implications, Sources34]

DNA Backbone Provides Foundation for Sensitive New Multi-material Sensor

Prof. Eric Kool of Stanford Univ., Stanford, CA, and colleagues report sticking small sets of sensitive fluorescent detector compounds onto short strands of one of the two long parallel chains of sugar and phosphate molecules forming the backbone of DNA to produce a new, highly effective sensor for organic vapors. The DNA structure provides an ideal framework in which the sensing molecules can react with the target and with each other to produce the indicative effects. Changing the identity and sequence of the attachments along the chain produced different fluorescence patterns for the test materials. This raises the possibility of combining a number of such units into a versatile sensing system for environmentally significant components. [August 2010. Military Implications, Sources 5]

U.S.-China Ozone Microbubbles Provide Widely Applicable Cleanup Technique

Prof. Andy Hong of the University of Utah has developed a technology, "heightened ozonation treatment (HOT)" that is claimed to have the potential to aid a wide range of environmental cleanup efforts, such as removing oil and gas byproducts from water, and organics and heavy metals from industrial sites, and removing harmful algae from lakes. The University, in cooperation with the Chinese company Honde LLC and the Chinese government, is testing the technique to remediate a lakeshore industrial site. [October 2010. Military Implications, Source36]

Laser Detector Offers Fast Gas Analysis

Scientists at the JILA laboratory operated by the National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder report having extended into the mid-infrared (IR) range the coverage of a laser-based spectroscopic system capable of fast molecular analysis of complex gas mixtures, with parts-per billion (ppb) precision, using an "optical frequency comb." The researchers plan to extend this coverage to an important longer wavelength portion of the IR spectrum. [October 2010. Military and Implications, Source37]

New Colorimetric Sensor Uniquely Detects Vapor from TATP Explosive

Prof. Kenneth Suslick and Hengwei Lin of the University of Illinois at Urbana-Champaign claim development of a fast, inexpensive colorimetric sensor array device that can quantitatively detect levels of vapor from the explosive triacetone triperoxide (TATP) down to 2 ppb. TATP is a high-powered explosive that has been used in several bombing attempts. The sensor uses an inert plastic film with 16 tiny colored dots - each a different pigment - where a solid acid catalyst breaks down TATP into detectable components that cause the pigments to change color in an indicative pattern. It is being commercialized by iSense, a sensor manufacturer based in Palo Alto CA. [October 2010. Military Implications, Sources38]

Spectrometer Provides Accurate Beta/Gamma Detection in 15 Minutes

Profs. David Hamby and Abi Farsoni of Oregon State Univ. have announced development of a new type of radiation spectrometer that can take as little as 15 minutes to determine the type and amount of beta- and gamma-emitting radionuclides present in materials such as soil. The development will be commercialized by Avicenna Instruments, of Corvallis, Oregon. [January 2011. Military Implications, Source39]

Molecular Imprinted Polymers Provide Basis for Sensors of Multiple Compounds

Prof. Rigoberto Advincula and colleagues of the Depts. of Chemistry, and Chemical and Biomolecular Engineering at the Univ. of Houston, are developing a family of sensors based on molecular imprinted polymers, which can be tailored to show an affinity for certain chemicals. These materials, prepared by electropolymerization directly on a gold surface, can form the basis for sensitive detectors for hazardous compounds in the environment. [January 2011. Military Implications, Sources40]

Russian Enterprise to Mass Produce Low Cost Detectors for More than 40 Substances

The Russian firm Neutron Technologies has received funding for a project that will mass produce detectors of explosives and narcotics, using labeled neutron technology. The detectors are designed to operate in any kind of surroundings, can identify more than 40 different kinds of explosives, narcotics, and highly toxic substances, and are claimed to be significantly less expensive and more effective by numerous measures than other countries' offerings. [December 2010. Military Implications, Source41]

Flexible Supercapacitor Could Power Wearable Environmental Sensors

Prof. Zhong Lin Wang of the Georgia Inst. of Technology and Jong Min Kim of South Korea's Samsung Electronics claim development of a prototype flexible supercapacitor that can be incorporated into textiles. The devices use zinc oxide nanowires as electrodes. Combined with their previously developed flexible fiber

nanogenerators, these units could power wearable environmental sensors. [January 2011. Military Implications, Source42]

Marine Bacteria Which Can Metabolize Steel Discovered

A new species of bacteria was discovered corroding the Titanic. The newly identified species, while potentially dangerous to vital underwater installations such as offshore oil and gas pipelines, could also offer a new way to recycle iron from old ships and marine structures, according to the researchers from Dalhousie University in Halifax NS, Canada, and Seville University in Spain. Evidence for this species of marine bacteria originated with investigation into strange formations, referred to as "rusticles", found on the underwater wreckage of the Titanic, hence the name designation of Halomonas titanicae. In the context of marine bioremediation and recovery of recyclable metals, this discovery provides yet another avenue of investigation into these types of metabolic processes, and the potential organisms (naturally occurring and genetically engineered) utilizing them. [December 2010. Military Implications, Source43]

Improved Method to Remove Pollutants from Gas and Liquids

University of Illinois researchers led by Prof. Mark Rood have created a continuous process for the creation of tailororable carbon/iron-based catalysts. The technology uses ultrasonic spray pyrolysis, also developed at the University, to produce porous carbon spheres with iron nanoparticles dispersed throughout, differentiating it from previous processes which typically provided only one ingredient or the other. The group will now work on developing catalysts to remove three bioaccumulating pollutants from gas streams simultaneously; where now such pollutants are addressed individually. [December 2010. Military Implications, Source44]

Nano-based Olfactory Sensor Offers Diversity, Extreme Miniaturization

Prof. Andrei Kolmakov, of the Physics Dept. at Southern Illinois Univ. at Carbondale, and colleagues, have announced developing a chemical sensing device (an "electronic nose") based on a wedge-like nanowire (nanobelt) of tin dioxide in a new structural configuration providing multiple sensitivities in a single wire. Ultimate sizes for the devices could be in the range of micrometers. [August 2010. Military Implications, Sources45]

New Index Aids Characterization of Biological Reaction to Nanomaterials

Prof. Xin-Rui Xia and colleagues at NC State University have published a method for predicting how biological proteins will react with nanoparticles of given compositions. According to their paper's abstract, "The method successfully predicted the adsorption of various small molecules onto carbon nanotubes,. the nanodescriptors were also measured for 12 other nanomaterials . [and] can be used to develop pharmacokinetic and safety assessment models for nanomaterials." [August 2010. Military Implications, Sources46]

Autonomous Network of Sea Skimmers Could Speed Oil Spill Cleanup

According to an article in Nanowerk News, the SENSEable City Laboratory at MIT has developed one prototype unit of a proposed fleet, Seaswarm, of autonomous solar-powered robot vessels, each of which moves a conveyor belt covered with a thin absorbent nanowire mesh over the sea surface to remove oil. The fabric can absorb up to twenty times its own weight in oil while repelling water. By heating the material, the oil can be removed and the nanofabric reused. The "swarm" would use GPS and a communications network to self-manage a coordinated attack on a spill. [September 2010. Military Implications, Source] 47

New Technique Provides Simple, Sensitive Analysis of Aerosols

Dr. Patrick Roach and colleagues at DOE's Pacific Northwest National Laboratory, Richland WA, have announced a new technique, Nanospray-Desorption/Electrospray Ionization (NanoDESI) for introducing aerosols into a mass spectrometer for detailed analysis of their molecular content. This single, generally applicable method,

unlike former ones, does not require expert technicians or significant sample preparation. [September 2010. Military Implications, Sources48]

Photocatalytic Pavement Removes Nitrogen Oxides from City Air

F. C. Nudling Betonelemente of Fulda, Germany, has developed the "Air Clean" nitrogen oxide-reducing paving slab, which is coated with photocatalytic titanium dioxide nanoparticles that convert harmful substances such as nitrogen oxides into nitrates that are harmlessly washed away. One test, in Erfurt, indicated an average degradation rate of 20% for NO₂ and 38% for NO. [August 2010. Military Implications, Source49]

New Water Testing and Purification Technologies50

Scientists at the Univ. of Central Florida, led by Prof. J. Manuel Perez, have developed a fast, sensitive, and probably less expensive test for cholera toxin in water. The test uses the sugar dextran coated with iron oxide nanoparticles, with a positive result detected by magnetic relaxation measurements.

ABSMaterials, Inc. of Wooster, OH is offering water purification systems based on the properties of a new swellable nano-structured glass, Osorb®, developed at the College of Wooster. In a demonstration, the material expands to eight times its original volume in the presence of hydrocarbons, purifying a gasoline-tainted sample of drinking water for consumption. [January 2011. Military Implications, Sources51]

A new disposable filter that looks like a tea bag and fits into the neck of a bottle reportedly can clean highly polluted water. The inside of the tea bag material is coated with a thin film of biocides, encapsulated within nanofibers, which kill pathogenic microbes. The bag is filled with active carbon granules that remove all harmful chemicals, e.g., endocrine disruptors. According to the developers, each "tea bag" filter can purify one liter of the most polluted water to the point where it is 100% safe to drink. It is discarded after use. The invention was developed by a team of scientists led by Prof. Eugene Cloete, Dean of the Faculty of Science at Stellenbosch Univ. in South Africa, and is one of the first major projects of the new Stellenbosch Univ. Water Institute.

A team of researchers at Stanford University, Stanford CA, have demonstrated a new water purification technique in which water flows thru electrified (-20 V) cotton cloth dyed with ink containing bactericidal silver nanowires and carbon nanotubes. The electric potential greatly improves the effectiveness of the nanosilver. The high-speed process de-activates 80-90% of the bacteria, but multiple units could be cascaded to produce acceptable reductions, or the device could be used as a preprocessor for other purification systems, reducing their bacterial load.

The International Journal of Nuclear Desalination article Nanotechnology for water purification offers an overview of nanotech-based devices for water treatment. According to the abstract, "[n]ew sensor technology combined with micro and nanofabrication technology is expected to lead to small, portable and highly accurate sensors to detect chemical and biochemical parameters in water. Potential opportunities and risks associated with this technology are also highlighted." [August 2010. Military Implications, Sources52]

Electrified Nanotube-Fabric Filter Offers Cheap, Fast Water Purification.

The abstract of a research paper by Prof. Yi Cui of the Dept. of Materials Science and Engineering at Stanford University and colleagues states that an inexpensive, fast acting electrical water purification system has been developed using silver nanowires and carbon nanotubes on a cotton base. This operates at 100,000 L/(h x m²) and can deactivate >98% of bacteria within several seconds. The deactivation is achieved by large electric field concentrations near the silver nanowire tips. [December 2010. Military Implications, Sources53]

Graphene-based Composite Removes Arsenic from Drinking Water

Researchers at Pohang University of Science and Technology in Pohang, Republic of Korea, claim creation of a new magnetite composite, based on reduced graphene oxide (RGO), which absorbs arsenic when dispersed in

water, and can then be removed with a magnet. Compared to present methods, the highly efficient new material can be used in continuous-flow systems for longer periods. [July 2010. Military Implications, Sources54]

New Catalyst Enables Water Decontamination by Visible Light

Scientists at the Shenyang National Laboratory for Materials Science in Shenyang, China, have announced a catalytic water purification technique using visible light rather than UV. The catalyst is made from a grid of titanium oxide fibers impregnated with nitrogen, augmented with palladium nanoparticles. The bactericidal action continues for up to 24 hours after light is removed. Professor Shang has stated that this new technique is both more energy-efficient and more effective than previous UV photocatalysts and will also kill some of the toughest microbes such as spores. [July 2010. Military Implications, Sources55]

Adding Flocculation Agents to Runoff Filter Socks Improves Performance

Scientists from the Agricultural Research Service's Animal and Natural Resources Institute in Beltsville MD, and researchers from Filtrexx International, say they improved on the performance of filter socks used to partially remove contaminants from storm water runoff from construction sites and other disturbed earth sites. Adding flocculation agents to the compost inside the socks improved reduction percentages of contaminants by up to one-third, including reducing E. coli and motor oil by 99%. [July 2010. Military Implications, Source56]

Counter Bioterrorism or Pandemic Technologies

Portable Virus Detector Could Check Pandemics

More Reliable "Kill Switch" Found for Genetically Engineered Microbes

Potential Bioweapon Countermeasure against Ebola and Marburg Virus

Portable Virus Detector Could Check Pandemics

A team at the A*STAR Institute of Bioengineering and Nanotechnology (IBN) in Singapore, led by Pavel Neuzil, reports developing a portable device for rapid detection of viruses in the environment. The unit implements a real-time polymerase chain reaction capability by using a silicon-based micromachined 'lab-on-a-chip', replacing the conventional light source with a light-emitting diode, and replacing the photomultiplier tube with a photodiode. The developers claim that the system can detect H5N1 viruses in as little as 35 minutes and is some 50 times cheaper than competing devices. This technology, when commercialized, could greatly improve the efficiency of detecting pathogenic organisms in the environment. [November 2010. Military Implications, Sources57]

More Reliable "Kill Switch" Found for Genetically Engineered Microbes

Prof. James Collins and colleagues at Boston University claim development of a highly tunable genetic "switch" offering a high degree of control over genetically engineered microbes, lessening worries about "rogue" organisms escaping into the environment. According to a descriptive article, they have devised a "highly tunable genetic [RNA] 'switch' that ... makes it possible to stop the production of a protein and restart it again. The switch, which could be used to control any gene, can also act as a 'dimmer switch' to finely tune how much protein a microbe would produce over time." [August 2010. Military Implications, Source] 58

Potential Bioweapon Countermeasure against Ebola and Marburg Virus

Scientists of the University of Illinois at Chicago have identified a family of small molecules that apparently inhibit the Ebola and Marburg virus entry into human cells. Although not a cure, the breakthrough could represent a potential bioweapon countermeasure against use of those agents. [January 2011. Military Implications, Source59]

Promising Environment-friendly Technologies

Nanoimprint May Create Synthetic, Chemical-Free, Anti-Bacterial Surfaces

Optical Link Facilitates Exploration of the Underwater Environment

Advances in Wireless Location Detection

Charged Particle Generators Produce Desert "Rainstorms"

Metal-Organic Frameworks (MOFs) Give Greatly Improved CO₂ Storage

Carbonates for Construction Drawn from Carbon Dioxide

Improved Plastic Recycling

New Cement Process Greatly Reduces Energy Load and CO₂ Emission

Sustainable Method to Recycle Rubble into Durable Construction Material

New Forms of Air Conditioning Assuming Larger Role

Nanoimprint May Create Synthetic, Chemical-Free, Anti-Bacterial Surfaces

Singapore's A*STAR Industrial Consortium On Nanoimprint and collaborating organizations are working on a project to create synthetic, chemical-free, anti-bacterial surfaces that can protect external structures from harboring pathogenic organisms. The nanoimprint technology creates complex nanometer-sized patterns on surfaces to mimic the texture of natural contaminant-repelling materials. [January 2011. Military Implications, Sources61]

Optical Link Facilitates Exploration of the Underwater Environment

Engineers at Woods Hole Oceanographic Institution have developed an optical modem system which allows data and command communication with an autonomous undersea research vehicle without the need for tethering with bulky cables. The system demonstrated error-free transmissions at 1 megabit per second at a range of more than 100 meters. [July 2010. Military Implications, Source62]

Advances in Wireless Location Detection

MIT's Laboratory for Information and Decision Systems (LIDS) is developing an exploratory model of wireless "limits" that has relevance for improved, practical, high resolution location communication applications, which can utilize low cost, limited battery life mobile devices. The researchers say this is the first study of its kind and that they have "designed novel location-aware networks with sub-meter accuracy and high reliability" by calculating optimal efficiencies of signal detection within various wireless positioning systems. The group's work will appear as a pair of papers in the IEEE Transactions on Information Theory October issue. [September 2010. Military Implications, Source63]

Charged Particle Generators Produce Desert "Rainstorms"

Scientists from the Swiss company Metro Systems International, working in the United Arab Emirates, have been trying to produce rainfall in the desert. Their system uses electronic ion generators to produce charged dust particles, which rise in the atmosphere and attract moisture that then falls as rain. Their claim of having created at least 52 specific "rain storm events" with this system has been met with some skepticism, although most

of the storms were in July and August, when usually there is no rain at all. [January 2011. Military Implications, Source64]

Metal-Organic Frameworks (MOFs) Give Greatly Improved CO₂ Storage

Researchers from UCLA and Seoul's Soongsil University report development of several new MOF materials with greatly improved capability for CO₂ capture and storage. [July 2010. Military Implications, Sources65]

Carbonates for Construction Drawn from Carbon Dioxide

Utilizing funding from Italian energy company Eni, Prof. Angela Belcher of MIT and two graduate students have developed a bench-scale, biological process to remove CO₂ from the environment and transform it into solid carbonate. The procedure produces approximately two pounds of carbonate for each pound of CO₂, without the use of heating, cooling, or toxic chemicals. The MIT group plans to test scaling the process by applying it to the CO₂ emissions at a fossil-fuel-burning power plant. They also believe the process's mineral ions can be obtained from briny water that is a byproduct of water desalination. [September 2010. Military Implications, Source66]

Improved Plastic Recycling

Warwick Ventures at the University of Warwick, Coventry, England, has announced a new technology, using pyrolysis and fluidized beds that they claim will allow the recycling of 100% of household plastics instead of only 11% processed today (as measured in the U.K.). [December 2010. Military Implications, Source67]

New Cement Process Greatly Reduces Energy Load and CO₂ Emission

A project led by chemist Peter Stemmermann at Germany's Karlsruhe Institute of Technology reports a new variety of cement called Celitement. It requires less energy to manufacture and emits less CO₂ in the production process. Cement manufacturing is responsible for about 5% of global CO₂ emissions. [January 2011. Military Implications, Sources68]

Sustainable Method to Recycle Rubble into Durable Construction Material

Researchers at Georgia Tech describe a technique to recycle such building debris as that from the Haiti earthquake into a strong concrete material using sands and other natural materials widely available locally. While concerns remain about the variable quality of the concrete rubble and local materials, and the need to conduct further research on recycled concrete in general, lab tests show the new building substance "meets or exceeds the minimum strength standards defined by the American Concrete Institute and used in the U.S." [January 2011. Military Implications, Sources69]

New Forms of Air Conditioning Assuming Larger Role

Restrictions on appliance energy requirements and energy usage are forcing a trend away from the conventional refrigeration-based units and toward other means, such as radiant cooling and evaporative coolers. [Related item: Only Very Low-Energy Buildings to Be Built in EU after 2020 in May 2010, and Increasing Energy Efficiency in July-August 2008 reports.] [August 2010. Military Implications, Source70]

Increasing Energy Efficiency Technologies

New Insights into Photosynthesis Could Change Energy Storage and Transmission

Adding Graphene to Lithium-Ion Batteries Dramatically Reduces Recharge Time

Carbon Nanotube Cathodes, Silicon Anodes Improve Battery Performance

New Solar-Powered Process Converts Atmospheric CO₂ to Solid Carbon

Solar Energy Conversion System Uses Both Photovoltaic and Thermal Technologies

New Supercapacitor Design Claims Large Improvements in Energy Storage

New Window Developments Aim at Saving, Generating Energy

NSF Makes 14 Grants in Renewable Energy and Sustainability

New Insights into Photosynthesis Could Change Energy Storage and Transmission

Researchers at MIT have observed the maximal efficiencies of chromophores (light-sharing molecules active in photosynthesis) via a laboratory-based construct of artificial self-assembling molecules. The researchers believe they now have a macro-understanding of the photosynthetic process. With this new understanding, scientists in the field believe synthetic chemical systems based on photosynthesis have the potential to store and transmit solar energy with far greater performance ratios than today's photovoltaic technology. [Related item: Photoelectric Energy Efficiency Increase by Photosynthesis-type Semiconductor Structure in March 2009 environmental security report.] [November 2010. Military Implications, Source] 71

Adding Graphene to Lithium-Ion Batteries Dramatically Reduces Recharge Time

DOE's Pacific Northwest National Laboratory, Vorbeck Materials Corp. of Jessup MD, and Professor Ilhan Aksay of Princeton University collaborated in developing a new technology incorporating graphene into lithium-ion batteries, thereby reducing their recharge times by factors from 10 to 30. [July 2010. Military Implications, Source] 72

Carbon Nanotube Cathodes, Silicon Anodes Improve Battery Performance

Contour Energy Systems, Inc. of Azusa CA has announced its licensing from MIT of a carbon nanotube technology that it says can dramatically improve the power capability of lithium-ion batteries. Prof. Shao-Hom of MIT stated, "These carbon nanotubes contain numerous functional groups on their surfaces that can store a large number of lithium ions per unit mass ... [Thus] for the first time, carbon nanotubes can serve as the cathode in lithium-ion batteries, instead of the traditional role that carbon materials have played as the anode in such systems," producing faster reactions and delivering high power, approaching 10 times current total power delivery capability. Corvus Energy of Vancouver reports achieving 22% better power storage by using lithium nickel manganese cobalt instead of lithium iron phosphate.

According to Nanowerk News, Prof. Sibani Lisa Biswal, of Rice University and colleagues there and at Lockheed Martin have developed a new anode material for lithium-ion batteries consisting of silicon densely filled with pores 1 micron wide and 10-50 microns long in which lithium can be absorbed and released - as much as 10 times as much as with equivalent carbon material. This structure overcomes the previous deficiency of a silicon base: cracking after a limited number of recharge cycles. [October 2010. Military Implications, Sources73]

New Solar-Powered Process Converts Atmospheric CO₂ to Solid Carbon

Professor Stuart Licht of the Department of Chemistry and Solar Institute at George Washington University and collaborators report the STEP (Solar Thermal Electrochemical Photo) process, which uses solar radiation both to heat a molten lithium carbonate electrolyte that splits the CO₂ into free oxygen and solid carbon that is formed at the cathode, and to provide energy for the electrolysis. [July 2010. Military Implications, Sources74]

Solar Energy Conversion System Uses Both Photovoltaic and Thermal Technologies

Prof. Nick Melosh of Stanford University and colleagues have reported a new solar energy conversion technology, "photon enhanced thermionic emission," (PETE) which allows a photovoltaic cell to operate at temperatures over 200°C, enabling the construction of a solar energy conversion system that utilizes both solar light and heat to produce electricity. [August 2010. Military Implications, Source] 75

New Supercapacitor Design Claims Large Improvements in Energy Storage

Prof. Yury Gogotsi of Drexel Univ., Philadelphia PA, and colleagues have announced the development of a supercapacitor which they describe as having more power per volume comparable to electrolytic capacitors, as well as four orders of magnitude higher capacitance, an order of magnitude higher energy per volume, and three orders of magnitude higher speed. According to the announcement and abstract, the microsupercapacitors are produced by integrating into a microdevice, without the use of organic binders and polymer separators, a component comprising a several-um-thick layer of onion-like 6-7 nm. carbon spheres, yielding a high surface-to-volume ratio of active material. [August 2010. Military Implications, Sources⁷⁶]

New Window Developments Aim at Saving, Generating Energy

Soladigm, Inc. of Milpitas, CA is working on a line of lower cost electrochromic windows which allow electronic control of the radiation passing through them, keeping out unwanted solar heat in summer and allowing it to pass during winter, thereby reducing air conditioning and heating costs. The windows contain multiple electronic control layers sandwiched between two layers of glass. The company has licensed technology to resolve problems with the idea. Its overall cost-competitiveness with conventional windows, or with low-E windows, that both passively block near-infra-red is uncertain.

EnSol AS, of Bergen, Norway, in cooperation with the Univ. of Leicester, Dept. of Physics and Astronomy, has patented a novel thin film solar cell technology that they claim could be coated as a thin transparent film (on, for example, windows in buildings) to produce power on a large scale. They hope for commercial availability by 2016. [August 2010. Military Implications, Sources⁷⁷]

NSF Makes 14 Grants in Renewable Energy and Sustainability

The National Science Foundation Office of Emerging Frontiers in Research and Innovation announced 14 grants for fiscal year 2010, awarded to 62 investigators at 24 institutions, working over the next four years on storing energy from renewable sources; and engineering sustainable buildings. According to the announcement, the groups "will pursue creative new approaches to making large-scale energy storage efficient and economical. They aim to construct capacitors and regenerative fuel cells with unprecedented capabilities to harness the sun's thermal energy, to produce chemical fuel on demand, and to trap off-shore wind as compressed air" and "will investigate the critical flows and fluxes of buildings--power, heat, light, water, air and occupants --to create new paradigms for the design, construction, and operation of our homes and workplaces." [October 2010. Military Implications, Source] 78

Technologies for New Generations of Cars

Experts Say Possible Rare Earth Shortages Not A Real Problem for Electric Cars

In response to questions about the possible shortage or non-availability of the rare earth elements required for much of current electronics, in particular electric cars, experts on The Millennium Project's global-energy listserv have indicated that the problem, for electric cars at least, is, in a sense, illusory: the automotive industry need only move over to switched reluctance motors (SRM), which do not need rare earth components and work better in cars than the current permanent magnet (PM) ones; the real problem is technological inertia - a lack of demand for what is actually a better solution to propulsion. Further, there is currently no availability problem with import of rare-earth-using PM motors. [August 2010. Military Implications, Source⁸⁰]

Space Technology

NASA's SERVIR Environmental Imaging-Decision Support System Extended from Mesoamerica and Africa to Asia

According to an announcement, NASA and the Agency for International Development have unveiled SERVIR-Himalaya, a Web-based environmental imaging and management system based in Kathmandu, Nepal. NASA's SERVIR system, already in use in Mesoamerica and Africa, combines satellite imagery, data management tools, and interactive visualization capabilities to help scientists and decision-makers address climate change, biodiversity, and environmental threats, such as flooding, forest fires, and storms. [Related item: Increased Use of Space Technology for Monitoring Environmental Events in September 2008 environmental security report.] [October 2010. Military Implications, Source 1]

Technologies that Could Trigger New Forms of Arms Race

A number of significant technology-related trends - including the development of laser weapons, electronic warfare and technologies that impede access to space - appear poised to have major global effects that will impact on NATO military planning and operations.

- Active Engagement, Modern Defence. Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation adopted by Heads of State and Government in Lisbon. 19 Nov. 2010

Robot Planes for Environmental Monitoring and Warfare Raise Legal Concerns

Robot planes are proliferating, as are moral and legal concerns regarding their use. The European Space Agency's Business Incubation Centre at Darmstadt, Germany, and a German start-up company, MAVinci, have developed an unmanned aircraft system guided by satellite navigation (satnav) that uses autonomous micro-air vehicles (MAVs) with a wingspan of less than two meters, to inspect land areas. Boeing's Phantom Works' Vulture II program is developing Solar Eagle, a demonstration solar-powered unmanned aerial vehicle (UAV) that will make its first flight in 2014, and is designed to lead to a large vehicle that can remain on station in the upper atmosphere for up to five years. An analogous effort is the hydrogen-powered demonstrator, Phantom Eye, designed to stay aloft for up to four days and scheduled to make its first flight in 2011. These are only a few of the latest advancements in remote-controlled warfare with promising positive environmental and security results. Nevertheless, recently, a trial in a Las Vegas court against the anti-drone protesters group Creech 14, who allegedly trespassed onto Creech Air Force Base in April 2009, was delayed for four months. This sets the stage for a debate concerning the eventual need for clear regulations regarding the circumstances for using remote-controlled warfare components. [September 2010. Military Implications, Sources] 83

B. Preventing or Responding to Environmentally Caused Conflicts

Key environmental and resource constraints, including health risks, climate change, water scarcity and increasing energy needs will further shape the future security environment in areas of concern to NATO and have the potential to significantly affect NATO planning and operations.

- Active Engagement, Modern Defence. Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation adopted by Heads of State and Government in Lisbon. 19 Nov. 2010

Security Implications of Environmental Aspects

New Website Addresses Conflict-sensitive Conservation

While most of the discourse is around environmental protection in case of conflict, a new website is addressing conflict-sensitive conservation (CSC) in order to prevent conservation activities from exacerbating conflict or impeding peacebuilding. Since many of the world's biodiversity hotspots are located in socially and/or

politically unstable zones, conservation organizations have to "adopt conflict-sensitivity". IISD, one of the project's founding organizations, notes that conservation activities could exacerbate conflict situations by restricting populations' access to key livelihood resources; introducing new or additional economic burdens or risks; and/or causing unequal distribution of benefits. The CSC website offers a portal for understanding the links between conservation and conflict in order to reduce their potential negative backlash, while also suggesting best practices and ideas for improving situations. [July 2010. Military Implication, Sources86]

Extinction Threatening 21% of Africa's Freshwater Species Could Have Security Implications

According to the Red List by the International Union for Conservation of Nature (IUCN), 21% of all African freshwater species are currently under threat of extinction due to such factors as pollution, deforestation, and overfishing. The assessment was carried out over five years by 200 scientists who investigated over 5,000 species. Their report indicates that species extinction is directly related to food security in Africa and that a "whole systems" approach is required to ensure that infrastructure and agricultural development projects in Africa include freshwater management for biodiversity. [Related items: Biosafety Protocol Advances in February 2010, and Food and Water Security in June 2008 environmental security reports.] [September 2010. Military Implications, Source] 87

Possible Conflicts over National/Regional Geoengineering Projects

A study published in Nature Geoscience warns that conflicts are possible between those who do and those do not implement "cheap" geoengineering projects. The most likely to be tried are solar radiation management projects using aerosols inserted into the stratosphere to increase solar heat reflection, since the effects of such efforts cannot be entirely foreseen even for the areas directly targeted, let alone neighboring ones. Similar warnings were issued by a Science and Technology Committee earlier this year, and by the Met Office. Additionally, an international team of scientists reports that, unless involving extreme measures, geoengineering approaches would have little efficiency in curbing sea levels rising. The findings, assessing five geoengineering approaches were summarized in the paper Efficacy of geoengineering to limit 21st century sea-level rise, published by the NAS. [Related item: Geoengineering May Require International Environmental Regulations in January 2010 environmental security reports.] [August 2010. Military Implications, Sources88]

Indigenous People Demanding Regulations for Addressing Climate Change and Mining

The Forum of Indigenous Peoples Mining, Climate Change and Well Being, held in Lima, November 18-20, 2010, has issued the Lima Declaration demanding measures to address implications of climate change and mining on indigenous land. The Declaration calls on governments to enact measures limiting (or revoking) transnational companies' rights to mine on indigenous land without consultation with the indigenous people, and the adoption of laws to determine zones prohibited for mining on indigenous territories. It calls upon the UN to declare indigenous peoples "the rightful owners since the ancient times of the soil, subsoil and natural resources" of their territories. They also declare being "committed to instrumentalize the International Court of Justice Climate" and the "construction of a national and regional agenda for climate justice." [Related item: Indigenous Peoples Demand More Involvement in Environmental Policies in May 2008 environmental security report.] [December 2010. Military Implications, Sources] 89

Race for Natural Resources

Natural Resources Fuel Violence in Eastern D.R. Congo

Approximately 500 citizens in eastern Democratic Republic of the Congo were attacked by militias allegedly including Rwandan and Congolese rebel forces. The attacks occurred in several areas of the Kivu provinces at the epicenter of mineral mining activities and in proximity to forests and forest preserves where illegal timber logging and rare mineral extraction have historically fueled conflict. UN aid workers estimate that 890,000 people are internally displaced in the provinces, while UN Assistant Secretary-General for Peacekeeping Atul Khare indicated that current security forces in the region have been unable to maintain their peacekeeping mandate, which includes the protection of civilians and, by extension, control of natural resources through training and other

military assistance to the government. Meanwhile, reports from international agencies, including the World Bank, have concluded that weak legal, financial, and policy frameworks in D. R. Congo discourage formulation of national development goals that can be aligned with judicious natural resource use. The weakness also inhibits implementation of effective control mechanisms for natural resource stewardship, including an inability to monitor, evaluate, and secure the use of land for productive agricultural purposes. [Related item: The Race for Natural Resources a Potential Impediment for Peace in June 2010 environmental security report.] [September 2010. Military Implications, Sources⁹¹]

Protests in Peru over Dam Irrigation and Hydroelectric Project Part of a Regional Picture

A major Peruvian irrigation and electricity project that includes diversion of water from the Apurimac River is protested by local citizens who claim they were not consulted during the tender process and that the project will destabilize their water source. A Spanish-Peruvian consortium received a concession to dam and divert water for irrigation and electricity capacity to encompass approximately 66,000 hectares (163,000 acres) of new land and to generate more than 500 Mw of power. The Majes-Siguas Special Project does not appear to require contractual provisions for the benefit of local populations. An environment ministry official said that there are around 1,000 ongoing conflicts over water in this one region, of which more than 40 are potentially serious. [Related items: International Lawsuits for Environmental Crime Proliferate in January 2010, and Indigenous Peoples Demand More Involvement in Environmental Policies in May 2008 environmental security reports.] [September 2010. Military Implications, Sources] 92

The Battle for Rare Earth Elements Continues

A Japanese government-backed enterprise plans to deploy remote-controlled robots to mine rare earth elements up to a depth of 6,600 ft. from the seabed in proximity to the Izu and Ogasawara island chain and southwestern Okinawa islands. The project is targeting seabed volcanoes in search of minerals released from hydrothermal vents. Precious metals and methane hydrate, a potential next-generation fuel, are also a potential area of focus. [Related item: Chinese Rare Earth Restrictions in September 2010 environmental security report.] [January 2011. Military Implications, Sources⁹³]

Chinese Rare Earth Restrictions

China announced it is reducing its annual rare earth exports by 40%. This limits shipments to a little over 30,000 tonnes, which is 15,000-20,000 tonnes less than consumption by non-Chinese producers. Prices of the minerals have skyrocketed over the past year, and countries are searching for replacement sources; possibilities include the U.S., Australia, Vietnam, Kazakhstan, Afghanistan, and Tanzania. The export curtailment follows a period of low Chinese prices that caused many countries' mines to be dismantled and closed completely. The rate of discovery or reactivation for sources may be enough to prevent shortages; however, some of these countries have problems of stability, finances, qualified work force, and environmental policies, since the extraction of these elements involves the use of highly toxic chemicals. [September 2010. Military Implications, Sources⁹⁴]

China Applies for Seabed Mining Permit in Search for New Mineral Resources

China has filed the first application with the International Seabed Authority for deep seabed mining in international waters to search for valuable metals such as copper, nickel, cobalt, gold and silver. This application for mining of sulfides in the southwest Indian Ocean at depths of more than 5,000 feet below the surface is expected to be heard April 2011. If successful, many more applications are expected to follow from China and other countries. Environmental experts are already expressing concerns about the potentially major consequences that deep-sea mining could have on the marine ecosystem. [Related item: The Race for Natural Resources a Potential Impediment for Peace in June 2010 environmental security report.] [New estimates show large resources may be possible in Afghanistan.]

Apart from these relatively common metals, the world could experience shortages of rare earth minerals needed for renewable energy and information technologies as soon as 2012. China produced more than 97% of the world's rare earth oxides in 2009, and controls about 50% of the globe's known reserves. Recently it announced a

72% cut in its exports of rare earths for the second half of 2010. In order to decreasing its dependence on foreign minerals, the U.S. is considering reviving the domestic rare earths mining industry, most probably beginning with the Mountain Pass CA mine that plans to increase mining and processing to 20,000 tons of rare earths by 2012, from the current 2,000 tons a year. [July 2010. Military Implications, Sources⁹⁵]

China to Build Support Base for Seabed Exploration

China has announced that it will build a \$73 million support base at Qingdao, on the Shandong Peninsula, between Beijing and Shanghai, for its deep-diving submersible research vessel "Jiaolong", designed to dive as deep as 7,000 meters. This emphasizes the increasing role that the seabed will play in the worldwide rivalry for new resources. [August 2010. Military Implications, Source⁹⁶]

Arctic and South China Sea Resource Issues Causing U.S. to Review Law of the Sea

A Joint Statement of the 2nd US-ASEAN Leaders Meeting reaffirmed regional peace in accordance with principles of international law including the UN Convention on the Law of the Sea, which is a main legal tool for protection against China's claims in the South China Sea. "Disagreements over territorial claims and the appropriate use of the maritime domain appear to be a growing challenge to regional stability and prosperity," stated Secretary of Defense Robert Gates at a multilateral event in Hanoi, Vietnam, with reference specifically to the South China Sea. Secretary of State Hillary Clinton also underlined that the U.S. will "prioritize the Law of the Seas next year. It is critical to how we're going to manage the Arctic. It is critical to our credibility in working with nations in Southeast Asia over questions regarding activities in the South China Sea." The Convention has 161 parties (including the European Union), and out of the 35 nonparties, 17 are land-locked states. [Related item: Resources Trigger Overlapping Claims for Maritime Areas in May 2009 environmental security reports.] [October 2010. Military Implications, Sources] ⁹⁷

Arctic Debate

"The Arctic: Territory of Dialogue" forum was hosted by the Russian Geographical Society on September 22-23, 2010, attended by foreign and Russian scientists, political figures, NGOs, and business representatives. The main purpose of the forum was to discuss potential international cooperation in the Arctic. The Russia-Norway treaty was cited as an example several times. While highlighting that in 50 years the Arctic may become a major source of energy and a key transportation route, Vladimir Putin noted that priorities should be creating comfortable life conditions for the people living in the region, and respect for the fragile ecosystem by "the most stringent environmental requirements," as well as development of research and environmental infrastructures. Well-known polar explorer and state Duma deputy Artur Chilingarov suggested that the forum should become a regular event, and a Polar Decade launched. Experts also noted the need to create a single global database on the Arctic, while Russian Emergencies Ministry Sergey Shoygu (who is also president of the Russian Geographic Society) said that an atlas of the Arctic would be prepared soon. Along the same lines, the statement produced by the 9th Conference of Parliamentarians of the Arctic Region, hosted by the European Parliament in Brussels, September 13-15, 2010, highlights the need for continuous improvement of the assessment of the social and economic consequences of natural resource exploration and exploitation, consequences of climate change for Arctic populations and wildlife habitats, cooperation in education and research, and the tighter economic and geopolitical links. September 2010. Military Implications, Sources] ⁹⁹

Literature Addressing Arctic Security

Protecting the Arctic Biodiversity: Limitations and Strengths of Environmental Agreements, a report by UNEP, assesses the status and adequacy of current multilateral environmental agreements that deal with protecting the Arctic from the effects of climate change. It underlines that changes in Arctic biodiversity also impact neighboring countries and regions, given the migratory nature of many of the Arctic species, and that global effort is needed to address climate change causes and effects. Challenges include the generally outdated nature of the MEAs—based on past understandings of the Arctic environment—as well as insufficient implementation, which makes it difficult to assess progress and adequacy. Recommendations include: an audit of the MEAs on the Arctic

to assess their effectiveness, relevance, and options for improvement, as new actors become involved in the Arctic and its resources; and an increased role of the Arctic Council to ensure sustainable use of the Arctic.

The Arctic Sea Competition and Key Strategic Challenges for Europe. an article published in Second Line of Defense summarizes the present state of affairs in the Arctic, highlighting its economic and strategic importance.

The Canadian Arctic: Threat from Terrorists and Extremists. a newly declassified intelligence assessment, prepared by the Integrated Threat Assessment Centre, claims that in recent years, vessels with links to human smuggling, drug trafficking, and organized crime have attempted to access the Canadian Arctic. It also notes that over the past 10 years, the population of the Canadian Arctic increased by 16%. Visitors to the area have also increased, including cruise ships, tourists, and peace activists, leading federal agencies to increase monitoring of incoming people, goods, and threats from the North.

The Security in Canada's North: Looking Beyond Arctic Sovereignty report by the Conference Board of Canada suggests "community security" should be considered instead of only military sovereignty. [November 2010. Military Implications, Sources100]

Natural Disasters and Scientific Evidence

Scientific Evidence and Potential Consequences of Climate Change

(Listed by month in reverse chronological order)

2010 was one of the two warmest years on record (tied with 2005), and the 34th consecutive year above the 20th century average, announced the World Meteorological Organization (WMO) based on data from the UK Meteorological Office Hadley Center, NOAA, and NASA. Exceptionally warmer regions included much of Africa and southern and western Asia, Greenland, and Arctic Canada, with some sub-regions registering temperatures 1.2 to 1.4°C (2.2 to 2.5°F) above the long-term average. The WMO also notes that 2001-2010 was the warmest decade on record, with the global average 0.46°C above the 1961-1990 average. WMO also underlines the high number of extreme weather events in 2010, including severe floods in Pakistan, Sri Lanka, the Philippines, Brazil and Australia, as well as the heat wave in Russia.

2010 was also one of the deadliest years of the least two decades, according to the Centre for Research on the Epidemiology of Disasters. There were 373 disasters registered, which killed 296,800 people, affected 207 million, and caused damages estimated to \$109 billion. Some 89% of all those affected by disasters in 2010 lived in Asia. Similarly, according to Munich Re, 2010 natural catastrophes killed 295,000 people, costing approximately \$130 billion. By its standards, there were 950 natural disasters in 2010 (365 in the Americas, 310 in Asia, 120 in Europe, 90 in Africa and 65 in Australia and Oceania); 90% were weather-related. The other major reinsurer, Swiss Re, reported that man-made and natural disasters in 2010 caused worldwide economic losses of \$222 billion, more than three times more than in 2009.

Mapping the impacts of natural hazards and technological accidents in Europe, a report by the European Environment Agency, found that the number and impacts of disasters in Europe have increased over the period 1998-2009, causing nearly 100,000 fatalities and economic losses of about €150 billion (approx. \$200 billion). It warns that losses due to climate change are likely to increase in the future. [January 2011. Military Implications, Sources] 103

Since 1970, each decade has been warmer than the preceding one, and 2000-2010 has been the warmest one on record, conclude preeminent meteorological organizations, despite some uncertainties and differences of measurement methodologies. Based on preliminary data from NASA and NOAA, 2010 might be the warmest year on record.

The Climate Vulnerability Monitor 2010 estimates that the number of countries with most acute vulnerability will increase from 17 in 2010 to 48 in 2030. Using color-coded graphics, the report shows the worldwide vulnerability to climate change, comparing today's situation with forecasts to 2030 as to health impacts,

weather disasters, habitat loss, and economic stress. For example, annual deaths due to changing climate conditions could rise from 350,000 now, to 1 million by 2030, unless adaptation policies are implemented in vulnerable countries. Floods will cause most of the deaths from extreme weather.

Climate Risk Index 2011 by Germanwatch shows that in the period 1990-2009, developing countries are among the ten most affected by extreme weather and noted the importance of comprehensive risk management which includes new regional and international insurance approaches in accordance with the 'polluter pays' principle. [December 2010. Military Implications, Sources104]

Unusually heavy rains since mid-September have caused Benin's worst floods in half a century. The UN Office for the Coordination of Humanitarian Affairs reported that floods affected over 680,000 people in two-thirds of the country, and severely damaged schools, hospitals, and infrastructure, and that there were about 850 reported cases of cholera. Since rains were predicted to continue through November, the total devastation is likely to increase. Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention, a joint report by the World Bank and the UN, estimates that by the end of this century, annual global losses from natural disasters could triple to \$185 billion, without calculating the impact of climate change, which could add \$28-68 billion per year from tropical cyclone damages alone. By 2050, the number of people exposed to storms and earthquakes in large cities could double, to 1.5 billion.

The report outlines a number of measures to prevent death and destruction from natural hazards, calling for increased spending for early warning systems, particularly weather forecasting. [November 2010. Military Implications, Sources1 5]

2010 will be the warmest for Nuuk, the capital of Greenland, in 138 years. Four glaciers lost more than 10 square miles (25.90 sq km) each. Since glacier ice losses seem to be accelerating, sea level rise projections might also need to be revised. [October 2010. Military Implications, Sources106]

A report by the Russian Federal Service for Hydrometeorology and Environmental Monitoring revealed that over the past century, the country's average temperature rose almost twice as fast as the global average and nearly three times faster in parts of Siberia during the winter.

The U.S. National Oceanic and Atmospheric Administration notes that the Atlantic Ocean was considerably warmer this year, with temperatures in some parts being 3°F above the average by the end of August. The National Hurricane Center identified 15 tropical cyclones by the end of September, including seven hurricanes compared with two in an average season when waters are cooler. The Center predicts that by the end of the 2010 Atlantic hurricane season, there will be about 20 storms with at least 39 mph winds, compared with 11 in a typical year. These storms are serious threats to offshore oil facilities, as well as coastal communities. According to the New York-based Insurance Information Institute, eight of the ten most expensive U.S. catastrophes were caused by hurricanes. [September 2010. Military Implications, Sources] 107

The 2009 State of the Climate report released by the U.S. National Oceanic and Atmospheric Administration concludes that there is no doubt that the world is warming. The past decade was the hottest on record, each of the last three decades was warmer than the one before, and the average temperature increased a little over 0.5°C (0.9°F) over the past 50 years. The report is based on compilation of 10 indicators, including historical data on temperatures, humidity, sea levels, sea ice, glaciers and spring snow cover going back to 1940 or 1850, depending on the type of data. The results show increases in: temperature of air over land and oceans, and of sea surface; sea level; ocean heat; humidity; and temperature in the troposphere. At the same time, there were decreases in: Arctic sea ice; glaciers; and spring snow cover in the northern hemisphere. The report is the result of collaboration among about 300 scientists from 160 research groups in 48 countries. It makes no comments about the potential causes of warming.

The World Meteorological Organization has published information on the unprecedented sequence of recent extreme weather events. A longer time range is required to determine whether an individual event is attributable to climate change, but the sequence of current events matches IPCC's projections of more frequent and more intense extreme weather events due to global warming, says the WMO. While the northern hemisphere had to

deal with extreme heat waves, the southern hemisphere witnessed intense cold and record snows. There are fears that the abnormal weather triggers social and environmental problems around the world. [August 2010. Military Implications, Sources108]

Mass bleaching of coral reefs has been reported throughout Southeast Asia, the Indian Ocean, and the Pacific. The damage so far has been the worst since 1997/1998 when high ocean temperatures killed an estimated 16% of the world's reefs, but with ocean temperatures reaching record levels and combined with the end of an El Nino episode, scientists warn that even more damage could come. While reefs can often recover from bleaching, it could take corals between 10 and 70 years to recover from bleaching events of such magnitude. Also, a recent study showed that rising temperatures slow the speed of coral growth. In the Red Sea, coral growth declined by a third over the past 12 years, and scientists warned that coral there would cease growing entirely by 2070 if warming continues.

Meantime, worldwide phytoplankton levels decreased 40% since the 1950s, reveal Canadian and U.S. scientists in a study published in the journal Nature. They say that the likely cause is global warming, which increases difficulty for plant plankton to get vital nutrients. The most dramatic changes are noted in the Arctic, southern, and equatorial Atlantic and equatorial Pacific oceans, while the Indian Ocean is not showing a decline. [July 2010. Military Implications, Sources109]

Migration Triggered by Environmental Causes

Climate Refugees Trends

Following November's Brasilia Declaration, Mexico has recently passed a unique Law on Refugees and Complementary Protection, becoming the first country in the region to grant "complementary protection" for those not considered refugees but at risk of other threats.

Within Africa's Sahel, a region of approximately 60 million inhabitants, extreme drought and unpredictable weather patterns continue to worsen food and water security, and interregional migration. Additionally, insecurity triggered by spending money from natural resources (such as the oil money in Chad) on soldiers and military weaponry, exacerbates human migration.

The IOM reports that, worldwide, there are an estimated 740 million internal migrants and 214 million international migrants, with approximately 60% of all migration occurring within countries in the same category of development. [December 2010. Military Implications, Sources112]

The Tarawa Climate Change Conference held November 9-11, 2010 in Tarawa, Kiribati, as a session of the Climate Vulnerable Forum, concluded with the release of the Ambo Declaration. Participants called for a number of actions, including design of strategies for protecting people displaced within or across borders due to climate change, and establishing a mechanism for climate change disaster risk. The Declaration was adopted by: Australia, Brazil, Canada, China, Cuba, Fiji, Japan, Kiribati, Maldives, Marshall Islands, New Zealand, Solomon Islands, and Tonga. [November 2010. Military Implications, Sources] 113

The website for the Climate Change Displaced Persons Convention Project has added a frequently asked questions (FAQ) section. It gives a comprehensive overview of issues related to climate change-caused displacement.

At the request of Marshall Islands leaders, Michael Gerrard, who leads Columbia Law School's Center for Climate Change Law, issued a call for papers and is organizing a conference on the questions related to national sovereignty of countries (or parts of countries) that might disappear due to rising sea levels; e.g., citizenship of their people, control of offshore rights, etc.

An estimated 18 million people were displaced by the floods in Pakistan—in what is considered the worst natural disaster to date attributable to climate change. In the southern Sindh province, as the Indus River was running at 40 times its normal volume of water, almost one million people were displaced in addition to some 17

million people already displaced by monsoon floods. An estimated 1.2 million homes were destroyed and 3.2 million hectares (7.9m acres) of farmland representing about 14% of Pakistan's cultivated land were damaged, triggering famine and water concerns. [August 2010. Military Implications, Sources114]

Advocating for Safe Movement as a Climate Change Adaptation Strategy for Pastoralists in the Horn and East Africa, a new report by the Security Mobility Initiative, finds increasing levels of migration and conflict over often scarce resources. According to the report, vulnerability, a lack of preparedness, and appropriate, timely and relevant responses to natural disasters left millions in need of humanitarian assistance. The report recommends urgent actions to help pastoralists cope with the growing impacts of climate change, for example, to facilitate safe passage across borders in the Horn and East Africa region. In June, the European Commission adopted a €20 million humanitarian financial package to support 12 million people affected by drought in the Greater Horn of Africa in developing resilience to drought and adapting to climate change.

The International Food Policy Research Institute (IFPRI) assesses the extent to which Northern Nigerian households migrate in response to weather-related variability and shocks. Its discussion paper, Migratory responses to agricultural risk in Northern Nigeria, finds that households use migration as a risk management strategy. The author underscores the importance of understanding how climate affects migration decisions in order to better target resources to cope with climate change. [July 2010. Military Implications, Sources115]

Renewed Protection for Refugees in Latin America

The "Brasilia Declaration on the protection of refugees and stateless persons in the Americas" was adopted by the delegates of 18 Latin American countries meeting in Brasilia, Brazil, November 11, 2010. In addition to renewed pledges stipulated in previous treaties, the Declaration calls for improved mechanisms for the protection of refugees, migrants, internally displaced, and stateless persons in Latin America by addressing new displacement situations. It reiterates the, "...unrestricted respect for the principle of non-refoulement (non-forced return), including non-rejection at the border and indirect non-refoulement, as well as for the nonpenalization of illegal entry, and non-discrimination, as the fundamental principles of international refugee law". Since climate change-related factors are expected to increase the number of displaced people around the world, new approaches for potentially larger numbers of such displaced persons seem necessary. The UN High Commissioner for Refugees considers the Declaration, ".a valuable international precedent", which could help, ".accelerate global efforts to improve the situation of displaced people and end the scourge of statelessness," and encourages other world regions to follow the example. [November 2010. Military Implications, Sources116]

Melting Sea Ice and Glaciers

Regional Evidence and Trends

The WMO reports that Arctic sea-ice cover in December 2010 was the lowest on record, with an average monthly extent of 12 million square kilometers, 1.35 million square kilometers below the 1979-2000 average for December. Greenland also experienced record surface melting and runoff in 2010, with the annual melting season up to 50 days longer than the average observed between 1979 and 2009, and with summer snowfall below average, notes an international group of researchers in a study published in the journal Environmental Research Letters, on January 21, 2011. [January 2011. Military Implications, Sources118]

Recent research shows that the waters off the Western Antarctic Peninsula are warming exponentially, accelerating the melting ice shelf. [December 2010. Military Implications, Sources119]

A new ice island broke from the Petermann Glacier, one of the two largest remaining glaciers in Greenland. Satellite imagery reveals that the Petermann Glacier lost about 25% of its 43-mile long floating ice-shelf. The new ice island has an area of at least 100 square miles and is 600 feet thick. As it floats towards the Atlantic, there are concerns that it might threaten Canada's offshore platforms and shipping in the area.

Permafrost temperatures during the International Polar Year (2007-09) were 2°C (3.6°F) warmer than they were 20 or 30 years ago, found scientists based on data collected from 575 boreholes located throughout North

America, Russia and the Nordic region. They also noted that the rate of thawing of cold permafrost is higher than that of warmer permafrost. [August 2010. Military Implications, Sources] 120

Food and Freshwater

Food Security Issues

The sixth edition of the Global Risk report by the World Economic Forum identifies the "water-food-energy" nexus as one of three key clusters of risks (the other two being macroeconomic imbalances and illegal economy). The UN Food and Agriculture Organization (FAO) announced that food prices hit a record high in December 2010. Its Food Price Index was 214.7, the highest since 1990 when it was created. In its report Guide for Policy and Programmatic Action at Country Level to Address High Food Price, FAO urges countries to refrain from export bans and other actions that could exacerbate the current food crisis. Speaking at the World Economic Forum in Davos, Susilo Bambang Yudhoyono, President of Indonesia, warned that the next economic war could be over scarce resources, if problems of rising food prices, poverty and population growth are not addressed and urged that food security must be a G20 priority. [January 2011. Military Implications, Sources]123]

The Food Security Risk Index 2010 reveals that the countries most at risk from shocks to food supplies are also among the countries with serious security problems. Rated at most "extreme risk" are: Afghanistan, Democratic Republic of the Congo, Burundi, Eritrea, Sudan, Ethiopia, Angola, Liberia, Chad, and Zimbabwe. The Index, assessing basic food staple risks for 163 countries using 12 criteria, is compiled by Maplecroft and developed in collaboration with the World Food Programme. [August 2010. Military Implications, Sources] 124

The World Bank's new initiative "Roadmap for Action: Agriculture, Food Security and Climate Change" stresses the role agriculture can play in climate and finance, such as: enhanced resilience and carbon sequestration.

The World Bank notes considerable increase in acquisition of farmlands since 2008. Over the first 11 months of 2009, there were signed deals covering at least 110 million acres, compared to an average 10 million acres per year before 2008.

Food security, farming, and climate change to 2050 by the International Food Policy Research Institute (IFPRI) has 15 scenarios that examine potential population and income growth. While warning that climate change could push staple food prices up 130%, it suggests that improved agricultural productivity, broad economic growth, and robust international trade could mitigate the adverse impacts of climate change on food security. [December 2010. Military Implications, Sources] 125

FAO's Food Outlook report notes that global grain production will drop by 2% (63 million metric tons) this year, putting the world "dangerously close" to a new food crisis. The bills for food import for the poorest countries are predicted to rise 11% in 2010 and by 20% for the low-income food-deficit countries.

The Global Conference on Agriculture, Food Security and Climate Change took place October 31-November 5, 2010, at the World Forum in The Hague, around the theme 'It's Down 2 Earth.' The Conference initiated a roadmap for action which links agriculture-related investments, food security, and climate change. The roadmap focuses on climate-smart agriculture and includes sections on: policies and strategies; tools and technologies; financing for transformational change; forging partnerships; and the way forward. The Conference was a follow-up to the Shared Vision Statement agreed to at the 17th Session of the Commission on Sustainable Development (CSD 17) in May 2009; the next follow-up conference will be hosted by Vietnam in 2012. [November 2010. Military Implications, Sources]126]

The WFP and the FAO released the 2010 edition of The State of Food Insecurity in the World: Addressing food insecurity in protracted crises. According to the report, the number of undernourished people has declined but remains unacceptably high (925 million), with 22 countries being in protracted food crises.

According to the World Bank, up to 30 million hectares (74 million acres) of farmland are lost each year due to severe degradation, conversion to industrial use, and urbanization. Additionally, more than a third of large-

scale land acquisitions—which in 2009 reached some 45 million hectares—are intended to produce agrofuels rather than food, increasing poverty. The problem is more severe in Africa, where 90% of land is not documented with land rights and ownership. [October 2010. Military Implications, Sources] 127

According to the latest estimate, the number of hungry people worldwide decreased in 2010 to 925 million, from 1.023 billion in 2009, but is still unacceptably high, says the FAO and the World Food Programme.

At the emergency meeting convened on September 24th in response to the wheat export ban in Russia and food riots in Mozambique which killed 13 people, experts from FAO Member States agreed that there was no indication of an impending world food crisis. Nevertheless, recognizing that unexpected price hikes "are a major threat to food security" it was agreed that new measures to limit food price volatility and manage associated risks should be explored.

Among the root causes of volatility, the meeting identified "Growing linkage with outside markets, in particular the impact of 'financialization' on futures markets". The paper "Food Commodities Speculation and Food Price Crises" by Olivier De Schutter, UN's special rapporteur on food, warns that the increases in price and the volatility of food commodities can be explained only by the emergence of a "speculative bubble." In the meantime, ActionAid cautions that hunger could cost poor nations \$450 billion a year - more than 10 times the amount needed to meet the Millennium Development Goal on halving hunger by 2015. At the "Securing Future Food" meeting convened by the UK Food Group, De Schutter said that the only long-term way to resolve the crisis would be to shift to "agro-ecological" ways of growing food that do not depend on fossil fuels, pesticides, or heavy machinery.

According to the World Bank report *Rising Global Interest in Farmland: Can It Yield Sustainable and Equitable Benefits?* investment overseas in agricultural land has increased tenfold since the 2008 food price rise. While large-scale farmland deals have the potential to deliver benefits to developing countries, the report warns against practices that harm the rights and opportunities for development of local people. Noting that the trend of overseas investment in agricultural land is likely to continue to grow, the report outlines seven principles for responsible agro-investment, including transparency, food security, and social and environmental sustainability. [September 2010. Military Implications, Sources] 128

A study by the FAO and the International Rice Research Institute (IRRI) finds that rising temperatures during the past 25 years have already cut the yield growth rate of rice by 10-20% in several locations in Asia, which currently produces more than 90% of the world's rice.

China's soil erosion has reached nearly 17% of its total land cover. If current trends continue, 40% of food production will be lost in the next 50 years, according to a study led by the Ministry of Water Resources, and science and engineering academies.

Grain prices have soared in August as Russia, the world's third wheat producer in 2009/10, banned grain exports until the end of the year as the fires and worst drought on record ravaged crops. Grain exports from Ukraine, the world's sixth largest wheat exporter, are also facing delays after the introduction of a new system of customs controls. Russia said it would also ask Belarus and Kazakhstan (also major grain exporters and co-members of a regional customs union), to enact a similar ban.

The International Center for Agricultural Research in the Dry Areas (ICARDA) released a book of abstracts from the Food Security and Climate Change in Dry Areas meeting held in February 2010, in Amman, Jordan. The abstracts are organized into themes on: scenarios for climate change in dry areas; impacts on natural resource availability, agricultural production systems and environmental degradation; impacts on food security, livelihoods and poverty; mitigation, adaptation and ecosystem resilience; and enabling environments to cope with impacts. [August 2010. Military Implications, Sources] 129

Professor Dana Cordell of the University of Technology in Sydney estimates that world phosphate demand is over 150 million tons per year, that demand will exceed production by 2033, and states, "There is nothing on the market that can replace phosphate on the scale that we need it." Phosphate is critical for life support and essential for agriculture. U.S. reserves might be exhausted by 2050. Since the lower concentration phosphate deposits are

laced with radioactive elements like uranium and thorium, or heavy metals like cadmium, environmental concerns might complicate their exploitation. Addressing phosphorus supply and its environmentally sustainable exploitation and use should be part of strategies addressing food and environmental security. [November 2010. Military Implications, Sources130]

Freshwater Security Issues

(Listed by month in reverse chronological order)

The Abu Dhabi Water Declaration adopted by the 31st Gulf Cooperation Council Summit stresses the connection between water security and diversification of energy and food security as important priorities. The GCC states are expected to create legislation to increase water efficiency, including the pricing system, review of the agricultural sector, and the efficiency of water desalination plants.

The Managing Blue Gold: New Perspectives to Water Security in the Levantine Middle East study by the Finnish Institute of International Affairs depicts future challenges of water security in this part of the Middle East and focuses on the ability of governments to secure a sustainable water supply for their populations. [December 2010. Military Implications, Sources132]

The new Africa Water Atlas released by UNEP shows how the challenges of water scarcity in Africa are compounded by high population growth, socioeconomic and climate change impacts, and, in some cases, policy choices. UNEP warns that the findings indicate a decline in the availability of water per person in Africa, and that only 26 of the continent's 53 countries are on track to reach the UN Millennium Development Goals on water. It also features new solutions and success stories across the continent. [November 2010. Military Implications, Sources] 133

According to the Asian Development Bank, Asia could face a 40% gap between water supply and demand in 2030. In order to meet its goals of providing drinking water and sanitation, it would need around \$8 billion a year, most of it having to come from the private sector. [October 2010. Military Implications, Sources134]

The International Water Management Institute (IWMI) released a paper that describes the need for systematic planning in water storage and management to cope with increased rainfall variability. Although water storage increases water security, agricultural productivity, and adaptive capacity, the paper warns that poorly planned storage is a waste of financial resources and may aggravate climate change impacts. It calls for systems that combine complementary storage options and urges consideration of uncertainty in planning. [September 2010. Military Implications, Sources 135]

Water Issues between Nepal, India & Bangladesh, a paper by the Institute of Peace and Conflict Studies, notes that the largely agrarian characteristics of the countries in the region and their volatile relations make the region highly prone to water related crises. The paper concludes that water issues are essentially a product of the political relations in the region and points to the benefits of developing joint water management schemes, such as information sharing mechanisms, disaster preparation, and maintenance of a specific quality of water, which, in addition to resolving water issues, would also enhance regional stability. Meantime, tensions between India and Pakistan are growing, with Pakistan filing a case with the international arbitration court to stop the construction of a hydroelectric dam in India in May.

The UN calls upon the international community to help the more than 10 million hungry people across Africa's drought-stricken Sahel region. The hardest hit is Niger, where more than 7 million people — almost 50% of the population — is suffering from lack of food. [July 2010. Military Implications, Sources136]

Health

Potential Impacts of Climate Change

An Animal Migration and Infectious Disease Risk study published in Science magazine, warns about potential change of patterns of infectious diseases and their transmission from animals to humans due to climate change and environmental degradation, changes of migration patterns, and greater interaction between human and animal habitat. [January 2011. Military Implications, Sources] 139

The WHO has published the report of the consultation on Essential Public Health Package to Enhance Climate Resilience in Least Developed Countries. The consultation was held in September 2010, in Geneva, Switzerland, with representatives from vulnerable countries, the UNFCCC Secretariat, and relevant WHO departments. There was broad agreement on enhancing resilience through linking environment and health surveillance, vector control, and disaster risk reduction. [November 2010. Military Implications, Sources] 140]

The WHO, together with the Pan-American Health Organization (PAHO) and the Government of Costa Rica, organized a meeting in July 2010 to share experiences in evaluating health risks. Representatives from 16 countries discussed draft guidance for health vulnerability and adaptation assessment that was produced by PAHO, and shared their experience in carrying out national assessments. A new version of the guidance incorporating national inputs will be published later this year. [August 2010. Military Implications, Sources] 141]

UNEP Study on Inter-Linkages of Climate Change, POPs, and Human Health

The UNEP study Climate Change and POPs Inter-Linkages is the first systematic review of the link between climate change and the release of persistent organic pollutants (POPs), and the impact on human health and the environment. The study reveals that melting glaciers and ice sheets are releasing POPs trapped years ago, while severe and more frequent flooding triggered by climate change could lead to the secondary emissions of POPs through inundation of agricultural lands and POP storage sites. The study underlines the major impact on human health due to bio-magnification through the food chain. The full study will be presented to the 5th meeting of the Conference of the Parties to the Stockholm Convention, to be held in Geneva, Switzerland, in April 2011. [Related items: New Chemicals Considered for Toxic Lists in January 2009 environmental security report.] [December 2010. Military Implications, Sources] 142

Energy Security

Scientists Create 20-Year Roadmap for Nuclear Energy

Scientists at University of Cambridge and Imperial College London have outlined a global plan for nuclear energy to the year 2030. The first stage would replace or extend the life of existing reactors while the second would deploy portable, more efficient reactors with replaceable parts. These scientists claim that flexible "out of the box" modular reactors and those that can be moored offshore would require less maintenance and minimal infrastructural support, have 70-year operational lives, and provide better opportunity for safe radioactive waste recycling. [August 2010. Military Implications, Sources] 144]

World Energy Outlook 2010

The World Energy Outlook 2010 is looking at alternatives for switching to a reliable and environmentally sustainable energy system and post-Copenhagen solutions to limit the global temperature increase to 2°C and how these actions would impact oil markets and renewable energy. It presents updated projections to 2035 of energy demand, production, trade and investment by fuels and regions, and, for the first time, it includes the results from a new scenario based on governments' pledges to tackle climate change and growing energy insecurity. [September 2010. Military Implications, Source] 145]

China is Now the Largest Energy Consumer in the World

The International Energy Agency has announced that China's energy consumption is now the highest in the world; its energy consumption has doubled since 2000. IEA notes that China's per capita consumption is one-third of the OECD countries' average, and credits China's government for its efforts in reducing energy intensity and becoming a global leader in renewable energy technologies. Meantime, the Netherlands Environmental Assessment

Agency report No growth in total global CO₂ emissions in 2009 notes that OECD countries reduced their greenhouse gas emission by 7% during 2009. This reduction has been offset by increases from China and India. CO₂ emissions per capita in China increased from 2.2 tons in 1990, to 6.1 tons in 2009, while, in the same time period, the 15 EU nations decreased from 9.1 tons to 7.9 tons and the U.S. decreased from 19.5 tons to 17.2 tons. Considering the rising Chinese public discontent over pollution and an estimated \$25 trillion cost to clean up environmental damage associated with the country's rapid industrialization, China's government is increasingly concerned by the interdependence between economic and security issues. Therefore, in its 2011-2015 state plan, 39% of the performance indicators for government officials focus on "green" issues, up from 3% in the previous plan. [July 2010. Military Implications, Sources 146]

Nordic Countries to Support Mekong Energy and Environment Partnership

The Ministry for Foreign Affairs of Finland and the Nordic Development Fund are supporting the Energy and Environment Partnership for the Mekong region, a program to promote the use of renewable energy, energy efficiency, and clean technologies in Cambodia, the Lao PDR, Thailand, and Vietnam. [Related items: Climate Change Requires Water Management Changes in February 2010 and Unless Water Management Improves, Conflicts over Water Are Inevitable in August 2006 environmental security reports.] [September 2010. Military Implications, Source 147]

Coal-fired Power Plants under Fire

The U.S. Environmental Protection Agency is contemplating introducing rules to reduce environmental effects of coal-fired power plants as part of its steps on regulating greenhouse gas emissions. Additionally, a new rule for reducing the emissions of mercury from coal-fired power plants is to be issued November 2011 with enforcement three years later. It is estimated that this will force about 20% of U.S. coal-fired electric generation capacity to retire by 2015. Similarly, in Australia, the Greens are advocating 100% replacement of coal with renewable energy sources such as sun, wind, and wave. [July 2010. Military Implications, Sources 148]

Prevention and Adaptation

Policy Recommendations and Actions for Adaptation to Climate Change

The UNEP Latin America and the Caribbean: Atlas of our Changing Environment is highlighting environmental challenges in the region due to climate change, loss of biodiversity, deforestation, the impacts of mining and natural disasters, changes in land use, and degradation of coastal areas.

According to the ECLAC report Economics of Climate Change in Latin America and the Caribbean, in the region's temperate countries, losses from climate change may amount to around 1% of annual GDP by 2100 in the scenario of highest emissions (A2 of the IPCC). [December 2010. Military Implications, Sources 150]

A technical paper "Guiding principles for adaptation to climate change in Europe" by the European Topic Centre on Air and Climate Change of the European Environment Agency presents a set of guiding principles and implementation mechanisms for adaptation to climate change in Europe. The paper is based on opinions from more than 250 adaptation experts from 35 European countries, who took part in a survey conducted by the Potsdam Institute for Climate Impact Research and Effect.

More than 400 technical experts and policy makers met in Cairo, Egypt, November 2-3, at the Fifth Symposium on ICTs and the Environment & Climate Change (ICT = Information and Communication Technologies). Emphasizing the climate change monitoring and mitigation requirements of Africa and other developing regions that can be met through ICT solutions, the symposium issued the "Cairo Roadmap," a six-step program for the use of ICTs to benefit environmental management. [November 2010. Military Implications, Sources 151]

Over 700 participants met in Addis Ababa, Ethiopia, for the Seventh African Development Forum under the theme of "Acting on Climate Change for Sustainable Development in Africa" from 12-15 October 2010. As

one of the outcomes of the Forum, a partnership on Africa's options for a Green Economy, backed by the African Union, African Development Forum (AfDB), UN Economic Commission for Africa (UNECA) and UNEP, was established. One of the first activities of the partnership will be to organize an Africa-wide conference on a low carbon, resource-efficient Green Economy, scheduled to take place in 2011. [October 2010. Military Implications, Sources] 152

The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has launched a Regional Cooperative Mechanism on Drought Monitoring and Early Warning. The Mechanism will provide an information portal—the Asia-Pacific Gateway on Disaster Risk Reduction and Development -- and aims to provide satellite products for drought monitoring. It will assist members in developing locally tailored services to facilitate decision making.

"The World Disasters Report 2010" by the International Federation of Red Cross and Red Crescent Societies focuses on urbanization and climate change risk. It highlights that 2.57 billion urban dwellers living in low- and middle-income nations are exposed to unacceptable levels of risk fuelled by rapid urbanization, poor local governance, population growth, and poor health services. Urban planning should consider the effects of climate change to reduce vulnerability of millions of people, mostly those living in low-elevation coastal zones. Tackling urban risk is essential to reducing poverty and urban violence. [September 2010. Military Implications, Sources153]

The World Bank's Synthesis Report on the Economics of Adaptation to Climate Change Study, estimates the costs of adaptation to climate change to be between \$70-100 billion per year between now and 2050. The study argues that investments in adaptation should start with low-regret options: measures that tackle existing weather risks, such as increased investment in water storage in drought-prone basins or protection against storms and flooding in coastal zones and/or urban areas.

On August 16th, the UN launched the Decade for Deserts and the Fight Against Desertification, which will run from 2010 to 2020 with the goal of raising awareness and action to improve protection and management of the world's drylands. The global launch took place in Fortaleza, Brazil, during the Second International Conference on Climate, Sustainability and Development in Semi-arid Regions (ICID 2010).

The UN Secretary-General launched a High-Level Panel on Global Sustainability to "explore approaches for building low-carbon, green and resilient economy" that can efficiently address together poverty and climate change. The High Level Panel's report, to be issued by the end of 2011, will provide inputs into inter-governmental processes, including the Rio 2012 conference, and the annual meetings of the United Nations Framework Convention on Climate Change (UNFCCC).

The fifth Annual Meeting of the Pacific Disaster Risk Management Partnership Network took place 9-13 August 2010, in Suva, Fiji under the theme "Enhancing the Implementation of the Pacific Disaster Risk Reduction and Disaster Management Framework for Action through a Multi-stakeholder Approach." The meeting aimed to, among other goals, share preliminary findings of the regional progress review in implementing the Regional Framework for Action (RFA) and strengthen South-South Cooperation with the Caribbean community. [August 2010. Military Implications, Sources154]

The World Bank Institute has published a series of multimedia learning modules on Climate Adaptation for Water, Agriculture, and Natural Resource Management. The modules address issues including rehabilitating degraded watersheds; innovative cultivation strategies; legal aspects of water use; and public-private partnerships in irrigation management. The modules are available at: <http://vle.worldbank.org/moodle/course/view.php?id=402> [July 2010. Military Implications, Sources155]

Reports on Sustainability and Climate Change

The MIT Sloan School of Management has produced its Special Report, The Business of Sustainability - Findings and Insights from the First Annual Business of Sustainability Survey and the Global Thought Leader's Research Project, assessing how leading organizations are responding to sustainability-related business forces.

Informing an Effective Response to Climate Change, a new report by the National Research Council, "examines the types of information systems and communication tools needed to ensure that national, state, and local decision makers and the public base climate change policies and personal choices for responding on the best available science." Among other conclusions, it calls for a systematic framework to effectively address challenges posed by climate change and for improved decision-taking and evaluation. The report is part of the America's Climate Choices suite of studies. [July 2010. Military Implications, Sources] 157

FAO Launches Global Fire Information Management System

The UN Food and Agriculture Organization has launched the Global Fire Information Management System (GFIMS), a monitoring system that integrates remote sensing and GIS technologies to deliver MODIS hotspot/fire locations to natural resource managers and other stakeholders around the world. (MODIS is the Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite). It is offering almost real-time detection of emerging fires, and alerting users through an online portal or via e-mail, and soon by text messages. [September 2010. Military Implications, Sources] 158]

New Global Land Cover Maps

A global land cover map was created by European Space Agency and the Belgian Universite Catholique de Louvain using 12 months of 2009 data from Envisat's Medium Resolution Imaging Spectrometer at a resolution of 300 m. (<http://ionia1.esrin.esa.int/>)

A pan-European land cover and use map for 2009 created by ESA's GlobCorine project is now available on-line. (<http://ionia1.esrin.esa.int/globcorine/>)

The first regional atlas on the state of the environment in Latin America and the Caribbean, with more than 200 images illustrating the principal environmental issues of the region was prepared by UNEP in cooperation with others. (http://www.cathalac.org/lac_atlas/) The new on-line National Atlas of the U.S. produced by the USGS has scores of layers covering a wide range of environmental topics. (<http://nationalatlas.gov/>) [January 2011. Military Implications, Sources] 159]

Climate Modeling and Scenarios

Climate Projection Models

A computer modeling of climate change to the year 3000 shows that even with zero CO₂ emissions beginning in 2100, climate change effects will continue for the next 1,000 years. Regional changes in temperature and precipitation would still be considerable, although the global mean temperature would likely remain the same. The West Antarctic Ice Sheet would collapse by 3000, raising global sea levels by approximately 4 meters. The model was produced by researchers at the Univ. of Victoria and Univ. of Calgary in Canada. [January 2011. Military Implications, Sources] 161]

The Chalmers Climate Calculator is a simple climate model for online use, developed by Chalmers University of Technology. The model shows potential impacts on global temperature rise under different CO₂ emissions scenarios shaped by reductions' timeframes and scales, climate sensitivity, and the net aerosol forcing in year 2005. The model also allows visualizing the different impacts of emission cuts by Annex I and Non-Annex I countries, as well as the role of deforestation. The global model is accessible at: www.chalmers.se/ee/ccc, while the model considering Annex I grouping and deforestation is available at www.chalmers.se/ee/ccc2.

Similarly, an interactive climate map from Google shows potential future impacts of a 4°C global temperature rise, illustrating rising water levels and reduced crop yields in different parts of the world. The map is continuously updated as new data become available. It is available at: <http://www.fco.gov.uk/google-earth-4degrees.kml> (requires Google Earth installed.) [July 2010. Military Implications, Sources] 162]

A new global study by climate scientist Aiguo Dai concludes that much of the world's land area is susceptible to extreme drought over the next 90 years. Using current GHG emission projections and the 22 computer models from the IPCC's 2007 report to gather information on temperature, precipitation, humidity, wind speed, and the planet's radiative balance, Dai calculated the Palmer Drought Severity Index (PDSI) through the end of the century. The report determines that drought risk will decrease across the upper reaches of the Northern Hemisphere and in some Southern Hemispheric locations, while increasing significantly in Africa, Australia, the United States, Southwest and Southeast Asia, Latin America, and the Mediterranean Sea region. There is concern that over the next 30 years regions are likely to experience drought of severity and duration that has not been experienced in at least the past several hundred years. [October 2010. Military Implications, Sources163]

Scenarios

Forum for the Future (FF) with support from the British Department of International Development (DFID) has developed four scenarios exploring how climate change would transform low-income countries over the next 20 years. The study warns that unless strong and urgent action is taken, climate change would reverse years of work reducing poverty in the developing world. In addition, shortages of food and natural resources and climate change impacts could lead many nations to question the Western model of economic development and democracy. The study stresses that the impacts of climate change must be factored into development decisions to ensure they continue to yield benefits in the long-term. [July 2010. Military Implications, Sources165]

C. Protecting the Environment Due to Its Inherent Moral Value 166

Environmental Security-Related International Regulations That Have Been or Are Close To Coming into Force since July 2010

Broad Environmental Aspects

Progress on International Environmental Governance

The First Meeting of the Consultative Group of Ministers or High-Level Representatives on Broader International Environmental Governance Reform was held from July 7-9, 2010 in Nairobi, Kenya. The Consultative Group is formed of delegates from 59 countries. Using the original 24 points proposed by UNEP, the group identified nine options for further consideration. While there is general agreement that there are gaps in the current environmental governance system, views differ about potential solutions. Some countries favor creating a global policy organization with universal membership to manage the global environmental agenda, while others advocate a new specialized UN agency on the environment, or argue for an umbrella organization on sustainability. However, there is general support for other broad reforms, such as an encompassing global information network, establishing a tracking system on environmental finance, and enhancing UNEP presence within existing country offices. The Group agreed to a roadmap for its work through the 2011 Governing Council. The second meeting is tentatively scheduled for late November 2010 in Helsinki, Finland. [Related item: UNEP Conference Further Environmental Governance in February 2009 environmental security report.] [July 2010. Military Implications, Sources169]

The Protocol on Strategic Environmental Assessment to the UNECE Espoo Convention Entered into Force on July 11, 2010

The Protocol on Strategic Environmental Assessment to the UNECE Espoo Convention sets the legal framework for better integration of environmental and health assessments, as well as public participation in decisionmaking at the earliest stage of projects and programs. It ensures that environmental protection and health concerns are an integral part of sustainable development. The SEA Protocol entered into force on July 11, 2010. [Related item: Protocol on Strategic Environmental Assessment (SEA) in May 2003 environmental security report] [July 2010. Military Implications, Source] 170

Repository of Multilateral Environmental Agreements

Multilateral Environmental Agreements: State of Affairs and Developments 2010, edited by Philip Drost, Senior Legal Counsel at the Directorate International Affairs, Netherlands Ministry of Housing, Spatial Planning and the Environment, is a repository of the texts of the most important global Multilateral Environmental Agreements, "including the most recent texts of Rules of Procedure, Financial Rules and Compliance Procedures." The chapter "Year Ahead" outlines the key negotiating issues for the forthcoming year. [July 2010. Military Implications, Sources171]

Biodiversity

New International Mechanisms Adopted for Protection of Biodiversity

The 10th Conference of the Parties of the Convention on Biological Diversity (CBD) held in Nagoya, Japan, adopted several new mechanisms for increasing protection of biodiversity and assessed new and emerging issues. The 2011-2020 Strategic Plan for Biodiversity identifies 20 targets, such as: expanding the world's protected areas to include 17% of terrestrial surface and 10% of the marine surface; the restoration of a minimum 15% of ecosystems already degraded; and halving, or bringing as close as possible to zero, the rate of loss of the world's natural habitats. The "Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization" will enter into force after 50 ratifications. The attendees also agreed that signatories to the CBD must ensure that no geoengineering projects take place until risks to the environment, as well as social, cultural, and economic impacts, have been properly assessed. A sample of other outcomes includes the: Global Biodiversity Outlook; Multi-year Programme of work; Biofuels and Biodiversity; and Invasive Alien Species. [Related item: Biosafety Regulations Reviewed in Context of Worrying Forecasts in October 2010 environmental security report.] [November 2010. Military Implications, Sources173]

Chemicals and other Hazardous Compounds Stockholm Convention Updates

Amendments Adding Nine Chemicals to the Stockholm Convention Entered into Force

Amendments to the Stockholm Convention on persistent organic pollutants (POPs) adding nine chemicals to Annexes A, B and/or C of the Convention entered into force on August 26, 2010 for the 152 of the 170 Parties to the Stockholm Convention that have not submitted a notification or a declaration. The amendments cover the following chemicals: alpha hexachlorocyclohexane; beta hexachlorocyclohexane; chlordanone; hexabromobiphenyl; hexabromodiphenyl ether and heptabromodiphenyl ether (commercial octabromodiphenyl ether); lindane; pentachlorobenzene; perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride; and tetrabromodiphenyl ether and pentabromodiphenyl ether (commercial pentabromodiphenyl ether). [Related item: Stockholm Convention Updated with Nine New Chemicals in May 2009 environmental security reports] [August 2010. Military Implications, Sources 175]

Stockholm Convention on Persistent Organic Pollutants (POPs) Updated

The sixth meeting of the Persistent Organic Pollutants Review Committee (POPRC-6) of the Stockholm Convention on Persistent Organic Pollutants (POPs) took place October 11-15, 2010 in Geneva, Switzerland. It formed a working group to prepare a draft risk management evaluation for hexabromocyclododecane (HBCD), risk management evaluation for endosulfan and recommended its listing in Annex A, with exemptions, risks of combined exposures, and other related conditions. The Committee considered a revised draft risk profile and further evaluation of short-chained chlorinated paraffins (SCCPs), and it provided for increased harmonization of relations with the Basel Convention. [October 2010. Military Implications, Source176]

EU Parliament Adopts Restrictions on Nanoproducts

The European Parliament reached agreement that "nano-sized ingredients and food from nanotech processes should be subject to novel foods regulations," and called for a moratorium until specifically-designed risk assessments verify their safety. The action was welcomed by the European Environmental Bureau, Europe's largest federation of environmental citizens' organizations. [Related item: EU Restrictions on Nanofoods Expected to Pass in July, in June 2010 environmental security report.] [July 2010. Military Implications, Sources] 177

Germany publishes criteria for substances of very high concern

The Federal Institute for Risk Assessment (BfR) has published the criteria for selecting substances of very high concern (SVHC). BfR proposes the chemicals for Germany's REACH (EU Regulation, Evaluation, Authorization and Restriction on Chemicals) candidate list. [Related items: EU Updates the REACH System, and WEEE andRoHS Directives in December 2008 and other chemicals-related items in previous environmental security reports.] [August 2010. Military Implications, Sources178]

Water

UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

The UN General Assembly adopted a resolution recognizing access to clean water and sanitation as a human right, a move that might be a step forward towards a future treaty. The non-binding resolution received 122 votes in favor, no votes against, while 41 countries abstained—including Australia, Britain, Canada, and the U.S. Introducing the resolution, Bolivia's representative pointed out that more children are killed annually by lack of access to water than by AIDS, malaria and measles combined, while lack of sanitation affects 40% of the world's population. [August 2010. Military Implications, Sources179]

UN Human Rights Council Affirms Right to Water as Legally-Binding

Water tables are falling on all continents; more than 40% of humanity gets its water from watersheds controlled by two or more countries. About 900 million people lack clean water and 2.6 billion lack adequate sanitation. The UN Human Rights Council adopted a resolution affirming that rights to safe drinking water and sanitation are basic human rights contained in existing human rights treaties, and therefore legally binding. The International Covenant on Economic, Social and Cultural Rights (ICESCR), the UN Convention on the Rights of the Child (CRC), the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), and the Convention on the Rights of Persons with Disabilities (CRPD) give rise to obligations for States parties in relation to access to safe drinking water and sanitation. This action addresses previous objections by those nations who abstained from supporting this right in the UN General Assembly in July this year. The UN Human Rights Council calls upon all States to create the legal and procedural frameworks for assuring the implementation, monitoring and enforcement mechanisms "to achieve progressively the full realization of human rights obligations related to access to safe drinking water and sanitation, including in currently unserved and underserved areas." [October 2010. Military Implications, Sources] 180

European Parliament Resolution on Jordan River Water Management Reform

The European Parliament has adopted a resolution on environmental and political concerns with regard to the Lower Jordan River area. It calls upon the leaders of Israel, Jordan, and Syria to address the humanitarian, security, and environmental threats posed by the Jordan River's over-exploitation and mismanagement. An estimated 98% of the river's freshwater has been redirected by Israel, Jordan, and Syria. Without intervention, large portions of the river are projected to run dry by 2011. This non-binding resolution opens the first official communication between the EU Parliament and these governments regarding the state of the Jordan River. [Related item: Call for International Intervention to Save the Jordan River in May 2006 environmental security report.] [September 2010. Military Implications, Sources] 181

Marine Environment

IMO MEPC Revises MARPOL, Addresses Emissions from Ships

The 61st session of the International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC), which took place 27 September-1 October 2010, in London, addressed technical, operational, and market-based measures. For the mitigation of emissions from maritime transport, it requested proposed amendments to Annex VI, the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP), with an intersessional meeting of the Working Group to be held in March 2011. It

adopted the revised MARPOL Annex III for the Prevention of Pollution from Ships expected to enter into force on 1 January 2014. It was also approved, in view of adoption at its next session, an updated Annex V of the Convention on Regulations for the prevention of pollution by garbage from ships. [Related item: Concerns over Maritime Air Pollution Increase in February 2008 environmental security report.] [October 2010. Military Implications, Sources183]

Chile Establishes 150,000 KM2 Protected Marine Reserve in Pacific

Chile has established the 150,000 km no-take Sala y Gomez Marine Park surrounding Sala y Gomez Island in the east Pacific, to protect what a National Geographic Ocean Fellow calls "one of the last undisturbed and relatively pristine places left in the ocean ... [with] deep seamounts with unique marine life." [October 2010. Military Implications, Source] 184

Ecuador to Join the UN Convention on the Law of the Sea

President Rafael Correa of Ecuador announced the accession to the UN Law of the Sea, pending endorsement by the National Assembly. Ecuador is one of the 16 countries that neither signed nor ratified the Law of the Sea Convention, although it claimed a 200 nautical mile sovereignty zone even before the concept of the Exclusive Economic Zone was created by the Convention. By joining the UNCLOS, Ecuador's claim to the 200-mile zone and the air space above will become official, and also opens the opportunity for eventual claims of extension. [July 2010. Military Implications, Source185]

New Technologies

Synthetic Biology Guidelines to Reduce Bioweapon Threats

Synthetic biological voluntary guidelines released October 13, 2010 by the U.S. Dept. of Health and Human Services call for sellers of synthetic double-stranded DNA products to know their buyers and their intended use. These guidelines will be reviewed and updated on a regular basis. Since synthetic biology could one day be misused to create bioweapons and potentially even weapons of mass destruction, international agreements to regulate this new technology seem both likely and warranted. The scale and scope of the expected future biological revolutions may one day require an international regulatory agency similar to the International Atomic Energy Agency. [October 2010. Military Implications, Source187]

The EU Strengthens Legislation to Counter Cybercrime

The European Commission is developing legislation for criminalizing cyber attacks. A proposed Directive addressing cyber crimes is supplemented by a proposal for strengthening the European Network and Information Security Agency. The strategy also includes setting up a 24-hour alert system in each member state, where citizens and companies can announce attacks. The EU's anti-terrorism coordinator Gilles de Kerckhove said that "state-driven or state-sponsored attacks" are identified as the highest risk to cyber security. He also warned that while having an international "code of conduct" regulating the use of cyberspace would be helpful, an international legally binding treaty could also legitimize state controls over content. Cybercrime is also identified in the EU Internal Security Strategy action plan as one of the five main areas needing more coordinated strategy to help member countries counter rapidly developing security threats—along with organized crime, international terrorism, borders' management, and response to natural and man-made crises and disasters. It is likely that the international discussions over coordinated action to counter cybercrime will accelerate and lead to some binding legal frameworks. [Related item: International Legal Frameworks Needed for Cybersecurity in April 2010 environmental security report.] [December 2010. Military Implications, Sources] 188

Pollution

New EU Directive on Industrial Pollution

The European Commission adopted a stricter policy on industrial emissions. It is merging seven pieces of pre-existing environmental legislation including the IPPC Directive (2008/1/EC, integrated pollution prevention and control). New parameters include a more rigorous process for permits by strengthening the Best Available Techniques (BAT), tightening emission limits for Europe's largest fossil-fuel-fired combustion plants and improving compliance tools for better verification and control. The new Directive comes into force 20 days after publication in the Official Journal, which is expected before the end of 2010. Then the member States have two years to start implementation. [Related item: EC Enforces Compliance with EU Environmental Regulations in June 2008 environmental security report.] [November 2010. Military Implications, Sources190]

Waste Management

Kenya to Implement E-Waste Management Program

The 40 million metric tons of e-waste generated annually around the world is expected to increase, adding toxins throughout the environment. Kenya is set to become the first East African nation to develop regulations on the management of electronic waste, following a national conference held at the United Nations Environment Programme (UNEP) in Nairobi. Delegates from Kenya's Environment Ministry and National Environment Management Authority, Microsoft, UNEP, and the telecommunications industry attended to chart a common way forward in dealing with e-waste management in line with the Basel Convention and other international frameworks. [October 2010. Military Implications, Source] 192

Proposed Treaties and/or Changes to Existing Ones

Biodiversity

Prosecution of Pillage of Natural Resources as War Crime

At a conference held in The Hague, under the auspices of the Open Society Institute's Justice Initiative in coordination with the Dutch and Canadian governments, lawyers and human rights activists suggested legal instruments for prosecuting pillage of natural resources as a war crime. While this would primarily apply to companies profiting from the trade of "conflict minerals" and to cases that use resulting revenue to fund armed conflict, concerns also include environmental degradation and social aspects. The most notorious situation is the Democratic Republic of the Congo. Other countries on the "watch list" include: Brazil, China, India, Mexico, and Turkey. In a related development, the U.S. Dodd-Frank Act (H.R. 4173) becomes effective on April 11, 2011. It includes a clause requiring companies to report on the use of certain minerals from the Democratic Republic of the Congo and neighboring countries. Non-compliance will be fined. [Related item: Natural Resources Fuel Violence in Eastern D.R. Congo in September 2010 environmental security report.] [January 2011. Military Implications, Sources195]

World's Humid Tropical Forests to Suffer Considerable Biodiversity Change by 2100

A study by Carnegie Institution's Department of Global Ecology reveals that the ecosystems of humid tropical forests will suffer profound changes due to combined effects of climate change and land use. Globally, only 18% to 45% of those forests' biodiversity might remain unchanged by the end of the century. The study identifies by region and ecosystem the combination, as well as the preponderant effect, of the different factors, thereby helping conservationists focus their efforts more efficiently. [Related items: International Body to Monitor Biodiversity Destruction in June 2010 and other items on similar issues in previous environmental security reports.] [August 2010. Military Implications, Source196]

Biosafety Regulations Reviewed in Context of Worrying Forecasts

The Meeting of the Parties to the Cartagena Protocol on Biosafety (COP/MOP 5) held October 11-15, 2010, in Nagoya, Japan, was preceded by the fourth meeting of the Group of Friends of the Co-Chairs on Liability and Redress in the context of the Biosafety Protocol, and followed by the tenth meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP10). The meetings considered a series of strategic, content,

and administrative issues, including new strategic plans and cooperation with other conventions, organizations and initiatives for improving capacity building, compliance and monitoring. The Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety (the Supplementary Protocol) is expected to further strengthen and increase its efficiency. Meanwhile, the Living Planet Report 2010 produced by the World Wildlife Federation (WWF) in collaboration with Global Footprint Network and the Zoological Society of London, and released prior to the Nagoya meetings, details alarming biodiversity declines along with the warning that humanity's ecological footprint reached 1.5 times Earth's capacity to produce renewable resources and is producing CO₂ at a rate 50% faster than the Earth can sustain. The Economics of Ecosystems and Biodiversity (TEEB) report, launched at the CBD COP10, documents the multi-trillion dollar importance to the global economy of the natural world, and suggests policy-shifts and market mechanisms that could help curb biodiversity loss. According to the report, halving current deforestation rates alone by 2030 is worth \$3.7 trillion in global climate change adaptation savings. [Related item: Strategic Plan for Biodiversity to Connect UN Conventions and UN Bodies in September 2010 environmental security report.] [October 2010. Military Implications, Sources] 197

New Protected Areas Proposed in the Pacific

The Univ. of Queensland Ecology Centre's marine protection blueprint has determined that 50% of the oceans in the southwest of the country will need to be protected in a network of marine sanctuaries to minimize risks to marine life, fish stocks, and ecosystems. The Australian federal government intends to plan new marine sanctuaries in the southwest of Australia. Indonesia has declared a protected zone around three coral-rich islands near Bali. Palau's Minister of the Environment, Natural Resources and Tourism announced the establishment of a marine mammal sanctuary covering over 230,000 mi² (600,000 km²) of the nation's waters. [Related item: Factors to Consider in Establishing and Operating Marine Protected Areas in March 2010 environmental security report.] [November 2010. Military Implications] 198

Chemical and Biological Safety International Biosecurity Initiative

U.S. Rep. Brad Sherman (D-Calif.), chair of the House Foreign Affairs Subcommittee on Terrorism, Nonproliferation, and Trade introduced the International Biosecurity Act of 2010 (HR 6297) to pursue efforts to establish international cooperation to counter both natural and man-made biological risks and assess the establishment of a global legal regime for biosecurity. The bill might be included in the proposed WMD Prevention and Preparedness Act of 2010 (HR 5498), which is awaiting a House floor vote. [Related items: BWC Meeting Improves International Resilience Systems to Address Infectious Disease and BioWeapons in August 2009, New Technologies Need New Regulations Systems in March 2009, and other items in previous environmental security reports.] [October 2010. Military Implications, Sources200]

Synthetic Biology Guidelines to Reduce Bioweapon Threats

Synthetic biological voluntary guidelines released October 13, 2010 by the U.S. Dept. of Health and Human Services call for sellers of synthetic double-stranded DNA products to know their buyers and their intended use. These guidelines will be reviewed and updated on a regular basis. Since synthetic biology could one day be misused to create bioweapons and potentially even weapons of mass destruction, international agreements to regulate this new technology seem both likely and warranted. The scale and scope of the expected future biological revolutions may one day require an international regulatory agency similar to the International Atomic Energy Agency. [October 2010. Military Implications, Source201]

New Regulations for Chemicals in California

California's Department of Toxic Substances Control (DTSC) is moving ahead with the regulation development phase of the state's Green Chemistry Initiative (AB 1879 and SB 509) to identify and prioritize chemicals for reduction or removal from consumer products. The preliminary list of Priority Chemicals will be published for public comment by June 1, 2012. The initiative is part of the larger state effort to regulate chemicals and includes the creation of a scientific advisory panel and toxics information clearinghouse with an Internet database component. Another California bill (revised SB 346) expected to get the governor's approval is a complex

legal compromise which limits the content of copper and other materials, such as lead, mercury, chromium and cadmium in brake pads. [Related item: New Substances Identified as Harmful to Human Health and the Environment in June 2009 environmental security report.] [September 2010. Military Implications, Source] 202

Greenhouse Gas Emissions

Post-Kyoto Protocol and Post-Copenhagen Negotiations

An update analysis on CO₂ emissions shows the global CO₂ emissions' decrease in 2009 by 1.3% appears to be only a "blip" on the radar due to the economic slowdown, with the emissions expected to return to the 3% yearly increase as the effects of the recession decline. The study also highlights that in 2009, while developed countries' carbon emissions fell—e.g. Japan (11.8%), United Kingdom (8.6%) and Germany (7%), they increased considerably in developing countries, mainly in China (8%) and India (6.2%).

As world attention turns towards the UN Climate Change Conference to be held in Cancun, Mexico, November 29-December 10, 2010, expectations of reaching agreement for a post-Kyoto greenhouse gas emissions treaty are low. Nevertheless, the high-profile meeting galvanized efforts and created the opportunity for holding many side-events that are all oriented toward improving energy efficiency, reducing GHG emissions, and promoting green technologies. [November 2010. Military Implications, Sources] 205

Over 2,300 delegates from governments, intergovernmental organizations, and the media attended the Tianjin, China climate change negotiations, held October 4-9, 2010. This was the last meeting before the climate summit to be held in Cancun, from November 29 to December 10, 2010. There was no significant progress, mainly due to the reluctance of the developing countries to meet the demands of the developed countries on measurement, reporting, and verification mechanisms. A revised Chair's proposal (FCCC/KP/AWG/2010/CRP.3) will be considered further in Cancun. As an alternative to the failure of reaching agreement for a second commitment period of Kyoto, the EU is considering creating a 'coalition of the willing' for continuing the fight to reduce GHG emissions. In the meantime, WWF warns that unless there are strong policies to fight GHG emissions, their worldwide level could overshoot by a third the threshold beyond which dangerous global warming looms. [October 2010. Military Implications, Sources206]

In preparation for the next session discussing the commitments for the Annex I Parties, to be held in Tianjin, China, October 4-9, 2010, the UNFCCC Secretariat has published several documents, including a draft proposal with amendments to the Kyoto Protocol <http://unfccc.int/resource/docs/2010/awg14/eng/12.pdf>. [September 2010. Military Implications, Sources207]

The Bonn negotiations for a post-Kyoto protocol, held August 2-6, 2010, made progress on planning for the substance of the November-December 2010 Climate Change Conference in Mexico It also focused on the scale of emission reductions from Annex I parties to the Protocol subsequent to the 2012 commitment period. The draft text was further developed and will form the basis for negotiations in Tianjin, China, in October, with the outcomes to be considered in Cancun, Mexico, in November.

At the 41st Annual Meeting of the Pacific Islands Forum (PIF), held August 3-6, 2010 in Port Vila, Vanuatu, the leaders of Smaller Island States discussed a consolidated Pacific position for the concurrent Cancun climate change conference, as well as potential international funding mechanisms related to the Copenhagen Accord. [August 2010. Military Implications, Sources] 208

The World Investment Report 2010 by UNCTAD notes that current national and international policy frameworks do not target private sector and transnational corporation contributions sufficiently and effectively, and underlines the importance of integrating international investment policies into the negotiations and design of the new post-2012 regime. The report proposes a global partnership to synergize investment and climate change mitigation for promoting sustainable development. One of the components of the proposal is setting up an international low-carbon technical assistance center (L-TAC).

Environmental and economic effects of the Copenhagen pledges and more ambitious emission reduction targets, a report by Germany's Federal Environment Agency (UBA), notes that the emission reduction targets of the world's major CO₂ emitters under the Copenhagen Accord are not yet sufficient to limit global warming to 2°C. Meantime, it shows that economic costs in terms of reduced GDP compared to baseline GDP in 2020 are no higher than 0.25%, assuming that emission allowances are traded globally. For the EU, the impact on GDP between 30% CO₂ reduction (instead of 20%) by 2020 compared to 1990 levels would be marginal.

Climate Stabilization Targets: Emissions, Concentrations, and Impacts Over Decades to Millennia by the National Research Council today assesses the levels of CO₂ reduction that would be necessary to stabilize climate at less than 2°C average global warming. It notes that efforts are needed imminently for a rapid decline to less than 80% of current emissions by mid-century. [July 2010. Military Implications, Sources209]

Cancun UN Climate Change Conference Consolidates Progress

The UN Climate Change Conference held in Cancun, Mexico, November 29-December 10, 2010, included the 16th session of the Conference of the Parties to the UN Framework Convention on Climate Change and the 6th session of Conference of the Parties to the Kyoto Protocol. Although no legally-binding outcomes emerged, the "Cancun Agreements" helped to reverse the pessimism from the stalled negotiations during the Copenhagen conference on climate change. The Cancun Agreements include: 1) long-term cooperative action for reducing greenhouse gas emissions and eventually keeping global warming under 2°C by the end of the century; 2) improved monitoring and reporting of national commitments by developed and developing countries; 3) enhanced action for adaptation, including establishing the Cancun Adaptation Framework, an Adaptation Committee, and a work program on loss and damages; 4) creation of the Green Climate Fund with a pledge of \$100 billion a year by 2020 to help developing countries reduce emissions and adapt to climate change; 5) acceleration of technology transfer; 6) strengthening of REDD+ (reduce emissions from deforestation and forest degradation) for lowering (or not raising) rates of deforestation (including fair treatment of indigenous people); and 7) capacity building. There were also around 20 other decisions covering administrative, financial, and institutional matters. The next Conference of the Parties to the UNFCCC is scheduled to be held in Durban, South Africa, November 28 December 9, 2011. [December 2010. Military Implications, Sources210]

International Civil Aviation Pact Cuts Climate Emissions from Aircraft

The Assembly of the International Civil Aviation Organization (ICAO) adopted a global agreement and roadmap for reducing greenhouse gas emissions from aircraft through 2050. Some key elements: improving aviation fuel efficiency 2% per year up to 2050; a framework for development and deployment of alternative fuels; and CO₂ emission standards for aircraft by 2013. The ICAO Environmental Report 2010 launched at the Assembly brings together scientific, technological, economic, political and regulatory aspects of aviation environmental protection. [Related item: Provisional Agreement for Including Aviation in the Emission Trading Scheme from 2012 in June 2008 environmental security report.] [October 2010. Military Implications, Sources211]

More Aggressive Action Needed to Curb Ozone Depletions

In The Scientific Assessment of Ozone Depletion 2010 by UN, EU, and US organizations present a comprehensive analysis of the effect of stratospheric ozone changes on the Earth's surface climate and of the effects of climate change on stratospheric ozone. It also includes several scenarios, finding that leakage from ozone-depleting substance (ODS) banks are the largest source of current ozone-depleting potential and warns that delaying capture and destruction of chlorinated fluorocarbon compound (CFC) bank leakage beyond 2011-2015 could reduce the possible ozone and climate benefits by about 30%. The report also includes policy options and recommendations. [Related item: Call for Expanding Montreal Protocol on Ozone-Depleting Substances in September 2007 environmental security report.] [January 2011. Military Implications, Sources212]

New Technologies

Reports Assessing Several Nations' S&T Advances

S&T Strategies of Six Countries: Implications for the United States outlines the S&T infrastructure of Japan, Brazil, Russia, India, China, and Singapore with details of each nation's priorities, weaknesses and areas of expertise, with predictions for each nation's medium term (3-to 5-year) implementation success, including economic and military outcomes. The study finds that the transinstitutional globalization of ST&I networks in conjunction with S&T's centrality to JBRICS economic-security agendas creates a unique challenge to U.S. competitive advantage in information, intelligence and economics. The report recommends the U.S. create better models for international monitoring of S&T while simultaneously creating the alliances, policies and culture that will stimulate U.S. education and investment in innovation and still protect national assets. The report notes that while certain standard indicators of S&T accurately measure some elements of S&T advancement across nations, new country-specific indicators are needed that more succinctly measure nuances of individual country environments.

Ranking the Nations on Nanotech: Hidden Havens and False Threats, a report by Lux Research, assesses 19 nations and ranks them according to the potential of their nanotechnology capabilities using conventional indicators. The authors state that in 2009 some nations significantly increased their spending and commitment to nanotech, while others have surpassed the U.S. in nanotechnology commercialization. [August 2010. Military Implications, Sources] 214

Nanotechnology

[ISO Published Standard for Inhalation Toxicity Testing of Nanoparticles](#)

[ISO Publishes Methodology for Nanomaterials Classification](#)

[The Geopolitics of Nanotech](#)

[Organizations Address Key Issues For Nanomaterial Definition](#)

[EC on Definition of Nanomaterials For Regulatory Purposes](#)

[EU Gearing Up for Active Nanotech Regulatory Year in 2011](#)

[European Officials Discuss Nanotech Regulation](#)

[New Report Analyzes European Nanotech Issues](#)

[New EU NanoSustain Project Aims for Sustainable Solutions for Nanotechnology](#)

[EU Launches Public Consultation on Risk Assessment of Nanomaterials in Food](#)

[German Paint Association Issues Nanomaterials Workplace Guidance](#)

[EPA Issues Final Significant New Use Rules \(SNUR\) on Carbon Nanotubes](#)

[GAO Tells EPA It Should Expand Nanomaterials Info and Regulatory Efforts](#)

[Discussion on Federal/State Regulation of Nanotech](#)

[California Asks Manufacturers for Nano Analytical Test Measures](#)

[Thailand Moves Toward Nanotechnology Safety and Ethics Strategy Plan](#)

[Thailand to Introduce New "NanoQ" Certification Mark](#)

India Soon to Have a National Regulatory Framework for Nanotechnology

Pakistan Establishes National Nanotech Commission; Environment a Focus

Effort and Care Vital in Communicating Nanotech to the "Public"

Study Analyzes Stakeholder Preferences in Regulating Nanotechnology

ASTM Forms New Subcommittee on Nano-Enabled Consumer Products

Nanotechnology Long-term Impacts and Research Directions: 2000-2020

What Can Nanotechnology Learn from Biotechnology?

Report Outlines Nanotech Research Directions for Societal Needs in 2020

International Handbook on Regulating Nanotechnologies

Chemical Heritage Foundation Issues Two Reports on Nanotech Regulation

Regulation of Products Containing Nanoscale Materials

Review of the Long History of Nanosilver Usage and Regulation, and Implications

Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path

Webinars on Nanotech Regulation Offered

New Book Addresses Nanotechnology Education and Workforce Training

Studies Discussing the Possibility of Understanding Nanotoxicology

Management of Nanomaterials Safety in Research Environment

ISO Published Standard for Inhalation Toxicity Testing of Nanoparticles

The International Organization for Standards (ISO) has published an International Standard to support the inhalation toxicity testing of nanoparticles: ISO 10808:2010, Nanotechnologies -Characterization of nanoparticles in inhalation exposure chambers for inhalation toxicity testing. An ISO official states, "In order to test inhalation toxicity it is necessary to monitor concentration, size and size-distribution of nanoscale particles in an inhalation chamber. Traditional methods used in other areas are considered insufficient for testing nanoparticles since parameters specific to them like particle surface area or number, might be crucial determinants of toxicity." [January 2011. Military Implications, Sources²¹⁶]

ISO Publishes Methodology for Nanomaterials Classification

The International Organization for Standardization has published a technical report, ISO/TR 11360:2010, Nanotechnologies - Methodology for the classification and categorization of nanomaterials, which offers a comprehensive, globally harmonized methodology for classifying nanomaterials. According to Nanowerk News, it "introduces a system called the 'nano-tree', which places nanotechnology concepts into a logical context by indicating relationships among them as a branching out tree. The most basic and common elements are defined as the main trunk of the tree, and nanomaterials are then differentiated in terms of structure, chemical nature and other properties." [August 2010. Military Implications, Source] 217

The Geopolitics of Nanotech

ETC Group, a Canadian NGO, has released a 68-page report, The Big Downturn? Nanogeopolitics, which "revisits nano's geopolitical landscape, providing a current snapshot of global investment, markets, governance and control, including intellectual property." The report devotes 24 pages to questions of nanotech regulation and public communication, pointing out that "industry is increasingly nervous about its health and environmental exposure." [December 2010. Military Implications, Source218]

Organizations Address Key Issues For Nanomaterial Definition

According to Nanowerk News, "The International Council of Chemical Associations (ICCA) has released a document addressing key issues that need [to be] addressed when considering the definition of manufactured nanomaterials for regulatory purposes. It advocates five 'Core Elements of a Regulatory Definition of Manufactured Nanomaterial' ". The proposed elements are: solid, particulate substances, intentionally manufactured at the nano-scale, with at least one dimension between 1 and 100nm, and their aggregates and agglomerates, with a weight based cut-off of either 10 wt-% or more of nano-objects or 50 wt-% or more of aggregates / agglomerates consisting of nano-objects.

The Center for International Environmental Law and the European Environmental Bureau submitted on behalf of a consortium of 46 organizations comments on the European Commission's proposed definition of "nanomaterial". The Reply begins by cautioning, "The present understanding of nanomaterials properties and potential health and environmental impacts is still very limited and therefore warrants much research and careful evaluation." [November 2010. Military Implications, Sources] 219

EC on Definition of Nanomaterials For Regulatory Purposes

Responding to a request of the European Parliament, the EC Joint Research Centre (JRC) published a reference report, Considerations on a definition of nanomaterial for regulatory purposes. According to Nanowerk News, "The report discusses possible elements of a definition aiming at reducing ambiguity and confusion for regulators, industry, and the general public. It recommends that the specific term 'particulate nanomaterial' should be employed in legislation to avoid inconsistencies with other definitions and that size should be used as the only defining property." Meantime, the European Commission has requested that the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) provide advice on the essential elements of a science-based working definition of "nanomaterials." Part of this process is a public consultation on the preliminary version, in which stakeholders are invited to submit comments and proposals. [July 2010. Military Implications, Sources220]

EC Committee Presents Scientific Basis for the Definition of "nanomaterial". According to nanowerk.com, the EC's Scientific Committee for Emerging and Newly Identified Health Risks (SCENIHR) has published a 46-page paper - Scientific Basis for the Definition of the Term "nanomaterial, in which it basically concludes that size should be the basis for this definition. The Executive Summary from the paper briefly lays out the multitude of considerations and qualifications related to this complex question. [December 2010. Military Implications, Sources221]

EU Gearing Up for Active Nanotech Regulatory Year in 2011

Nanowerk News reported on a conference, held within the framework of the Belgian Presidency of the EU, on the development of nanomaterials management and information tools. The Belgian Minister for Energy, Environment, Sustainable Development and Consumer Protection stated, "We await the next European Environment and Health Action Plan which is expected to address the challenge of nanomaterials among its priority areas. In 2011, the Commission will also have to respond to the European Parliament Resolution adopted in April 2009, on the regulatory aspects of nanomaterials. According to the resolution, various ambitious measures will be taken in order to ensure safety with regard to nanomaterials and nanotechnology." The Minister put forward proposals for five specific responses. [September 2010. Military Implications, Source] 222

European Officials Discuss Nanotech Regulation

Government officials from Germany, Austria, Switzerland, and Liechtenstein met at the 4th International Nano Authorities Dialogue, organized by the Innovation Society, St. Gallen, focusing on legal and technical issues about the insurability and regulation of nanotechnologies. According to a news release, key elements of the presentations were that "nanotechnologies must be insurable, ... the potential risks of manufactured nanomaterials for human health and the environment must be thoroughly and continuously monitored, and ... the exchange of safety information between the industry and the authorities and along the value chain plays an important role to ensure that risks are identified in an early phase and measures can be taken proactively." [September 2010. Military Implications, Sources] 223

New Report Analyzes European Nanotech Issues

According to Meridian Nanotechnology and Development News, the NanoCode Project, a UK-based group comprising the Royal Society, Insight Investment, the Nanotechnology Industries Assoc., and the Nanotechnology Knowledge Transfer Network, has published a Synthesis Report, "with the goal of exploring the societal and economic impact of the technical, social and commercial uncertainties related to nanotechnologies ... [and providing] a broad overview of current codes of conduct, voluntary measures and practices", also comparing them with the EC's proposed Code of Conduct. Nanowerk News has prepared a brief review of the 49-page report. [October 2010. Military Implications, Source224]

New EU NanoSustain Project Aims for Sustainable Solutions for Nanotechnology

The NanoSustain is a consortium comprising 12 partners from 8 different countries. The objective of the NanoSustain project is to develop innovative solutions for the sustainable design, use, recycling and final treatment of nanotechnology-based products, based on hazard characterization and life-cycle assessment (LCA). "This will be achieved by comprehensive data gathering and generation of relevant missing data, as well as their evaluation and validation for specific nano-products or product groups in relation to their human health and environmental hazards and possible impacts that may occur during after-production stages." [July 2010. Military Implications, Sources] 225

EU Launches Public Consultation on Risk Assessment of Nanomaterials in Food

According to Nanowerk News, "...the European Food Safety Authority (EFSA) has launched a public consultation on its draft guidance document for engineered nanomaterial (ENM) applications in food and feed . [that] sets out for applicants, the data needed to understand the specific properties of the ENM, allowing a risk assessment to be carried out." [January 2011. Military Implications, Source226]

German Paint Association Issues Nanomaterials Workplace Guidance

The German Paint and Printing Ink Association published a guideline document to inform its members on the responsible handling of nanoscale materials at the workplace. [July 2010. Military Implications, Sources227]

EPA Issues Final Significant New Use Rules (SNUR) on Carbon Nanotubes

The EPA has issued final Significant New Use Rules (SNUR) for single- and multi-walled carbon nanotubes, which had been the subject of premanufacture notices (PMN P08177, P08328). Persons who intend to manufacture, import, or process either of these materials for a use that is designated as a significant new use by the final rule must notify EPA at least 90 days before commencing that activity. EPA states that it believes the SNURs are necessary because these chemical substances may be hazardous to human health and the environment. [September 2010. Military Implications, Sources228]

GAO Tells EPA It Should Expand Nanomaterials Info and Regulatory Efforts

A new GAO report, Nanotechnology: Nanomaterials Are Widely Used in Commerce, but EPA Faces Challenges in Regulating Risk, says EPA should proceed with previously announced plans to increase the

information the agency has on nanomaterials and expand its oversight of them. The EPA has said it agrees, and concurred with the GAO recommendations. [July 2010. Military Implications, Sources229]

Discussion on Federal/State Regulation of Nanotech

A recent article in Nanotechnology Now, We Should Have Seen It Coming: States Regulating Nanotechnology, discussed the increasing trend for individual states to consider or enact nanotech regulations, reflecting a discontent with actions (or inaction) on the part of the federal government. A subsequent piece, State-level nano regulation: Yes, indeed, the industry "should have seen it coming" - it caused it!, appeared in an Environmental Defense Fund blog, and attributed that trend indirectly to the nanotech industry's efforts to block or weaken federal controls. [September 2010. Military Implications, Sources] 230

California Asks Manufacturers for Nano Analytical Test Measures

The California Department of Toxic Substances Control (CDTSC) has issued a call to manufacturers for information regarding analytical test methods for nanosilver, nano zero valent iron, nano titanium dioxide, nano zinc oxide, nano cerium oxide, and quantum dots, citing the almost total lack of such information. [December 2010. Military Implications, Source231]

Thailand Moves Toward Nanotechnology Safety and Ethics Strategy Plan

According to Nanowerk News, the Thai National Nanotechnology Center, NANOTEC, and the Nanotechnology Assoc. of Thailand are working on the country's first strategy plan on nanotech safety and ethics, to be submitted to the government in 2011, with full regulation expected in five years. [January 2011. Military Implications, Source232]

Thailand to Introduce New "NanoQ" Certification Mark

According to Meridian Nanotechnology and Development News, the Nanotechnology Association of Thailand will launch a certification mark, NanoQ, in 2011, to encourage domestic development of nanoproducts and to promote consumers' acceptance of such products. Companies wishing to obtain the NanoQ mark will be required to have their products tested by the National Nanotechnology Center, and undergo a yearly auditing process. [October 2010. Military Implications, Source233]

India Soon to Have a National Regulatory Framework for Nanotechnology

According to the Times of India, the country will soon have a national regulatory framework for nanotechnology, according to the Union minister for science and technology and earth sciences. The minister said that there are close to 1,000 researchers working in the nanotechnology field, and, "The framework will be drafted to sort out issues of ethics and copyrights [sic; presumably patents]" [October 2010. Military Implications, Source234]

Pakistan Establishes National Nanotech Commission; Environment a Focus

The government of Pakistan has established a National Commission on Nano-Science and Technology (NCNST) with a mandate to help universities and research centers set up nanotech laboratories. Dr. Aftab Ahmed, President of the National Academy of Young Scientists, pointed out that one of the most important applications of nanotechnology is the environment, where nanoparticles significantly increase the efficiency of groundwater pollutants filtration. [August 2010. Military Implications, Source235]

Effort and Care Vital in Communicating Nanotech to the "Public"

Several recent articles have emphasized the care that must be taken in communicating to the "public" the benefits and risks of nanotech-based products. The first, in Nature Nanotechnology, by Fern Wickson of the Gen0k

- Centre for Biosafety in Tromsø, Norway, and colleagues, emphasizes that communications must be tailored to the specific character and background of the recipients - who should not just be lumped into categories of laypersons, consumers, or stakeholders. The second is a report from the UK consultancy College Hill, discussed by Meridian Nanotechnology and Development News, that warns that "more than 90 percent of the UK population is confused or concerned about purchasing food containing manufactured nanoparticles, with 38 percent saying they would be unlikely to buy such foods", and urges the food and beverage industry, "...to consider how they can best educate, prepare and inform the public." [October 2010. Military Implications, Sources236]

Study Analyzes Stakeholder Preferences in Regulating Nanotechnology

According to Meridian Nanotechnology and Development News, a recent analysis conducted by Steffen Foss Hansen, a postdoctorate student at the Technical Univ. of Denmark, used Multicriteria Mapping (MCM) to study why some nanotechnology regulatory options, such as bans, moratoriums, and voluntary measures, are deemed to be either acceptable or unacceptable to various stakeholders in the United States. His findings are quoted as saying, "[A]dopting an incremental approach and implementing a new regulatory framework have been evaluated as the best options whereas a complete ban and no additional regulation of nanotechnology were the least favorable." [July 2010. Military Implications, Sources] 237

ASTM Forms New Subcommittee on Nano-Enabled Consumer Products

The ASTM International (formerly the American Society for Testing and Materials) Committee E56 on Nanotechnology has announced formation of a subcommittee to develop standards for nanotech-using consumer products. It will develop standard terms, toxicity test methods, workplace handling guidance and other voluntary standards for organizations that work with nano-materials, concentrating initially on nano-silver. The group is soliciting responses from experts to work with the new subcommittee, including in the area of environmental chemistry. [October 2010. Military Implications, Source238]

Nanotechnology Long-term Impacts and Research Directions: 2000-2020

The National Science Foundation sponsored a study, conducted by the World Technology Evaluation Center, with 200 experts from 35 countries, on the long-term view for nanotechnology. Workshop presentations and the draft report, in particular its 46-page Chapter 4, Nanotechnology Environmental, Health, and Safety Issues, are now available. [October 2010. Military Implications, Sources239]

What Can Nanotechnology Learn from Biotechnology?

What Can Nanotechnology Learn from Biotechnology? is a collection of papers by experts-proponents and opponents--reviewing the social, environmental, ethical, and regulatory issues of nanotechnology by comparison to biotechnology controversies, mainly in agricultural and food-related applications. [July 2010. Military Implications, Sources240]

Report Outlines Nanotech Research Directions for Societal Needs in 2020

The Wilson Center/Pew Trusts' Project on Emerging Nanotechnologies has issued a new report, Nanotechnology Research Directions for Societal Needs in 2020, that, according to Meridian Nanotechnology and Development News, "...outlines the foundational knowledge and infrastructure development in the last decade, the current ~\$15 billion in R&D programs underpinning about \$250 billion of products incorporating nanoscale components in the world in 2009, and the likely evolution towards a general purpose technology by 2020." [November 2010. Military Implications, Sources241]

International Handbook on Regulating Nanotechnologies

A new 648-page International Handbook on Regulating Nanotechnologies seems to be a comprehensive examination of the regulatory challenges presented by nanotechnologies, with speculations on potential future

evolution of the regulatory landscape, including, "potential legislative responses that could be employed by governments [and] a range of other options available to stakeholders," says the press release. [November 2010. Military Implications, Sources242]

Chemical Heritage Foundation Issues Two Reports on Nanotech Regulation

The Chemical Heritage Foundation's Studies in Sustainability series has issued two white papers on nanotechnology regulation. The two titles are Emerging Nanotechnologies and Life-Cycle Regulation: An Investigation of Federal Regulatory Oversight from Nanomaterial Production to End of Life and Nanotechnology Regulation: Policies Proposed by Three Organizations for the Reform of the Toxic Substances Control Act. [November 2010. Military Implications, Sources243]

Regulation of Products Containing Nanoscale Materials

According to Meridian Nanotechnology and Development News, this article, prepared by lexology.com, addresses regulatory issues of nanotechnology and takes an in-depth look at how the EPA, FDA, and OSHA, ".have dealt with nanotechnology regulation since a November 2007 memorandum from the Office of Science and Technology Policy, and the Council on Environmental Quality, stated that federal agencies 'must implement sound policies to protect public health and the environment' from risks related to nanotechnology.' " [November 2010. Military Implications, Sources244]

Review of the Long History of Nanosilver Usage and Regulation, and Implications

A recent paper, 120 Years of Nanosilver History: Implications for Policy Makers, points out that nanosilver in the form of colloidal silver has been used for more than a century and has been registered as a biocidal material in the U.S. since 1954, and states, "it would be a mistake for regulators to ignore the accumulated knowledge of our scientific and regulatory heritage in a bid to declare nanosilver materials as new chemicals, with unknown properties and automatically harmful simply on the basis of a change in nomenclature to the term 'nano.'" [January 2011. Military Implications, Source245]

Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path

The Wilson Center/Pew Trusts' Project on Emerging Nanotechnologies has issued a 56-page report, Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path, that, according to the Project's director, "... is the most extensive analysis done to date of how voluntary programs can be applied to managing nanotechnology's possible environmental and health effects [with] . analysis and recommendations [that] extend beyond nanotechnology to the newer generation challenges that we face as science rapidly advances." [November 2010. Military Implications, Sources246]

Webinars on Nanotech Regulation Offered

The Keller Heckman law firm is offering a webinar series Nanotechnology Today 2010, focusing on state regulation of nanotechnology in the absence of national regulation, the impact of nanomaterial regulation in Europe and North America, environmental applications of nanotechnology, and benefits and risk communication for nanomaterials. The series will comprises four sessions, in July, September, October, and November, and can be purchased for either live on-line viewing or three post-session on-demand viewings of each event. [July 2010. Military Implications, Source247]

New Book Addresses Nanotechnology Education and Workforce Training

According to an item in Meridian Nanotechnology and Development News, the new book Nanoscience Education, Workforce Training, and K-12 Resources, by Miguel Aznar, of the Foresight Institute, is divided into four parts:

- * Historical perspective and the emerging technology
- * Teaching the skills for understanding and evaluating the emerging technologies
- * The current status of, and links to, teaching materials, and evaluation of the US model vs. elsewhere
- * Plans of action and links to sustainable development tools

[November 2010. Military Implication, Source248]

Studies Discussing the Possibility of Understanding Nanotoxicology

David B. Warheit from the DuPont Haskell Global Centers for Health and Environmental Sciences and colleagues has written an article addressing five issues that they perceive to be myths and misconceptions regarding nanotoxicology, generally related to the complex relationships, still the subject of much research, between the chemical and physical properties of nanomaterials and their biological effects. The emphasis of the paper is on the deficiencies in current knowledge and its application and the need for a very large amount of further detailed investigation before specific nanomaterials can be fully "trusted". Similarly, a study paper produced by the German Federal Environment Agency (Umweltbundesamt) on the release and behavior of nanoparticles in the environment indicates, not too surprisingly, that the characteristics they exhibit depend on a multitude of factors, both of the material and the environment through which they pass - factors whose effects are as yet largely unknown in detail. The materials tested were nanosilver, titanium dioxide, carbon black, and cerium oxide. The study concludes, "...current knowledge is insufficient for making any generalised statements which are relevant for risk assessment." [November 2010. Military Implication, Sources249]

Management of Nanomaterials Safety in Research Environment

According to Meridian Nanotechnology and Development News, "This article . presents a practical, 'user-friendly' procedure for university-level safety management of nanomaterials. ... The procedure .. involves classifying laboratories into risk classes, with a list of risk mitigation measures given for each hazard level." It is currently being implemented at the Ecole Polytechnique de Lausanne, Switzerland, in more than 100 research labs. [December 2010. Military Implications, Source250]

Biotechnology

Bioethics Commission Calls for Enhanced Federal Oversight of Synthetic Biology

The Presidential Commission for the Study of Bioethical Issues has released its first report, New Directions. The Ethics of Synthetic Biology and Emerging Technologies - a comprehensive review of the emerging field of synthetic biology, including 18 recommendations, covering such topics as the risks likely to be encountered and approaches to regulation. With respect to seven of those 18, the Commission recommends "ongoing review by the government, in consultation with the relevant scientific, academic, international, and public communities, with initial action completed within 18 months and made public." [December 2010. Military Implications, Sources251]

NRC Committee Recommends Sequence-based Tracking of Possible Pathogens

The Sequence-Based Classification of Select Agents: A Brighter Line report by the National Research Council (NRC) recommends moving to a DNA-sequence-based classification system for the regulation of dangerous pathogens. "The US regulates a list of 82 pathogens and toxins . deemed to pose a biosecurity threat, . [b]ut currently, nothing identifies them beyond taxonomic labels, such as Bacillus anthracis for anthrax.... The report also describes a 'yellow flag' biosafety system that would address sequences of concern — snippets of DNA that are not in themselves select agents, but could be part of one or otherwise used to produce a bioweapon," writes Nature News. [August 2010. Military Implications, Sources252]

Space

India Urges Strengthening Outer Space Treaty

The "Space, Science, and Security" conference held in New Delhi, January 19-21, 2011, addressed eventual updates to the Outer Space Treaty to better address security aspects. Keynote speaker Air Chief Marshal S. Krishnaswamy, India's former head of the Air Force, in addition to amendments to the Treaty, suggested establishing, "a strong policing force in the UN," to prevent militarization of space. He underlined that the new amendments should specifically outlaw installing nuclear and other weapons of mass destruction, as well as establishing military bases or conducting testing or military maneuvers in space or on celestial bodies. However, any research and use of equipment for peaceful purposes shall not be prohibited. The conference was organized by Observer Research Foundation, Secure World Foundation, and Stockholm International Peace Research Institute. [Related item: Steps for an International Regime for Space Debris and Space Traffic Control System in May 2009 environmental security report.] [January 2011. Military implications, Sources253]

Improved Enforcement of Environmental Regulations

"Public Interest" Environmental Suits Increasing

Reportedly, in the past twenty years, tens of thousands of public interest lawsuits have been filed against the Indian government and corporations on grounds, among others, that large development projects threaten livelihoods, land, or the environment. These suits have led to landmark rulings on education, the environment, and human rights (PILs can relate to any public issue, not just the environment), but their volume has burdened the judicial system. Therefore, in an effort to reduce the caseload, the Indian government has introduced new directives, requiring higher standards of proof and sanctioning the petitioner if a project was delayed by a public interest litigation that is later dismissed. Note: similar public interest legal provisions as those in India are also included in jurisprudence in South Africa, Pakistan, Nepal, and Bangladesh.

[Related item: Environmental Courts and Tribunals Are Rapidly Increasing Around the World in April 2010 environmental security report, as well as Item 4 on European SEA in this report.]. [July 2010. Military Implications, Source255]

International Consortium Created to Curb Environmental Crime

The International Consortium on Combating Wildlife Crime (ICCWC) came into effect, by the signing of a Letter of Understanding by the heads of five organizations: INTERPOL, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the UN Office on Drugs and Crime (UNODC), the World Bank, and the World Customs Organization. In the same spirit, the resolution adopted by INTERPOL's 79th General Assembly, attended by 650 delegates from 141 countries, underlines that environmental crime is "multi-disciplinary in nature due to the complexity and diversity of crime types." Since it is "not restricted by borders and involves organized crime networks.", a global response is needed, with INTERPOL and the National Central Bureaus playing a leading role. The resolution also stipulates that environmental crime impacts the global economy and security, and recommends that INTERPOL form the Environmental Crime Committee. [November 2010. Military Implications, Sources256]

The ICC to Establish an Independent Oversight Mechanism

The 9th session of the Assembly of States Parties to the Rome Statute of the International Criminal Court, held December 6-10, 2010, was attended by representatives of the 114 ICC States Party and over 150 NGOs. The decisions adopted include a resolution on creating an Independent Oversight Mechanism and its operational mandate, to enhance the Court's efficiency. The IOM's working procedures will be set out in a manual over the coming year, to be adopted at the next Assembly of States Parties, in December 2011. An omnibus resolution, "Strengthening the International Criminal Court and the Assembly of States Parties," covers a wide range of policy and practical issues relating to the ICC and international criminal justice. [Related item: Updates of the Rome Statute Include Amendments on the Crime of Aggression and Expansion of Criminalizing the Use of Certain

Weapons in Non-international Conflicts in July 2010 environmental security report.] [December 2010. Military Implications, Sources] 257

Strategic Plan for Biodiversity to Connect UN Conventions and UN Bodies

Representatives of biodiversity-related conventions met for the first time on September 1, 2010 in Switzerland to improve international environmental governance. Participants agreed that the 2011-2020 strategic plan should provide a framework for all biodiversity-related conventions and UN bodies. Capacity-building activities should be coordinated among the conventions, and national biodiversity strategies and action plans updated to cover implementation of all biodiversity-related conventions. The Strategic Plan is expected to be adopted at the 10th meeting of the COP to be held in October 2010, in Nagoya, Japan. A Nordic symposium on synergies among biodiversity-related MEAs, held earlier this year in Helsinki, noted that considering impediments, six conventions form a potentially manageable and coherent cluster: CBD, CITES, CMS, Ramsar, WHC and ITPGRFA, while the CBD, UNFCCC and UNCCD cluster would assure a better integration of biodiversity with climate change issues. Enhancing cooperation and coordination among the biodiversity-related MEAs follows the success of the synergies developed among the three on chemicals and waste - the Basel, Rotterdam and Stockholm Conventions (see First Joint Meeting of the Main Conventions on Hazardous Chemicals to Improve International Environmental Governance in February 2010 report). [September 2010. Military Implications, Sources] 258

UN Review of Sustainable Development in Preparation for Rio+20 in 2012

The First Intersessional Meeting for the UN Conference on Sustainable Development in preparation for the Rio+20 to be held in 2012 took place January 10-11, 2011. The advanced unedited version of the Synthesis Report presented to the delegates is a comprehensive assessment on the implementation of Agenda 21 and the Barbados Programme of Action, based on feedback from member states and UN agencies. It identifies, "Low political priority for integrated decision making..." (para. 44) as nations' most important challenge, while, "Unclear mandates, low accountability, competition for funds, conflicting interests, the absence of institutional mechanisms for joint work and collaboration all exacerbate these [implementation] problems, which are also reflected in the UN system." (para. 50) [Related item: UN Reform Report Stresses Environmental Issues in March 2005 environmental security report.] [January 2011. Military Implications, Sources] 259

International Atomic Fuel Banks to Reduce Nuclear Proliferation

Following the March 2010 agreement with the IAEA, the Russian government opened the world's first reserve of low enriched uranium (LEU) at the International Uranium Enrichment Center in Angarsk, Siberia. The plant is holding 120 metric tons of LEU enriched between 2.00% and 4.95%, a safe level compared with the 90% enrichment required for weapons grade uranium. The LEU reserve is intended for IAEA member states, and is part of the global effort to control nuclear proliferation. Separately, on December 3, 2010, the IAEA Board of Governors decided to establish an IAEA LEU bank that will be owned and managed by the IAEA; the location has yet to be identified. [Related items: Advancements on Non-proliferation and Nuclear Disarmament in May 2009, and Advancements on Denuclearization in April 2010 environmental security reports.] [December 2010. Military Implications, Sources] 260

Prosecution of Pillage of Natural Resources as War Crime

At a conference held in The Hague, under the auspices of the Open Society Institute's Justice Initiative in coordination with the Dutch and Canadian governments, lawyers and human rights activists suggested legal instruments for prosecuting pillage of natural resources as a war crime. While this would primarily apply to companies profiting from the trade of "conflict minerals" and to cases that use resulting revenue to fund armed conflict, concerns also include environmental degradation and social aspects. The most notorious situation is the Democratic Republic of the Congo. Other countries on the "watch list" include: Brazil, China, India, Mexico, and Turkey. In a related development, the U.S. Dodd-Frank Act (H.R. 4173) becomes effective on April 11, 2011. It includes a clause requiring companies to report on the use of certain minerals from the Democratic Republic of the Congo and neighboring countries. Non-compliance will be fined. [Related item: Natural Resources Fuel Violence

in Eastern D.R. Congo in September 2010 environmental security report.] [January 2011. Military Implications, Sources261]

Regional Cooperation in Africa to Counter Wildlife Trafficking

Africa's only wildlife law enforcement NGO, Last Great Ape Organization (Laga), has coordinated successful transinstitutional 'sting' operations against wildlife crime in Cameroon, Gabon, CAR and DR Congo. For the first time, Gabon has jailed ivory dealers. The Laga founder noted, "African governments have started realizing international trafficking has to be fought internationally. These arrests in four neighboring countries are a warning... - no longer can you hide on the other side of a border." [December 2010. Military Implications, Sources262]

Hazardous E-waste Grows as Major Environmental Problem

More than 12 countries participated in the International Hazardous Waste Inspections Exercise at Seaports. The exercise was coordinated by the International Network for Environmental Compliance and Enforcement's (INECE) and the Seaport Environmental Security Network (SESN). Initial results indicate that 54% of the 72 total targeted inspections showed infringements. "The illegal waste streams most often encountered during the event were: e-waste wrongly declared as second-hand goods, waste batteries wrongly described as plastic or mixed metal scrap, and cathode ray tubes from television and computer monitors wrongly classified as metal scrap," said INECE. [Related item: Half of Transported European Hazardous Waste Could Be Illegal—How Much More Elsewhere? in April 2008 environmental security report.] [November 2010. Military Implications, Sources263]

Shipping Efficiency Database to Reduce Emissions from Maritime Transportation

Shippingefficiency.org is a database developed by the Carbon War Room, aiming to reduce greenhouse gas emissions from maritime shipping. The database contains energy efficiency ratings for over 60,000 international vessels based on the IMO's Energy Efficiency Design Index. While global shipping is responsible for about 3% of total man-made CO₂ emissions, 15% of the global fleet is responsible for 50% of all emissions. The new database will be helpful for monitoring and enforcing the Ship Energy Efficiency Management Plan and the expected revised regulations for mitigation of emissions from maritime transport. [Related item: IMO MEPC Revises MARPOL, Addresses Emissions from Ships in October 2010 environmental security report.] [December 2010. Military Implications, Sources264]

New Standards With Environmental Security Implications

Revised Standards Proposed for Corporate Greenhouse Gas Reporting

The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) released proposed new standards for how companies should report the GHG impact of their supply chains and products. These guidelines supplement the Corporate Accounting and Reporting Standard, which is (in turn) part of the GHG Protocol Initiative, which is a larger framework for calculating and reporting a company's environmental footprint. [Related item: Corporate CEOs Pledge Actions on Climate Change at UN Global Compact Summit in July 2007 environmental security report.] [November 2010. Military Implications, Sources266]

Comments Invited on EPA/DOT Proposed Heavy Truck Mileage/Emission Standards

EPA and the Dept. of Transportation announced a comprehensive, proposed national program to reduce greenhouse gas emissions and improve fuel efficiency of heavy-duty trucks and buses. This is projected to reduce GHG emissions by nearly 250 million metric tons and save 500 million barrels of oil over the lives of the vehicles produced within the program's first five years. [Related item: EPA Proposes Tougher Air-Quality Rules in January 2010 environmental security report.] [November 2010. Military Implications, Sources267]

ISO Publishes Methodology for Nanomaterials Classification

The International Organization for Standardization has published a technical report, ISO/TR 11360:2010, Nanotechnologies - Methodology for the classification and categorization of nanomaterials, which offers a comprehensive, globally harmonized methodology for classifying nanomaterials. According to Nanowerk News, it "introduces a system called the 'nano-tree', which places nanotechnology concepts into a logical context by indicating relationships among them as a branching out tree. The most basic and common elements are defined as the main trunk of the tree, and nanomaterials are then differentiated in terms of structure, chemical nature and other properties." [August 2010. Military Implications, Source] 268

Fuel Efficiency Standards Are Changing around the World

UNEP in cooperation with other agencies has developed guidelines on sustainable procurement of vehicles for the UN. Recent reports by international organizations are pointing to the need for globally harmonized standards for assessing the efficiency of different fuels and relevant new technologies. The UN Industrial Development Organization (UNIDO) report Motor Systems Efficiency Supply Curves notes the lack of a transparent methodology for quantifying the energy efficiency of motor systems and insufficient data for documenting present and future cost effectiveness potentials. The International Energy Agency's 50by50 Prospects and Progress report calls for global fuel economy reduction to about 8L/100km with emissions halved in new automobiles by 2030 and in all automobiles by 2050 (by the Global Fuel Economy Initiative). A European expert group states that alternative fuels could replace fossil fuels by 2050. A RAND Corporation study Alternative Fuels for Military Applications concludes that the military should direct its efforts more towards increasing energy efficiency rather than investing in alternative fuels. [January 2011. Military Implications, Sources269]

International Air Cargo Screening Cooperation Requested

The executive director of the Airforwarders Association cargo industry group asked the U.S. Transportation Security Administration to bring shipping countries together to share screening methods for inbound international packages on passenger planes to meet deadlines. The lack of international standardized procedures impedes the implementation of a global system. [January 2011. Military Implications, Source] 270

Miscellaneous Safety Issues

New Earth-Approaching Asteroid Discovered

The Hawaii-stationed Panoramic Survey Telescope & Rapid Response System (Pan-STARRS) detected its first potentially hazardous object (PHO) September 16th and predicted the 150-ft diameter asteroid would pass within four million miles of Earth by mid-October 2010. This is 16 times the distance between the Earth and the Moon. In March 2009 a different asteroid came 80% closer to the Earth than the Moon. No one knew it was coming. Although the more recent asteroid was not a threat, it will be catalogued and monitored with other known objects that may pose a danger within the next fifty years. Although scientists believe many of the largest PHOs have been discovered, there is concern that many with diameters less than one mile (5,280 ft.) are still unknown. Pan-STARRS is considered the world's most sophisticated system for PHO detection. [Related item: Steps for an International Regime for Space Debris and Space Traffic Control System in May 2009 environmental security report.] [October 2010. Military Implications, Sources271]

Hungary Industrial Plant Spill Might Trigger Tougher Environmental Regulations

Approximately 700,000 cubic meters (184 million gallons) of heavy-metal-contaminated sludge has impacted at least 40 km² (15.4 mi²) of territory, including what appears to be pollution of the Danube, due to a sludge spill from a bauxite refinery in Ajka, Hungary, a town 160 kilometers (100 miles) from Budapest. Experts warn that the chemically polluted sludge could flow from Hungary to countries downstream, polluting the water and agricultural land. The Danube basin is historically linked to the mining and industrial farming industries. Chemicals such as copper, manganese, and cadmium already contaminate its tributaries, while pollutants have accumulated in soils, sediments, and groundwaters of the region. Research conducted after the Ajka spill suggests there may be hundreds, possibly thousands, of unreported chemical facilities without jurisdictional clarity "orphaned" by the fall of communism and with failing containment infrastructures in the basin, posing a chemical

"time bomb" threat. International liability and redress issues are likely. [October 2010. Military Implications, Sources272]

Study Indicts Swimming Pool Disinfectants for Toxic Effects from Byproducts

According to Science Daily, research by Professor Michael Plewa of the University of Illinois at Urbana-Champaign and colleagues has linked the application of disinfectants in recreational pools to previously published adverse health outcomes such as asthma, bladder cancer, and DNA damage: "negative outcomes can occur when disinfection byproducts form reactions with organic matter [e.g., sweat, hair, sunscreen] in pool water". The scientists recommend that disinfectants containing bromine be avoided. [July 2010. Military Implications, Source273] Artificial Grass May Pose Threat of Lead Poisoning to Children

The Agency for Toxic Substances and Disease Registry in Atlanta GA has reported that some artificial grass can begin to release lead dust after a few years of wear and tear. It found lead levels above US legal safety limits for 12 out of 29 synthetic surfaces tested, as well as in two out of four new artificial turf products. The turf manufacturers' association claims that other US studies have concluded children are not at risk. [Relevant item: Call for Global Ban on Lead based Paints in October 2007 environmental security report.] [October 2010. Military Implications, Sources274]

China to Expand Weather Control Program

Reportedly, the Director of the China Meteorological Administration has said that chronic water shortages in parts of the country will worsen over the coming decades, and therefore the need for using weather-control technologies will increase. China already began last year to allocate a special budget for weather control activities, and spending grew 19% in the first ten months of 2010, to \$114 million. [Related item: Chinese Use of Weather Modification Technologies Might Cause Disputes in July 2004 environmental security report.] [December 2010. Military Implications, Source275]

Nanotechnology--Potential Environmental and Health Implications

Study Raises Doubts on PEN Nano Consumer Products Inventory (CPI)

Lack of Nanoparticle Characterization Obstructs Development of Nanomedicines

Structured Relationship Modeling Allows Prediction of Nanoparticle Properties

Sunscreens with ZnO, TiO₂ Nanoparticles May Pose Health Risk

Study Shows TiO₂ Nanoparticles Disrupt Aquatic Ecosystems

New Model Predicts Nanoparticle Cellular Toxicity

Transatlantic Partners to Analyze Environmental Safety and health (EHS) for Manufactured Nanomaterials

Toxicity of Silver Nanoparticles Increases During Storage

Some Types of Nanotubes Produce Harmful Oxygen in Sunlit Water

Nanosilver Compound Turns Up in Municipal Wastewater

French Lab to Be Set up for Study of Nanotube Toxicity in Aqueous Environments

Mouse Model Shows Reversible Reproductive Damage from Nanotubes

Scientific Review on Using Nanomaterials in Construction Materials

Use of TiO₂ Nanoparticles in City Pavement Raises Risk Questions

Reports on nanotechnology-related safety

Study Raises Doubts on PEN Nano Consumer Products Inventory (CPI)

A recent study, published in Nanotechnology Law & Business, of the Consumer Products Inventory (CPI) prepared by the Wilson Center/Pew Trusts' Project on Emerging Nanotechnologies came to the conclusion that the CPI has substantive deficiencies that call the validity of claims associated with the CPI into question. It also recommends a commitment of resources at the governmental level to produce and maintain a consumer product inventory. [July 2010. Military Implications, Source277]

Lack of Nanoparticle Characterization Obstructs Development of Nanomedicines

An item in NatureNews, discussing the recent first international workshop on nanotech medicines held by the European Medicines Agency (EMA) in London, reports on statements by several experts that the lack of reliable characterization techniques for nanoparticles, and the consequent inability to analyze and understand nanoparticle/biosystem interactions and possible hazards, are obstructing the development of nanomedicines. [September 2010. Military Implications, Source278]

Structured Relationship Modeling Allows Prediction of Nanoparticle Properties

Scientists led by Prof. Alexander Tropsha of the Univ. of NC School of Pharmacy have developed a structured modeling technique by which the biological effects of manufactured nanoparticles (MNPs) can be predicted using their chemical, physical, and geometrical properties. [November 2010. Military Implications, Sources279]

Sunscreens with ZnO, TiO₂ Nanoparticles May Pose Health Risk

Petra Kocbek of the Faculty of Pharmacy, University of Ljubljana, Slovenia, and colleagues have published a paper indicating that long-term exposure to zinc oxide and titanium dioxide nanoparticles, such as are found in sunscreen, has adverse effects on human skin cells in vitro, and that such materials are therefore a potential health risk. [October 2010. Military Implications, Sources280]

Study Shows TiO₂ Nanoparticles Disrupt Aquatic Ecosystems

A paper by environmental engineers April Gu and Carla Cherchi of Northeastern University in Boston reports that titanium dioxide nanoparticles, at the levels found in wastewater, ".could disrupt an aquatic ecosystem's carbon and nitrogen cycles", after experiments using a blue-green alga, *Anabaena variabilis*. [January 2011. Military Implications, Sources281]

New Model Predicts Nanoparticle Cellular Toxicity

Enrico Burello and Andrew Worth of the EC's Joint Research Centre in Ispra, Italy have developed a new theoretical model that predicts which materials will make nanoparticles that could damage living cells. The model matches available electronic energy levels in the nanoparticle structure with the oxidation potentials of reactions that would either remove antioxidants from cells or generate reactive oxygen species (ROS) like hydrogen peroxide or superoxide ions. The researchers are trying to add factors besides oxidative stress. [July 2010. Military Implications, Source282]

Transatlantic Partners to Analyze Environmental Safety and health (EHS) for Manufactured Nanomaterials

According to Nanowerk News, in Phase 2 of the Environmental Nanoscience Initiative, scientists from the UK and the US will collaborate on three major research projects:

- a risk assessment for manufactured nanoparticles used in consumer products;
- an investigation of how nanomaterials are transported into sewage treatment systems, soil and surface waters and sediments, and a range of organisms;
- an examination of the rate and behavior of nanomaterials carried into agricultural soil and absorbed into its biota, as well as new knowledge from a unique pilot-scale waste water treatment facility." [January 2011. Military Implications, Sources] 283

Toxicity of Silver Nanoparticles Increases During Storage

A new report, co-authored by Prof. Matthias Epple, of the University of Duisburg-Essen, Essen, Germany, shows that the toxicity of silver nanoparticles increases during storage because of their slow dissolution and the consequent release of silver ions. Further quantitative details of the process, e.g. behavior when a containing material is washed, still remain to be investigated. [August 2010. Military Implications, Sources 284]

Some Types of Nanotubes Produce Harmful Oxygen in Sunlit Water

A study by Chia-Ying Chen and Chad T. Jafvert of the Purdue University School of Civil Engineering, West Lafayette IN, has shown that single-walled carboxylated nanotubes dispersed in water and exposed to sunlight produce a variety of cell-damaging reactive oxygen species (ROS). This generation had been known in the presence of laser light, but not for natural illumination. [August 2010. Military Implications, Sources 285]

Nanosilver Compound Turns Up in Municipal Wastewater

According to an Environmental Defense Fund blog, scientists in The Center for NanoBioEarth at Virginia Tech identified and characterized silver sulfide* nanoparticles in the sewage sludge produced by an operating municipal wastewater treatment plant. This is the first time that such material has been detected in a field-scale study. It is not certain, although stated as "likely", that the material detected in the sludge originated from products containing silver nanoparticles that were converted to sulfides in the processing.

* - The blog post incorrectly identifies the nanoparticles as potentially toxic silver rather than the correct characterization as inert silver sulfide, as stated in the original paper. [September 2010. Military Implications, Sources] 286

French Lab to Be Set up for Study of Nanotube Toxicity in Aqueous Environments

A French component of the international firm Arkema, together with the Centre national de la recherche scientifique (CNRS), the Institut National Polytechnique de Toulouse, and the Universite Paul Sabatier have agreed to establish a joint research laboratory, NAUTILE (NAnotUbes et ecoToxIcoLogiE), dedicated to the study of the ecotoxicological impact of carbon nanotubes (CNTs) in aquatic environments. [September 2010. Military Implications, Source 287]

Mouse Model Shows Reversible Reproductive Damage from Nanotubes

Bing Yan, Director of the High-Throughput Analytical Chemistry Facility at St. Jude Children's Research Hospital, Memphis TN, and colleagues conducted a nanotoxicology study on the impact of carbon nanotubes on male reproductive health in a mouse model. Although the ill effects found were reversible and did not affect the hormonal levels, sperm health, or male mice fertility, the authors emphasize that further studies are urgently needed. [August 2010. Military Implications, Source 288]

Scientific Review on Using Nanomaterials in Construction Materials

Prof. Pedro J. Alvarez at Rice University and colleagues compiled a report listing current uses of nanomaterials in various construction applications and highlighting potential and promising future uses. They also outline benefits, exposure scenarios, and impact mitigation measures. [July 2010. Military Implications, Sources289]

Use of TiO₂ Nanoparticles in City Pavement Raises Risk Questions

The TiO₂ nanoparticles used for air purification in city pavement in Antwerp allegedly agglomerate to a larger molecule with a size of 1.5 micro m, and so escape suspicion of possibly producing "nanoparticle pollution", but questions have been raised about their long-term fate -whether weathering over the decades may result in their release in their original form or in a form that may be degrade after inhalation., creating an environmental problem. Dr. Anil Kumar Suresh of the Biological and Nanoscale Systems Group, Oak Ridge National Laboratory, warns," There's not much known about the fate, transport and transformation of these particles in the environment. The area is not so explored and we cannot tell what will happen if the concentration of nanoparticles increases in the atmosphere. We have to be very careful", a reasonable warning considering the widespread use of TiO₂-containing materials. [December 2010. Military Implications, Source290]

Reports on nanotechnology-related safety

According to an announcement, a new report outlines six regulatory and educational issues that should be considered whenever nanoparticles are going to be used in pesticides. Several issues specific to exposure to NBP_s are discussed, including: (1) disclosures of nanoparticle characteristics in product formulations; (2) additional uncertainty factors for NBPs with inadequate data; (3) route-specific approaches for assessing exposure; (4) testing with the commercial form of NBPs; (5) initiation of a health surveillance program; and (6) development of educational programs. [October 2010]

Exposure Assessment: Recommendations for Nanotechnology-Based Pesticides
<http://www.ijoeh.com/index.php/ijoeh/article/view/1482>

New Approaches Needed to Gauge Safety of Nanotech-based Pesticides
<http://oregonstate.edu/ua/ncs/archives/2010/oct/new-approaches-needed-gauge-safety-nanotech-based-pesticides>

OECD has published two new documents in its Series on the Safety of Manufactured Nanomaterials:

No. 27: List of Manufactured Nanomaterials and List of Endpoints for Phase One of the Sponsorship Programme for the Testing of Manufactured Nanomaterials: Revision

A list of representative manufactured nanomaterial selected by the OECD Working Party on Manufactured Nanomaterials (WPMN) for use in its work.

[http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=env/jm/mono\(2010\)46&doclanguage=en](http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=env/jm/mono(2010)46&doclanguage=en)

No. 28: Compilation and Comparison of Guidelines Related to Exposure to Nanomaterials in Laboratories

An overview of recently published guidelines regarding the usage of nanomaterials in a laboratory scale.

[http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=env/jm/mono\(2010\)47&doclanguage=en](http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=env/jm/mono(2010)47&doclanguage=en)
[December 2010]

A new OECD Report Sums Up Current Developments in Nanomaterial Safety. According to Nanowerk News, "a new document from the OECD, Current Developments/Activities on the Safety of Manufactured Nanomaterials, provides information on current/planned activities related to the safety of manufactured

nanomaterials in OECD member and non-member countries that attended at the 7th meeting of OECD's Working Party on Manufactured Nanomaterials (Paris France, 7-9 July 2010)", as well as written reports on relevant current activities in other international organizations such as International Organization for Standards (ISO), FAO, and the WHO. [September 2010]

Environment Directorate Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology

[http://www.oecd.org/officialdocuments/displaydocument/?cote=env/jm/mono\(2010\)42&doclanguage=en](http://www.oecd.org/officialdocuments/displaydocument/?cote=env/jm/mono(2010)42&doclanguage=en)

The Institut de recherche Robert-Sauve en sante et en securite du travail in Montreal has released the second edition of its report, Engineered Nanoparticles: Current Knowledge about Occupational Health and Safety Risks and Prevention Measures. According to Nanowerk News, the 153-page report concludes, "As for health hazards, many toxicological studies on different substances have demonstrated toxic effects on various organs. It is found that in general, an NP will normally be more toxic than the same chemical substance of larger dimensions, but it is currently impossible to determine which measuring parameter for exposure is best correlated with the measured effects." It also calls for a preventive and even precautionary approach and emphasizes the enormous need for developing new knowledge. [September 2010.] Engineered Nanoparticles. Current Knowledge about OHS Risks and Prevention Measures <http://www.irsst.qc.ca/files/documents/PubIRSST/R-656.pdf>

BfR, the German Federal Institute for Risk Assessment, has published three reports on German opinions and attitudes about nanotechnology-related risks.

Delphi Study on Nanotechnology: Expert Survey of the Use of Nanomaterials in Food and Consumer Products discussed nine general risk criteria and nine nano-specific test criteria.

Perception of Nanotechnology in Internet-based Discussions: The risks and opportunities of nanotechnology and nanoproducts: results of an online discourse analysis according to Nanowerk News, has as its purpose "to analyse German-language online discussions of nanotechnology in an attempt to identify the perceived risks, opportunities, benefits and expectations associated with this field of research and development."

Risk Perception of Nanotechnology - Analysis of Media Coverage report examines 2001-2007 media coverage of nanotechnology in almost 1700 articles published in German newspapers and magazines.

German Federal Institute for Risk Assessment publishes three new reports on nanotechnology
<http://www.nanowerk.com/news/newsid=17898.php>

According to Nanowerk News, the focus of the report Engineered Nanomaterials: Feasibility of establishing exposure standards and using control banding* in Australia "is to investigate the feasibility of:

- establishing group-based Australian National Exposure Standards for engineered nanomaterials
- using control banding for engineered nanomaterials in Australia." [*"Control banding" is a workplace risk assessment technique]

Its discussion begins with a detailed analysis of a similar study done earlier by the British Standards Institution. [August 2010]

Engineered Nanomaterials: Feasibility of establishing exposure standards and using control banding in Australia

<http://www.safeworkaustralia.gov.au/NR/rdonlyres/CFEFDBA0-2BD5-4110-A49F-04A4C9032C18/0/Engineered%20Nanomaterials%20feasibility%20establishing%20exposure%20standards%20August%202010.pdf>

New Safe Work Australia report investigates feasibility of exposure standards for nanomaterials
<http://www.nanowerk.com/news/newsid=17524.php>

Engineered Nanomaterials: Investigating substitution and modification options to reduce potential hazards provides a review of the current state in Australia of nanotech risk assessment and mitigation. The 81-page report presents the results of a "survey of the current substitution/modification practices used in Australian nanotechnology-related activities and a literature review in order to determine the potential substitution/modification options that may reduce the toxicity of engineered nanomaterials used in Australia," says Nanowerk. The study was commissioned by Safe Work Australia and conducted by RMIT University, Melbourne. [August 2010]

Engineered Nanomaterials: Investigating substitution and modification options to reduce potential hazards
<http://www.safeworkaustralia.gov.au/NR/rdonlyres/A47FBE60-DC28-44A1-A601-653B6EBD3890/0/Investigating%20substitution%20modification%20options%20reduce%20potential%20hazards.pdf> Safe Work Australia publishes reports on methods to reduce the risk of exposure to nanomaterials
<http://www.nanowerk.com/news/newsid=17525.php>

Proceedings of the International Conference on Safe production and use of nanomaterials, Nanosafe 2010, November 16-18, 2010 in Grenoble, France, are now available on-line. Topics at the event included:, Exposure assessment, Characterization, Detection and Monitoring, Nanomaterials life cycle, Toxicology, Environmental impact, Nanoparticle release from consumer products, Personal protection equipment, Secure industrial production, Safety parameters evaluation, Standardization, and Regulations. [December 2010] NanoSafe 2010 presentations now available online <http://www.nanowerk.com/news/newsid=19267.php> Poster presentations at Nanosafe 2010

<http://www.nanosafe.org/scripts/home/publigen/content/templates/show.asp?P=119&L=EN&SYNC=Y> Oral presentations at Nanosafe 2010

<http://www.nanosafe.org/scripts/home/publigen/content/templates/show.asp?P=118&L=EN&SYNC=Y>

2. Military Implications and Sources

1 NATO's New Strategic Concept Includes Environmental Security

Military Implications:

Referencing the quotation above from the strategic concept adopted in Lisbon, the Army Strategy for the Environment should be made available to all relevant personnel in NATO, with suggestions for collaboration on how environmental security aspects in crisis management, conflict resolution, and general strategic planning might be enhanced.

Sources:

Active Engagement, Modern Defence. Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation adopted by Heads of State and Government in Lisbon

http://www.nato.int/cps/en/natolive/official_texts_68580.htm EU-US Summit in Lisbon, Portugal: Joint Statement

http://eurunion.org/eu/index.php?option=com_content&task=view&id=3926&Itemid=58

2 NATO Continues to Develop Cyber Defense Policies

Military Implications:

Military personnel with cyber security expertise and their NATO counterparts should collaborate on creating global cybersecurity strategy, agreements, and enforcement measures.

Source:

Developing NATO's cyber defence policy http://www.nato.int/cps/en/natolive/news_70049.htm

3 Germany to Propose Adding Climate Change to UN Security Council Agenda

Military Implications:

Military personnel involved in UN peacekeeping and military-to-military planning and training should anticipate increased requirements for future missions related to adaptation to climate change, from increasing weather disasters to human resettlements and food shortages. Sources:

Security Council must tackle climate change: Germany

<http://www.france24.com/en/20101213-security-council-must-tackle-climate-change-germany> Surge in Demand for Humanitarian Assistance in High-Risk Environments Informs General Assembly Debate on Strengthening UN Disaster Relief Assistance <http://www.un.org/News/Press/docs//2010/ga11038.doc.htm>

4 Environmental Aspects Should Be Factored More Into Conventional Security Concerns

Military Implications:

While these are only reinforcing issues already on the agenda of defense and security organizations, they provide new motivations for increased attention to human and environmental security as main components of 21st century global security. Continued and expanded training is needed to ensure that any force sent to a conflict or disaster zone is competent enough at least 'do no harm' to the environment, as much as possible. Sources:

Environment key to U.S. security: Congress briefing

<http://www.reuters.com/article/idUSTRE68L5NR20100922>

Conventional versus Human Security: How Climate Risks Decrease Stability

<http://pisaspeak.wordpress.com/2010/09/04/conventional-versus-human-security-how-climate-risks-decrease-stability/>

5 UN Official Calls to "Securitize the Ground" as part of Human Security

Military Implications:

Relevant military personnel should explore how the concept of "securitizing the ground" would affect policy as a factor in conflict prevention and resolution.

Source:

The Third Annual Caux Forum for Human Security. 9-16 July 2010, Caux Switzerland Grounding security (Soil security a prerequisite for human security). Luc Gnacadja speech <http://www.unccd.int/publicinfo/docs/lghumansecurity.pdf>

6 International Consortium Created to Curb Environmental Crime

Military Implications:

AFRICOM and military personnel in other regions working in countries with governments with weak local customs or security organizations should consider how they might conduct military-to-military activities to help implement the intentions of the Consortium and explore cooperation on the full range of international environmental crime-related activities with the Consortium. Sources:

World's police at INTERPOL General Assembly rally against environmental crime
<http://www.interpol.int/Public/ICPO/PressReleases/PR2010/News20101110.asp> Powerful alliance to fight wildlife crime comes into effect <http://www.interpol.int/Public/ICPO/PressReleases/PR2010/PR098.asp> AG-2010-RAP-08, Appendix. Resolution: Subject: Sustainable Environmental Crime Programme

http://www.cites.org/eng/news/press/2010/20101108_Interpol_resolution.pdf

7 Environment-related Issues Dominate the UN General Assembly Debate

Military Implications:

Military and security organizations should increase efforts to identify ways to cooperate with relevant international and national organizations in addressing the causes and effects of climate change, forecast how they might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. The increasing attention being accorded to the general relationships between environment and security makes it increasingly probable that UN peacekeeping operations will be mandated to deal with environmental issues. If so, then increasing military-to-military assistance and training in these matters will be needed. Sources:

General Assembly of the United Nations. General Debate: 65th Session, statements <http://gadebate.un.org/>

Security Council holds first strategic reassessment in nearly 20 years
[http://www.un.org/apps/news/story.asp?NewsID=36107&Cr=security+council&Cr1="](http://www.un.org/apps/news/story.asp?NewsID=36107&Cr=security+council&Cr1=) We can end poverty 2015.
UN Summit, 20-22 September 2010 <http://www.un.org/en/mdg/summit2010/>

8 The UN and African Union to Increase Cooperation for Peace and Security

Military Implications:

If not already done, AFRICOM and other military and security entities in Africa should connect with the Joint Task Force and the Energy Partnership for better integration of all security-related activities. Sources:

UN and African Union launch joint task force on peace and security [http://www.un.org/apps/news/story.asp?NewsID=36192&Cr=African+Union&Cr1="](http://www.un.org/apps/news/story.asp?NewsID=36192&Cr=African+Union&Cr1=) First High-Level Meeting of the Africa-EU Energy Partnership <http://www.iisd.ca/ymb/energy/aEEP/>

First High Level Meeting of the Africa-EU Energy Partnership

<http://www.aeep-conference.org/>

AfDB's Response to Climate Change in Africa

<http://www.afdb.org/en/news-events/article/afdbs-response-to-climate-change-in-africa-7165/>

9 An Emerging Nordic-Baltic Alliance Might Have Security Implications

Military Implications:

Such new alliances could lead to new security arrangements and environment-related regulations; the military should begin to explore how to react and how the Army Strategy for the Environment could be applied. [See Arctic-related items in previous environmental security reports.] Sources:

UK: Northern summit was not anti-European <http://euobserver.com/19/31677> Nordic Baltic Summit <http://uknordicbaltic.readandcomment.com/> Arctic NATO to watch the Russians

<http://english.pravda.ru/world/europe/20-01-2011/116584-arctic-nato-0/>

UK-Nordic-Baltic Summit to form new "alliance"

<http://www.baltictimes.com/news/articles/27816/>

10 Pacific Region Programs for Addressing Environmental Security

Military Implications:

Military and security entities in Asia should consider collaboration with these and similar organizations and ensure that their strategies are taken into account when addressing security issues in the region. Also, it is important to cooperate with the priorities set by the PREP Secretariat and the eventual new regulations that might result from the Strategic Plan. Sources:

Pacific Environment Ministers' Communiqué <http://www.sprep.org/article/newsdetail.asp?id=822>

Focused Action: Priorities for Addressing Climate Change in Asia and the Pacific
<http://www.adb.org/documents/brochures/climate-change-priorities/default.asp>

11 Project on National Security Reform (PNSR) Vision Working Group Report

Military Implications:

Military personnel with foresight responsibilities should review this report as to potential impacts on their organizations, budgets, opportunities, and effectiveness. They should also consider how to participate in shaping, establishing, and collaborating with such a center. Sources:

Project on National Security Reform

<http://www.pnsr.org/index.asp>

Vision working group Report and Scenarios

<http://pnsr.org/data/files/project-on-national-security-reform-vwg.pdf>

12 Comprehensive Assessment of Environmental Security

Military Implications:

The book might provide some new insights into environmental problems and how environmental diplomacy could prevent conflict.

Source:

Environmental Security. A Guide to the Issues <http://www.greenwood.com/books/printFlyer.aspx?sku=A3197C>

International Treaties Related To Environmental Security and Military Actions

14 Updates of the Rome Statute Include Amendments on the Crime of Aggression and Expansion of Criminalizing the Use of Certain Weapons in Non-international Conflicts

Military Implications:

Although the U.S. is not a State Party to the ICC, relevant military personnel should review these new amendments to be prepared to cooperate or comply, as required by status of forces agreements, in those countries that are States Party.

Sources:

Review Conference of the Rome Statute <http://www.coalitionfortheicc.org/?mod=review>

States Parties Approve New Crimes for International Criminal Court. ASIL Volume 14, Issue 16
<http://www.asil.org/files/insight100622pdf.pdf>

15 UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

Military Implications:

Military-to-military personnel concerned with water-related causes of conflict should be made aware of this resolution to add justification to their continued or expanded operations. Although the resolution is voluntary, it gives a new rationale to all organizations, including peacekeeping and other military entities, to increase their efforts towards improving the water situation in the regions where they are stationed or are operating. The resolution increases the likelihood that actions by public and private security actors will be scrutinized more often and more thoroughly for their impact on water, up to and possibly including provoking charges of "aggression".

Sources:

General Assembly Adopts Resolution Recognizing Access to Clean Water, Sanitation as Human

Right, by Recorded Vote of 122 in Favor, None against, 41 Abstentions

<http://www.un.org/News/Press/docs/2010/ga10967.doc.htm>

General Assembly declares access to clean water and sanitation is a human right

<http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=sanitation&Cr1>

16 UN Human Rights Council Affirms Right to Water as Legally-Binding

Military Implications:

Senior military personal should explore military roles in implementing this resolution to reduce water-related conflicts in the future. Military-to-military personnel concerned with water-related causes of conflict should be made aware of this resolution to add justification to their continued or expanded operations. Since the UN Human Rights Council resolution is binding, it gives a new rationale to all organizations, including peacekeeping and other military entities, to increase their efforts towards improving the water situation in the regions where they are stationed or are operating. The resolution increases the likelihood that actions by public and private security

actors will be scrutinized more often and more thoroughly for their impact on water, up to and possibly including provoking charges of "aggression".

Sources:

UN united to make the right to water and sanitation legally binding

<http://www.ohchr.org/en/NewsEvents/Pages/DisplayNews.aspx?NewsID=10403&LangID=E> 15/... Human rights and access to safe drinking water and sanitation. Human Rights Council Resolution A/HRC/15/L.14 (Sept. 24, 2010)

<http://daccess-dds-ny.un.org/doc/UNDOC/LTD/G10/163/09/PDF/G1016309.pdf?OpenElement> UN landmark decision: right to water and sanitation is legally binding <http://internationallawobserver.eu/2010/10/14/un-landmark-decision-right-to-water-and-sanitation-is-legally-binding>

17 International Biosecurity Initiative

Military Implications:

Military and security personnel with biosecurity-related responsibilities should review this legislation, follow its legislative progress, and explore its implications with their international counterparts for reducing the full range of international biosecurity threats and improving the use of nanosensor and other networks (some of which have been referenced in these monthly reports). Sources:

Bill: To improve the international strategy of the United States for monitoring, reducing, and responding to biological risks, and for other purposes.

<http://www.govtrack.us/congress/bill.xpd?bill=h111-6297>

Bill Would Establish Global Biosecurity Body

http://gsn.nti.org/gsn/nw/20101005_4535.php

H.R. 5498: WMD Prevention and Preparedness Act of 2010

<http://www.govtrack.us/congress/bill.xpd?bill=h111-5498>

18 Synthetic Biology Guidelines to Reduce Bioweapon Threats

Military Implications:

International military liaisons with security, health, and environmental responsibilities should be aware of these guidelines and share them with their counterparts to speed the day when international agreements are written to monitor and control synthetic biology. Source:

Screening Framework Guidance for Providers of Synthetic Double-Stranded DNA
<http://www.phe.gov/Preparedness/legal/guidance/syndna/Documents/syndna-guidance.pdf>

19 High cancer rates in Fallujah, Iraq; New Study Raises Questions on Environmental Damage from Bombardments

Military Implications:

The results of this study will probably be added to similar preceding ones requiring further investigations on the potential implications of the use of certain weapons in urban environments. If the allegations prove justified, and depleted uranium is found to be the key cause, then it is fair to speculate that pressure from civil society will increase for restricted use of these weapons; hence, increased research for substitutes would be wise. The same might be hypothesized for conventional munitions propellants and combustion residues. Sources:

Toxic legacy of US assault on Fallujah 'worse than Hiroshima'

<http://www.independent.co.uk/news/world/middle-east/toxic-legacy-of-us-assault-on-fallujah-worse-than-hiroshima-2034065.html>

Cancer, Infant Mortality and Birth Sex-Ratio in Fallujah, Iraq 2005-2009

<http://www.scribd.com/doc/34158205/Cancer-Infant-Mortality-and-Birth-Sex-Ratio-in-Fallujah-Iraq-2005-2009>

20 Measuring Progress in Conflict Environments: A Metrics Framework

Military Implications:

The MPICE framework is a good resource for improving security activity in the field. Source:

Measuring Progress in Conflict Environments

<http://www.usip.org/resources/measuring-progress-in-conflict-environments-mpice-0>

21 Economic Argument for Peace-building in Sudan

Military Implications:

AFRICOM and security personnel associated with Sudan should review this report and use its data as a case for ongoing conflict prevention and capacity-building programs.

Sources:

Return to conflict in Sudan could cost in excess of US\$100 billion <http://www.frontier-economics.com/europe/en/news/1028/> The cost of future conflict in Sudan

<http://www.frontier-economics.com/library/pdfs/frontier%20report%20-%20the%20cost%20of%20future%20conflict%20in%20sudan.pdf>

22 Artillery Training Charges Pose Environmental Asbestos Threat

Military Implications:

The military should investigate the potential use of such hazardous material in installations and increase safety measures. It is not clear at this point what the results of the investigation will be, but there might be some recommendations for standards' improvements and enforcements, as well as replacement of potentially hazardous materials in such items. Source:

Artillery drills spark asbestos fears

<http://www.abc.net.au/news/stories/2010/06/29/2939489.htm?section=justin>

23 Latin American Initiatives for Environmental Security

Military Implications:

As part of its actions for addressing security in the region, the military with responsibility in Latin American and the Caribbean (USSOUTHCOM) should (if not already doing so) explore improvements for cooperation with international, national, and regional organizations to help the success of the environmental conservation programs as part of the region's stability strategy. Sources:

UNDP, Ecuador sign deal to protect Amazon from oil drill

<http://content.undp.org/go/newsroom/2010/july/PNUDyEcuadorssubscribenacuerdoparalainiciativaYasuni.en>

Working Towards Carbon Neutrality

<http://www.ipsnews.net/news.asp?idnews=52407>

US converts Brazilian debt into environmental protection

<http://news.malaysia.msn.com/business/article.aspx?cp-documentid=4269914>

UNDP LAC Regional Biodiversity Initiative Bulletin

<http://www.iisd.ca/larc/pdf/larc0107e.pdf>

24 First U.S.-Russian Environmental Protection Park

Military Implications:

This joint venture represents an example of how environmental concerns could improve confidence building among nations. The opening of this park within a year should be used to identify and initiate similar environmental joint projects with other nations. Increasing land areas being set aside for conservation increases the likelihood that future security operations from natural disaster mitigation to conflicts could occur on these lands; hence, new Rules of Engagement would be needed for these situations. Source:

A breakthrough in Beringia. Russia and the US are creating a giant international park in Chukotka and Alaska

<http://rt.com/Top News/Press/eng/2010-08-25/?fullstory>

25 CEC's Five-year Strategic Plan Increases North-American Environmental Integration

Military Implications:

Relevant military personnel should keep track of the CEC's work in view of potential new regulations or directives, as well as effects on collaboration among government agencies, that might affect some military operations and on collaboration among military counterparts. Sources:

CEC Ministerial Statement. Seventeenth Regular Session of the CEC Council <http://www.cec.org/Page.asp?PageID=122&ContentID=2968>

Government of Canada Releases Biomonitoring Data from the Canadian Health Measures Survey

http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/2010/2010_139-eng.php Monitoring Greenhouse Gases
<http://pubs.acs.org/cen/coverstory/88/8832cover.html>

26 EU to Set Resource Efficiency Targets

Military Implications:

The military and its contractors stationed in the EU should be prepared to adapt, as legally appropriate, to the new regulations, as it is not clear at this point if there will be exemptions for the military. Source:

EU moots link between resource efficiency and budgetary targets <http://euobserver.com/9/31704/?rk=1>

27 Islamic Conference of Environmental Ministers Approves Detailed Program

Military Implications:

The Islamic environmental program should be reviewed by military and related security personnel with environmental security responsibilities in Islamic nations. Opportunities should be explored to cooperate with programs to increase Islamic nations' participation in the fields of environmental science, sustainable environmental technologies, and environmental security strategies. Sources:

4th Islamic Conference of Environment Ministers Starts in Tunis

<http://www.thepeninsulaqatar.com/latest-news/128323-4th-islamic-conference-of-environment-ministers-starts-in-tunisia-.html>

4th Islamic Conference of Environment Ministers and Conference documents <http://www.sesric.org/event-detail.php?id=432>

28 Evolution of Environmental Management Philosophy in China

Military Implications:

The paper should be reviewed for its insights into environmental management activities in the PRC in preparation for any environmental security cooperation between the US and China.

Source:

The Evolution of Environmental Management Philosophy Under Rapid Economic Development in China (only preview available; purchase or subscription required for full text)
<http://www.springerlink.com/content/7215678t41281v40/>

Technological Breakthroughs with Environmental Security Implications

30 Nanowire Semiconductors for Nano-sensors and Nano-robotics

Military Implications:

The military should follow this development for its potential applicability to hazardous material detection in a variety of situations. Security organizations should also prepare for criminal and terrorist opportunities offered by self-powered and autonomous systems. Scenarios should be written to explore who will be able to control - or deactivate - such systems in strategic, unstable, developing countries where two or more 'sides' might want to exploit such devices. Sources:

Push-Button Logic on the Nanoscale <http://www.physorg.com/news200213686.html>

Strain-Gated Piezotronic Logic Nanodevices

<http://onlinelibrary.wiley.com/doi/10.1002/adma.201001925/abstract;jsessionid=3A96C84BCE895C3E76C39F13052E26FA.d02t01>

31 New Super-efficient Undersea Marine Research Robot

Military Implications:

This new technology should be investigated for its ocean research and environmental monitoring capabilities.

Source:

New long-range undersea robot goes the distance http://www.mbari.org/news/news_releases/2010/lrauv/lrauv-release.html

32 Cost-Effective Real-Time Electronic Monitoring for Coastal Ecosystems

Military Implications:

This new technology should be investigated for its potential in environmental cleanup of coastal military damage and environmental monitoring capabilities.

Source:

Researchers Developing Real-Time Electronic Monitoring For Coastal Waters
<http://news.ncsu.edu/releases/wmsdeanbaysensors/>

New Detection and Cleanup Techniques

34 Novel Micro-enabling Technology Potentials to Improve Detection Efficiency

Military Implications:

Military and security personnel concerned with cellular and molecular detection, computation0, and analysis should consider the techniques and/or contacting the company for possible partnership, for improving detection systems. Sources:

Miniature droplet technology receives Royal Society Enterprise Fund backing

<http://royalsociety.org/news/miniature-droplet-technology/>

Sphere Fluidics

<http://www.spherefuidics.eu/>

35 DNA Backbone Provides Foundation for Sensitive New Multi-material Sensor

Military Implications:

This technique should be evaluated for simple and inexpensive environmental sensing. Security organizations should evaluate this technology in the search for innovative combinations of new and of new-old sensing systems to anticipate future missions, as well as responding to current threats. Sources:

DNA puts Stanford chemists on scent of better artificial nose

<http://news.stanford.edu/news/2010/august/newnose-082310.html>

Polyfluorophores on a DNA Backbone: Sensors of Small Molecules in the Vapor Phase

<http://onlinelibrary.wiley.com/doi/10.1002/anie.201002701/abstract>

36 U.S.-China Ozone Microbubbles Provide Widely Applicable Cleanup Technique

Military Implications:

If the trials of this technology are successful, it should prove useful in pollution situations where the water contaminants and occurrence are appropriate.

Source:

Utah Microbubbles Clean Dirty Soil in China <http://www.unews.utah.edu/p/?r=101110-1>

37 Laser Detector Offers Fast Gas Analysis

Military Implications:

This technology should be reviewed for its ability to improve environmental assessments and other security applications.

Source:

JILA unveils improved 'molecular fingerprinting' for trace gas detection

<http://www.physorg.com/news/2010-10-jila-unveils-molecular-fingerprinting-gas.html>

38 New Colorimetric Sensor Uniquely Detects Vapor from TATP Explosive

Military Implications:

This device should be evaluated as a potentially valuable addition to the current set of environmental surveillance tools.

Sources:

Sniffing out shoe bombs: A new and simple sensor for explosive chemicals

<http://www.nanowerk.com/news/newsid=18571.php>

A Colorimetric Sensor Array for Detection of Triacetone Triperoxide Vapor

<http://pubs.acs.org/doi/abs/10.1021/ja107419t>

1 Spectrometer Provides Accurate Beta/Gamma Detection in 15 Minutes

Military Implications:

These detectors should be reviewed for their utility in cleaning up radiation-contaminated environmental sites.

Source:

New technology to speed cleanup of nuclear contaminated sites

<http://www.physorg.com/news/2010-12-technology-cleanup-nuclear-contaminated-sites.html>

40 Molecular Imprinted Polymers Provide Basis for Sensors of Multiple Compounds

Military Implications:

This research should be followed for its potential use in stationary and portable detection devices.

Sources:

Sensors to detect explosives, monitor food <http://www.nanowerk.com/news/newsid=19807.php>

Electropolymerized Molecularly Imprinted Polymer Films of a Bis-Terthiophene Dendron: Folic

Acid Quartz Crystal Microbalance Sensing

<http://pubs.acs.org/doi/abs/10.1021/am100805y>

41 Russian Enterprise to Mass Produce Low Cost Detectors for More than 40 Substances

Military Implications:

This product should be evaluated against current options for environmental sensors.

Source: RUSNANO Funds Project for Detectors of Explosives and Narcotics

<http://www.nanowerk.com/news/newsid=19545.php>

42 Flexible Supercapacitor Could Power Wearable Environmental Sensors

Military Implications:

This development should be explored to reduce weight on the soldier and improve mobile environmental sensor capabilities.

Source:

T-Shirt replaces battery: Fiber-based electrochemical micro-supercapacitor

<http://www.physorg.com/news/2011-01-t-shirt-battery-fiber-based-electrochemical-micro-supercapacitor.html>

43 Marine Bacteria Which Can Metabolize Steel Discovered

Military Implications:

Relevant military personnel should investigate to determine if this biological solution for iron conversion could help address underwater ship and unexploded ordnance cleanup.

Source:

Steel-munching bacteria are devouring the Titanic, say scientists

<http://www.guardian.co.uk/science/2010/dec/06/titanic-steel-bacteria-rusticles-pipelines>

44 Improved Method to Remove Pollutants from Gas and Liquids

Military Implications:

The military should evaluate this technique for environmental cleanup of contaminated water or improvements in emissions from combustion sources.

Source:

New method for making tiny catalysts holds promise for air quality

http://www.news.illinois.edu/news/10/1215carbon_spheres.html

45 Nano-based Olfactory Sensor Offers Diversity, Extreme Miniaturization

Military Implications:

These devices offer the possibility of very small and inexpensive environmental sensing systems; their further development should be closely monitored.

Sources:

Single-Nanobelt Electronic Nose: Engineering and Tests of the Simplest Analytical Element

<http://pubs.acs.org/doi/abs/10.1021/nn100435h>

'Smart' sand: grain-sized nanotechnology electronic noses are on the horizon

<http://www.nanowerk.com/spotlight/spotid=17373.php>

46 New Index Aids Characterization of Biological Reaction to Nanomaterials

Military Implications:

This method should be assessed for possible use in nanomaterial risk assessment. Sources:

An index for characterization of nanomaterials in biological systems. *Nature Nanotechnology*, 15 August 2010 | doi:10.1038/nnano.2010.164

<http://www.nature.com/nnano/journal/vaop/ncurrent/abs/mnano.2010.164.html> Predicting how nanoparticles will react in the human body <http://www.physorg.com/news201094921.html>

47 Autonomous Network of Sea Skimmers Could Speed Oil Spill Cleanup

Military Implications:

This is a promising development to add to the set of tools for remediating oceanic oil spills. It should be assessed for utility in diverse real-world conditions.

Source:

MIT uses nanotechnology to build autonomous oil-absorbing robot
<http://www.nanowerk.com/news/newsid=17787.php>

1 New Technique Provides Simple, Sensitive Analysis of Aerosols

Military Implications:

This improved technology should significantly simplify the task of identifying and controlling aerosol contaminants in the atmospheric environment. The technique should be evaluated by materiel developers, preventive health entities, and environmental managers for adaptation to identifying and quantifying chemical/biological war agents and environmental pollutants.

Sources:

Molecular Characterization of Organic Aerosols Using Nanospray-Desorption/Electrospray

Ionization-Mass Spectrometry

<http://pubs.acs.org/doi/abs/10.1021/ac101449p>

New technique provides sensitive analysis of atmospheric particles

<http://www.nanowerk.com/news/newsid=18004.php>

49 Photocatalytic Pavement Removes Nitrogen Oxides from City Air

Military Implications:

This material should be evaluated for potential use in military construction to help contribute to improving air quality. A downside is addition of nitrate nutrient to surface water runoff into rivers. Any evaluation of this and other nanoproducts, especially those to be openly exposed to becoming air or waterborne, must take into account nanomaterials' possible negative health and environmental concerns under study, as reported in this and prior environmental security reports. Source:

Nanoparticle-coated pavement that cleans the air <http://www.nanowerk.com/news/newsid=17444.php>

50 New Water Testing and Purification Technologies

51 January 2011 Military Implications:

These developments should be evaluated for their usefulness in areas with contaminated water and for managing hydrocarbon spills.

Sources:

Special Sugar, Nanoparticles Combine to Detect Cholera Toxin

<http://news.ucf.edu/UCFnews/index?page=article&id=00240041052a2b5bb012d4490764900622f>
Identification of Molecular-Mimicry-Based Ligands for Cholera Diagnostics using Magnetic Relaxation

<http://pubs.acs.org/doi/abs/10.1021/bc100442q>

NSF Webcast: Water and Oil Everywhere, and Now it's Safe to Drink

http://www.nsf.gov/news/news_summ.jsp?cntn_id=118400&WT.mc_id=USNSF51&WT.mc_ev=click

52 August 2010 Military Implications:

These developments should be followed as potential contributions to the set of water treatment methods available for mainly remote regions. New water technologies in combination with the increasing view that water is a human right, mean that security actors need to consider water as a key issue in any operations, especially ones outside the national borders of operation participants. Sources:

SU scientists develop a high-tech 'tea bag' filter for cleaner water

<http://blogs.sun.ac.za/news/2010/07/28/su-scientists-develop-a-high-tech-%E2%80%98tea-bag%E2%80%99-filter-for-cleaner-water/>

High Speed Water Sterilization Using One-Dimensional Nanostructures

<http://dx.doi.org/doi:10.1021/nl101944e>

Nanotechnology for water purification. International Journal of Nuclear Desalination 2010 - Vol. 4, No.1 pp. 49 - 57 (abstract)

http://www.inderscience.com/search/index.php?action=record&rec_id=33766&prevQuery=&ps=10&m=or

53 Electrified Nanotube-Fabric Filter Offers Cheap, Fast Water Purification

Military Implications:

This water purification technology should be tested for field applications.

Sources:

High-speed filter uses electrified nanostructures to purify water at low cost

<http://www.rdmag.com/News/2010/08/Materials-Nanotechnology-High-speed-filter-uses-electrified-nanostructures-to-purify-water-at-low-cost/>

High Speed Water Sterilization Using One-Dimensional Nanostructures (Abstract)
<http://pubs.acs.org/doi/abs/10.1021/nl101944e>

54 Graphene-based Composite Removes Arsenic from Drinking Water

Military Implications:

The new material should be evaluated for its applicability in systems for purifying arsenic-contaminated water sources.

Sources:

Graphene soaks up arsenic <http://physicsworld.com/cws/article/news/43162>

Water-Dispersible Magnetite-Reduced Graphene Oxide Composites for Arsenic Removal
<http://pubs.acs.org/doi/abs/10.1021/nn1008897>

55 New Catalyst Enables Water Decontamination by Visible Light

Military Implications:

This new technique should be further evaluated for its bactericidal effectiveness (e.g. E. coli needs to be reduced to zero) and economic feasibility (palladium is expensive). Sources:

Nanoparticles and light can purify water

<http://www.scidev.net/en/news/nanoparticles-and-light-can-purify-water.html>

Memory antibacterial effect from photoelectron transfer between nanoparticles and visible light photocatalyst

<http://www.rsc.org/publishing/journals/JM/article.asp?doi=b917239d>

56 Adding Flocculation Agents to Runoff Filter Socks Improves Performance

Military Implications:

This modification should be evaluated for possible use in reducing environmental damage on installations and at construction projects.

Source:

'Super socks' help stem pollution runoff <http://www.physorg.com/news199099635.html>

57 Portable Virus Detector Could Check Pandemics

Military Implications:

Relevant military and security personnel should explore the use of this technology to see if, indeed, it is better than current systems.

Sources:

Sensors: A portable device for virus detection <http://www.nanowerk.com/news/newsid=18701.php>

Rapid detection of viral RNA by a pocket-size real-time PCR system (by subscription only)
<http://pubs.rsc.org/en/Content/ArticleLanding/2010/LC/c004921b>

58 More Reliable "Kill Switch" Found for Genetically Engineered Microbes

Military Implications:

This technique should be explored for controlling genetically modified organisms, including biological threats, both intended and accidental. Security organizations should create joint training programs to practice working together with the switch in a variety of security threat situations. Source:

A 'Kill Switch' for Rogue Microbes <http://www.technologyreview.com/biomedicine/26094>

59 Potential Bioweapon Countermeasure against Ebola and Marburg Virus

Military Implications:

If not already underway, relevant military personnel should contact the scientists to expedite this research for its potential in bio-war countermeasures.

Source:

Small Molecules May Prevent Ebola Infection

http://tigger.uic.edu/htbin/cgiwrap/bin/newsbureau/cgi-bin/index.cgi?from=Releases&to=Release&id=3111&start=1287856211&end=1295632211&top_ic=0&dept=0

Promising Environmental-friendly Technologies

61 Nanoimprint May Create Synthetic, Chemical-Free, Anti-Bacterial Surfaces

Military Implications:

This technology should be followed, as it may provide a means for reducing the environmental impact of naturally or deliberately introduced contaminants.

Sources:

Singapore consortium learns from nature to produce new chemical-free, anti-bacteria plastic 'skins'

<http://www.nanowerk.com/news/newsid=19556.php> I.C.O.N. Project #2 : Towards Anti-Bacterial Surfaces
<http://www.imre.a-star.edu.sg/nil/project2.pdf>

62 Optical Link Facilitates Exploration of the Underwater Environment

Military Implications:

The military should keep in touch with this development for gathering environmental data on the underwater environment, such as scanning for unexploded ordnance or other hazardous materials. Source:

Revolutionary Communications System Promises New Generation of Untethered, Undersea Vehicles

<http://www.physorg.com/news197133272.html>

63 Advances in Wireless Location Detection

Military Implications:

The military should follow this research for its future applicability to device and personnel tracking within field and office milieus. Security organizations should also assess what these advances may mean in terms of the additional readiness and ability of terrorists/extremists to threaten disruption and/or violence.

Source:

Can you find me now?

<http://web.mit.edu/newsoffice/2010/location-sensing-0909.html>

64 Charged Particle Generators Produce Desert "Rainstorms"

Military Implications:

Global warming models predict that those areas with low rainfall will get less rain in the future. This could increase environmental migration, which can lead to conflicts in the receiving areas. This technology should be explored for its future potential to reduce such potential conflicts. Source:

Technology created 50 rainstorms in Abu Dhabi's Al Ain region last year

<http://www.dailymail.co.uk/sciencetech/article-1343470/Have-scientists-discovered-create-downpours-desert.html>

65 Metal-Organic Frameworks (MOFs) Give Greatly Improved CO₂ Storage

Military Implications:

DARPA should explore this capacity - if not already doing so - for carbon capture and storage to reduce the military carbon footprint.

Sources:

World records by UCLA chemists, Korean colleagues enhance ability to capture CO₂

<http://newsroom.ucla.edu/portal/ucla/world-records-by-ucla-chemists-163439.aspx> Ultra-High Porosity in Metal-Organic Frameworks <http://www.sciencemag.org/cgi/content/abstract/science.1192160v1>

66 Carbonates for Construction Drawn from Carbon Dioxide

Military Implications:

The military should follow this work for potential application to CO₂ reduction programs, water desalination plans, and construction projects. Any evaluation must consider how the metal ions required to produce insoluble carbonates are to be obtained without creating new environmental hazards. Source:

Putting carbon dioxide to good use

<http://web.mit.edu/newsoffice/2010/belcher-carbon-0922.html>

67 Improved Plastic Recycling

Military Implications:

If the process proves to be cost-effective with acceptable environmental impacts, then it could represent a substantial contribution to recycling in military installations and operations.

Source:

Researchers: New tech could recycle all household plastics

<http://www.smartplanet.com/people/blog/pure-genius/new-tech-could-recycle-100-percent-of-household-plastics-even-holiday-wrap/5195/>

68 New Cement Process Greatly Reduces Energy Load and CO2 Emission

Military Implications

This process should reduce military construction's CO2 emissions footprint and energy usage, but Celitement is not yet economically competitive with traditional manufacturing methods. DARPA or related research systems might explore cost reduction procedures. Sources:

New Chemistry, Less Energy Could Yield Greener Cement

<http://news.nationalgeographic.com/news/energy/2010/12/101209-green-cement-energy-greenhouse-gas/>

Celitement GmbH

<http://www.celitement.com/en/>

69 Sustainable Method to Recycle Rubble into Durable Construction Material

Military Implications:

Military personnel working in post-disaster environments with rubble debris crises should contact the researchers to find out how they can participate in researching and launching this recycling method in disaster locations. Sources:

Researchers Find Method for Recycling Rubble, Rebuilding Haiti

<http://www.gatech.edu/newsroom/release.html?nid=63746>

The American Ceramic Society Jan-Feb 2011 Bulletin

<http://ceramics.org/publications-and-resources/the-bulletin/>

Breaking Haiti's the reconstruction logjam: Progress through rubble reuse

http://americanceramicsociety.org/bulletin/2011_pdf_files/jan_feb_11/#/22/

70 New Forms of Air Conditioning Assuming Larger Role

Military Implications:

Centers such as the Western Cooling Efficiency Center at the University of California at Davis and the National Renewable Energy Laboratory should be consulted and their work monitored so that plans for outfitting

new or remodeled buildings can take these important trends and innovations into account.

Source:

Seeking to Cool Air Conditioning Costs

<http://news.nationalgeographic.com/news/2010/08/100812-energy-evaporative-air-conditioner/> Air conditioning: Cold comfort

<http://www.independent.co.uk/environment/air-conditioning-cold-comfort-2041647.html>

71 New Insights into Photosynthesis Could Change Energy Storage and Transmission

Military Implications:

This research offers key insights into harvesting nature's most abundant renewable energy source and should be followed to reduce oil-dependency and lessen the military environmental footprint. Source:

Fine-tuning photosynthesis

<http://web.mit.edu/newsoffice/2010/fine-tuning-photosynthesis.html>

72 Adding Graphene to Lithium-Ion Batteries Dramatically Reduces Recharge Time

Military Implications:

This technology could greatly improve the operational performance of portable/mobile environmental sensing systems, hybrid and electric vehicles, and other energy storage applications and should be monitored as it proceeds to commercial availability. Source:

Battery research could lead to shorter recharge time for cell phones

<http://www.physorg.com/news198309365.html>

73 Carbon Nanotube Cathodes, Silicon Anodes Improve Battery Performance

Military Implications:

The evolution of these technologies should be tracked by those responsible for reducing the military environmental footprint, meeting new energy standards, and improving power supply performance. Sources:

Contour Energy Systems Signs Exclusive Technology Licensing Agreement with MIT

<http://www.contourenergy.com/newsmodule/view/id/13/src/@random4c7d17e3c79cc/>

Monster power. Lithium-ion batteries start to take on the big stuff

<http://www.economist.com/node/17352944?fsrc=nwl>

Silicon strategy shows promise for batteries

<http://www.nanowerk.com/news/newsid=18492.php>

74 New Solar-Powered Process Converts Atmospheric CO₂ to Solid Carbon

Military Implications:

This development, if successfully scaled up, could be a significant addition to the set of CO₂-mitigation tools.

Sources:

New solar-powered process removes CO₂ from the air and stores it as solid carbon
<http://www.nanowerk.com/spotlight/spotid=17198.php>

A New Solar Carbon Capture Process: Solar Thermal Electrochemical Photo (STEP) Carbon Capture

<http://pubs.acs.org/doi/abs/10.1021/jz100829s>

75 Solar Energy Conversion System Uses Both Photovoltaic and Thermal Technologies

Military Implications:

This technology could provide a major increase in the overall efficiency of solar power systems, and should be closely followed for full exploitation as available. Such a system should reduce logistical requirements and could be left behind to help post-conflict local recovery. Source:

New solar energy conversion process could revamp solar power production
<http://www.nanowerk.com/news/newsid=17454.php>

76 New Supercapacitor Design Claims Large Improvements in Energy Storage

Military Implications:

When brought to a commercialized level, these devices could provide significant improvements in power supply performance in environmental equipment. Their further development should be followed.

Sources:

Ultrahigh-power micrometre-sized supercapacitors based on onion-like carbon. Nature Nanotechnology Newsletter (2010) DOI:10.1038/nnano.2010.162
<http://www.nature.com/nnano/journal/vaop/ncurrent/abs/nnano.2010.162.html> International research team develops ultrahigh-power energy storage devices <http://www.physorg.com/news201272263.html>

77 New Window Developments Aim at Saving, Generating Energy

Military Implications:

These developments, if/when they reach a level of practical applicability, could make a definite contribution to reducing the environmental footprint of installation buildings and/or provide power to remote or mobile devices. Their progress should be monitored.

Sources:

Making Smart Windows that Are Also Cheap <http://www.technologyreview.com/energy/25989/page1/>
Soladigm Company <http://soladigm.com/index.html>

New technique announced to turn windows into power generators

<http://www2.le.ac.uk/ebulletin/news/press-releases/2010-2019/2010/08/nparticle.2010-08-10.1427638716>

EnSol Company

<http://www.ensol.no/index.htm>

1 NSF Makes 14 Grants in Renewable Energy and Sustainability

Military Implications:

Organizations in the environmental security community should establish contact with the awardees to exploit their accomplishments as quickly as practicable.

Source:

Exploring Sustainability for Energy and Buildings

http://www.nsf.gov/news/news_summ.jsp?cntn_id=117731&WT.mc_id=USNSF_51&WT.mc_e_v=click

Technologies for New Generations of Cars

80 Experts Say Possible Rare Earth Shortages Not A Real Problem for Electric Cars

Military Implications:

Relevant military personnel should investigate the pros and cons of the SRM to reduce dependency on rare earth elements for electric vehicles.

Source:

Millennium Project "global-energy" listserve discussion; see this specific post in the Appendix List Archives: <http://mp.cim3.net/forum/global-energy/>

81 NASA's SERVIR Environmental Imaging-Decision Support System Extended from Mesoamerica and Africa to Asia

Military Implications:

Military and security personnel with environmental responsibilities in Central and South Asia should become familiar with this new environmental planning and management tool. If not already accomplished, AFRICOM should explore the use of SERVIR by African countries in their environmental security planning and training. Source:

SERVIR: Program brings satellite imagery, decision support tools to Himalayan region
<http://www.physorg.com/news205578190.html>

Technologies that Could Trigger New Forms of Arms Race

83 Robot Planes for Environmental Monitoring and Warfare Raise Legal Concerns

Military Implications:

Development of unmanned aircraft for environmental monitoring and warfare should consider built-in systems that would assure the respect of basic regulations such as those included in the Geneva Convention, for avoiding human victims and environmental damages. With the proliferation of UAV's, special attention should be given to preventing their misuse by non-state actors.

Sources:

Satellite navigation steers unmanned micro-planes

http://www.esa.int/esaCP/SEMMUZDODDG_index_0.html

The solar-powered spy plane that will be able to fly non-stop for FIVE years

<http://www.dailymail.co.uk/sciencetech/article-1313552/The-solar-powered-spy-plane-able-fly-non-stop-FIVE-years.html>

Vegas Drone Trial Makes History

<http://www.justicewithpeace.org/node/1763>

The law versus justice. Vegas anti-drone trial makes history

http://www.lasvegascitylife.com/articles/2010/09/23/news/local-news/iq_38222529.txt

B. Preventing or Responding to Environmentally Caused Conflicts

Security Implications of Environmental Aspects

86 New Website Addresses Conflict-sensitive Conservation

Military Implications:

Military personnel with environmental and land use planning responsibilities should explore this website for applications in planning.

Sources:

Conflict-Sensitive Conservation. MEA Bulletin Issue No. 97, Thursday, 29 July 2010

<http://www.iisd.ca/mea-l/meabulletin97.pdf>

Conflict-Sensitive Conservation website

<http://www.csconservation.org/>

87 Extinction Threatening 21% of Africa's Freshwater Species Could Have Security Implications

Military Implications:

Military personnel with African environment and water responsibilities should review this IUCN assessment for their region to help plan and implement sustainable projects that do not disrupt local food and material supplies. Since there are procedures for protecting some land animal and ocean fishing zones, procedures for protecting inland fish stocks should be considered. Source:

African fresh water species threatened - livelihoods at stake

<http://www.iucn.org/knowledge/news/?5898/African-freshwater-species-threatened—livelihoods-at-stake>

1 Possible Conflicts over National/Regional Geoengineering Projects

Military Implications:

Environmental security personnel should be on the alert for news of any geoengineering projects, and consider possible responses. Geoengineering could have potentially massively disruptive, if not destructive, unintended consequences. Therefore, every security organization should be at least aware of and considering response options to all geoengineering proposals that might be proposed by any parties. Geoengineering could be deliberately weaponized against specific targets and spill over to unintended victims. Sources:

Regional climate response to solar-radiation management

<http://www.nature.com/ngeo/journal/v3/n8/full/ngeo915.html>

'Cheap' solar geoengineering plans may have unintended consequences

<http://www.theecologist.org/News/news round up/562566/cheap solar geoengineering plans may have unintended consequences.html>

Efficacy of geoengineering to limit 21st century sea-level rise

<http://www.pnas.org/content/early/2010/08/20/1008153107>

Geoengineering won't curb sea-level rise

<http://www.nature.com/news/2010/100823/full/news.2010.426.html#B1>

89 Indigenous People Demanding Regulations for Addressing Climate Change and Mining

Military Implications:

Those involved in military-to-military operations on lands of indigenous peoples should review the Lima Declaration for implications for future operations.

Sources:

Indigenous Peoples in Latin America Unite Against Mining

<http://www.galdu.org/web/index.php?odas=4967&giella1=eng>

Lima Declaration - Forum of Indigenous Peoples Mining, Climate Change And Well Being

<http://www.culturalsurvival.org/news/peru/lima-declaration-forum-indigenous-peoples-mining-climate-change-and-well-being>

Race for Natural Resources

91 Natural Resources Fuel Violence in Eastern D.R. Congo

Military Implications:

AFRICOM should cite this situation to policymakers in the region to encourage implementation of military-to-military programs to address environmental degradation that could trigger security issues. Similar actions should be taken in collaborations with peacekeeping forces. Since the factors that lead to these conflicts are increasing, it would be wise to create a collective intelligence system to identify and assess better approaches with and for all relevant stakeholders in the region.

Sources:

Rising Global Interest in Farmland: Can It Yield Sustainable and Equitable Benefits?
<http://siteresources.worldbank.org/INTARD/Resources/ESW Sept7 final final.pdf>

MONUSCO Mandate

<http://www.un.org/en/peacekeeping/missions/monusco/mandate.shtml> UN has failed Congo mass rape victims, says investigator <http://www.guardian.co.uk/world/2010/sep/08/congo-mass-rape-500-khare> DR Congo: UN mission chief concerned over violence in troubled North Kivu
<http://www.isria.com/RESTRICTED/D/2010/SEPTEMBER 24/23 September 2010 62.php>

92 Protests in Peru over Dam Irrigation and Hydroelectric Project Part of a Regional Picture

Military Implications:

Southern Command's Public Private Cooperation program should reach out to the concession holders and Peruvian government to encourage a long-term partnership that honors the rights of local citizens. This could include education and training in relevant civil-military issues so that, if and when called upon, they can be effective immediately.

Sources:

Have the climate wars begun?

<http://www.guardian.co.uk/global-development/poverty-matters/2010/sep/21/climate-wars-machu-picchu-irrigation>

Cusco joins Espinar strike against Majes-Siguas project

<http://www.livinginperu.com/news-13201-outside-of-lima-peru-cusco-joins-espinar-strike-against-majes-siguas-project>

93 The Battle for Rare Earth Elements Continues

Military Implications:

[Similar to previous on this issue] Accelerated R&D for substitutes should be encouraged. One can reasonably ask whether the Chinese actions are a market aggression test to determine how far they can press their rare earth mineral resource advantages.

Sources:

China Seizes Rare Earth Mine Areas

<http://www.nytimes.com/2011/01/21/business/global/21rare.html>

Rare Earth Metals Leave Toxic Trail to Toyota, Vestas

<http://www.businessweek.com/news/2011-01-06/rare-earth-metals-leave-toxic-trail-to-toyota-vestas.html>

Japan deep-sea robots to seek minerals: report

<http://www.physorg.com/news/2011-01-japan-deep-sea-robots-minerals.html>

94 Chinese Rare Earth Restrictions

Military Implications:

Even though new sources for rare earths look promising, it would be wise to continue R&D for substitutes. One can reasonably ask whether the Chinese action is a market aggression test to determine how far they can press their rare earth mineral resource advantages. Sources:

Rare earths. Digging in. China restricts exports of some obscure but important commodities <http://economist.com/node/16944034>

The Application of Rare Earth Metals is Widening Despite Lack of Engineering Data

<http://www.docstoc.com/docs/5379510/rare-earth-elements>

New Deposits of Rare Earths Ores in Tanzania Substitute for China?

<http://agmetalminer.com/2010/04/08/new-deposits-of-rare-earths-ores-in-tanzania-substitute-for-china/>

95 China Applies for Seabed Mining Permit in Search for New Mineral Resources

Military Implications:

New regulations for these minerals and their exploitation are likely. Increased attention should be given to R&D for substitutions for these rare earths to reduce future likelihood for tensions over their access.

Sources:

Rush On for 'Rare Earths' as U.S. Firms Seek to Counter Chinese Monopoly

<http://www.nytimes.com/gwire/2010/07/23/23greenwire-rush-on-for-rare-earths-as-us-firms-seek-to-co-58814.html>

Deep-sea mining adds to fears of marine pollution

<http://www.independent.co.uk/environment/nature/deepsea-mining-adds-to-fears-of-marine-pollution-2016292.html>

96 China to Build Support Base for Seabed Exploration Military and Related Security Implications:

Rising interest in exploitation of deep sea resources triggers new types of environmental and security concerns. While deep-sea mining is an old concept, development of technologies and economics of resource shortage now raise this to the level of an emerging national security issue worthy of study. New regulations for deep-sea activities are likely. This is an opportunity to promote collective security, sharing of future benefits, and creating an international response system for deep-sea operations, as well as a topic of resource security.

Source:

China builds base to tap deep-sea energy: state media <http://www.physorg.com/news202104598.html>

1 Arctic and South China Sea Resource Issues Causing U.S. to Review Law of the Sea

Military Implications:

It is likely that the debates concerning rights to resources in the South China Sea, polar regions, and other maritime areas will increase rapidly. This opens the potential for new military roles in those regions to ensure the safety of individuals and ecosystems. While the U.S. is "prioritizing" the Law of the Seas ratification, relevant military and security personnel should increase cooperation with international counterparts to develop policies to reduce and/or manage tensions in these potential resources-conflict areas. Sources:

Joint Statement of the 2ND U.S.- ASEAN Leaders Meeting

<http://www.whitehouse.gov/the-press-office/2010/09/24/joint-statement-2nd-us-asean-leaders-meeting>

Remarks by Secretary Gates at ASEAN Defense Ministers Meeting Plus

<http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4700>

Secretary Clinton: Remarks on Innovation and American Leadership to the Commonwealth Club

<http://www.state.gov/secretary/rm/2010/10/149542.htm>

Arctic Debate

Military Implications:

[Same as others on related issues] The military should identify all its resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources:

99 September 2010

Putin identifies Russia's priorities in Arctic

<http://www.itar-tass.com/eng/level2.html?NewsID=15522974&PageNum=0>

Russia to draw up new Arctic atlas

<http://en.rian.ru/science/20100922/160679591.html>

The Arctic: Territory of Dialogue

<http://www.arctic.ru/>

Northeast Passage and Maritime Security

<http://blog.usni.org/2010/09/03/northeast-passage-and-maritime-security/>

Ninth Conference of Parliamentarians of the Arctic Region, European Parliament, Brussels, 13-15 September 2010. CONFERENCE STATEMENT

<http://www.europarl.europa.eu/euarcic/>

9th Conference of Artic Parliamentarians, European Parliament, Brussels, Belgium <http://www.europarl.europa.eu/arcticparl/>

100 Literature Addressing Arctic Security Military Implications:

Military and security personnel associated with the Arctic should review these reports for conflict prevention and support to police implications.

Sources:

Global action needed to conserve Arctic biodiversity

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=649&ArticleID=6800&l=en&t=long>

Protecting Arctic Biodiversity: Limitations and strengths of environmental agreements

<http://www.grida.no/publications/arctic-biodiversity/>

The Arctic Sea Competition and Key Strategic Challenges for Europe (Part One)

<http://www.sldinfo.com/?p=11635>

Arctic terror threats real: security agencies

<http://www.cbc.ca/canada/north/story/2010/11/10/cp-arctic-security-threats.html>

Climate change a top fear in North: report

<http://www.cbc.ca/canada/north/story/2010/11/16/arctic-security-conference-board.html>

Natural Disasters and Scientific Evidence

Scientific Evidence and Potential Consequences

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources (listed by month):

103 January 2011

It's Official: 2010 in a Statistical Tie for Warmest Year On Record

<http://www.climatecentral.org/news/its-official-2010-in-a-statistical-tie-for-warmest-year-on-record/> 2010 equals record for world's warmest year

[http://www.wmo.int/pages/mediacentre/press releases/pr 906 en.html](http://www.wmo.int/pages/mediacentre/press_releases/pr_906_en.html)

Killer year caps deadly decade - reducing disaster impact is "critical" says top UN disaster official

<http://www.unisdr.org/news/v.php?id=17613>

Overall picture of natural catastrophes in 2010 - Very severe earthquakes and many severe weather events

[http://www.munichre.com/en/media relations/press releases/2011/2011 01 03 press release.aspx](http://www.munichre.com/en/media_relations/press_releases/2011/2011_01_03_press_release.aspx)

Natural disasters 'killed 295,000 in 2010

<http://news.brisbanetimes.com.au/breaking-news-world/natural-disasters-killed-295000-in-2010-20110104-19e06.html>

Mapping the impacts of natural hazards and technological accidents in Europe'

<http://www.eea.europa.eu/publications/mapping-the-impacts-of-natural>

Disasters in Europe: more frequent and causing more damage

http://www.eea.europa.eu/highlights/natural-hazards-and-technological-accidents?utm_source=EEASubscriptions&utm_medium=RSSFeeds&utm_campaign=Generic

104 December 2010

Near record temperatures in 2010 to be followed by cooler 2011

<http://www.metoffice.gov.uk/corporate/pressoffice/2010/pr20101202b.html> 2010 sets new temperature records

<http://www.bbc.co.uk/news/science-environment-11903397>

How Will We Know if 2010 Was the Warmest Year on Record?

<http://www.climatecentral.org/news/tracking-the-temperature-of-a-warming-planet/>

Warmest November on Record, NASA Data Shows

<http://www.climatecentral.org/blog/warmest-november-on-record-nasa-data-shows/>

Climate Vulnerability Monitor 2010 report

<http://daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2010/>

Climate change effects vary widely between rich and poor countries

http://www.contracostatimes.com/environment/ci_16947877?nclick_check=1

Global Climate Risk Index 2011

<http://www.germanwatch.org/klima/cri.htm>

105 November 2010

Flood-Devastated Benin Requests Millions for Emergency Aid

<http://www.circleofblue.org/waternews/2010/world/africa/flood-devastated-benin-requests-millions-for-emergency-aid/>

Benin suffers worst floods since 1963

<http://www.guardian.co.uk/world/2010/oct/25/benin-worst-floods-since-1963>

Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention

<http://www.gfdrr.org/gfdrr/node/281>

106 October 2010

Warmer Arctic Probably Permanent, Scientists Say <http://planetark.org/wen/59961>

107 September 2010

Medvedev's Climate Moment

<http://www.themoscowtimes.com/mobile/article/413772.html> (Subscription required)

Record Heat Spawns Stronger Hurricanes Over Atlantic

<http://www.sfgate.com/cgi-bin/article.cgi?f=/g/a/2010/09/21/bloomberg1376-L91WX91A74E901-7919GG82QU9A38LTC82K8LVE8S.DTL>

National Hurricane Center

<http://www.nhc.noaa.gov/2010atlan.shtml>

108 August 2010

Global warming signs unmistakable: report

<http://www.cbc.ca/technology/story/2010/07/29/climate-change-study-noaa.html>

WMO Information on Current Extreme Events:

http://www.wmo.int/pages/mediacentre/news/extremeweathersequence_en.html

Climate change responsible for floods: experts

<http://www.dawn.com/wps/wcm/connect/dawn-content-library/dawn/the-newspaper/front-page/climate-change-responsible-for-floods-experts-380>

China's Heavy Rains Blamed on Unusual Climate Patterns

<http://www.voanews.com/english/news/Chinas-Heavy-Rains-Blamed-on-Unusual-Climate-Patterns-101458654.html>

Extreme hot, cold waves torturing world

<http://english.peopledaily.com.cn/90001/90777/90852/7088455.html> 109 July 2010

Coral reefs suffer mass bleaching

<http://www.telegraph.co.uk/earth/earthnews/7896403/Coral-reefs-suffer-mass-bleaching.html>

Ocean Warming Slows Coral Growth in the Central Red Sea

http://www.sciencemag.org/cgi/content/abstract/sci;329/5989/322?maxtoshow=&hits=10&RESULT_FORMAT=&fulltext=Red+Sea+coral&searchid=1&FIRSTINDEX=0&resourceType=HWCIT

Plankton, base of ocean food web, in big decline

http://news.yahoo.com/s/ap/20100728/ap_on_sc/us_sci_declining_plankton

Migration Triggered by Environmental Causes

Climate Refugees Trends

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources:

112 December 2010

UN High Commissioner Guterres welcomes breakthrough Mexico legislation on international protection

<http://www.unhcr.org/4d025bb66.html>

On the move in a warming world: The rise of climate refugees

<http://www.theglobeandmail.com/news/world/africa-mideast/on-the-move-in-a-warming-world-the-rise-of-climate-refugees/article1843024/page1/>

World Migration Report 2010

http://publications.iom.int/bookstore/free/WMR_2010_ENGLISH.pdf

113 November 2010

Kiribati's Tarawa Climate Change Conference (TCCC) <http://www.climate.gov.ki/tarawa> climate change conference.html

114 August 2010

Climate Change Displaced Persons Convention Project

<http://www.ccdpconvention.com/index.html> (see FAQ)

If a Country Sinks Beneath the Sea, Is It Still a Country?

<http://www.nytimes.com/cwire/2010/08/23/23climatewire-if-a-country-sinks-beneath-the-sea-is-it-sti-70169.html?ref=earth>

South Pakistan floods displace a million in 48 hours

<http://www.bbc.co.uk/news/world-south-asia-11105661>

Pakistan -- a Sad New Benchmark in Climate-Related Disasters

<http://www.nytimes.com/cwire/2010/08/18/18climatewire-pakistan—a-sad-new-benchmark-in-climate-re-4283.html> (article accessible free for a limited time; full text in the Appendix)

115 July 2010

Urgent Action Needed for Pastoralists to Cope with Climate Change

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=628&ArticleID=6634&l=en&t=long>

Security in Mobility Launch: Key Note Address: Mr. Mark Bowden, HC for Somalia

<http://ochaonline.un.org/OchaLinkClick.aspx?link=ocha&docId=1165384>

Greater Horn of Africa: EU Commission allocates € 20 million to support 12 million victims of recurrent droughts

http://europa-eu-un.org/articles/en/article_9879_en.htm

Migratory Responses to Agricultural Risk in Northern Nigeria.

IFPRI Discussion Paper 01007

<http://www.ifpri.org/sites/default/files/publications/ifpridp01007.pdf>

116 Renewed Protection for Refugees in Latin America

Military Implications:

SOUTHCOM and other military and security personnel in Latin America should consider the implications of future increasing environmental refugees in light of the principles stipulated in the Declaration, when designing security strategies.

Sources:

Latin America nations pledge more for the protection of the displaced and stateless

<http://www.unhcr.org/4cdd4dc09.html>

UN lauds Latin America's declaration on refugee protection

<http://www.globalsecurity.org/military/library/news/2010/11/mil-101112-unnews01.htm>

Brasilia Declaration on the Protection of Refugees and Stateless Persons in the Americas

<http://www.unhcr.org/4cdd3fac6.html>

Melting Sea Ice and Glaciers

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources:

118 January 2011

2010 equals record for world's warmest year

[http://www.wmo.int/pages/mediacentre/press releases/pr_906 en.html](http://www.wmo.int/pages/mediacentre/press_releases/pr_906_en.html)

Greenland's ice feels the heat in record-setting 2010

<http://www.nytimes.com/cwire/2011/01/21/21climatewire-greenlands-ice-feels-the-heat-in-record-sett-93789.html>

119 December 2010

Antarctic Melting as Deep Ocean Heat Rises

<http://news.discovery.com/earth/antarctica-melting-warming-penguins-101214.html>

120 August 2010

Greenland glacier calves island 4 times the size of Manhattan, UD scientist reports

<http://www.udel.edu/udaily/2011/aug/greenland080610.html>

Greenland's giant island of ice could pose threat to offshore platforms, shipping

<http://www.winnipegfreepress.com/world/breakingnews/greenlands-giant-island-of-ice-could-pose-threat-to-offshore-platforms-shipping-100369689.html>

Borehole network confirms, permafrost is thawing worldwide

<http://thearticsounder.com/article/1032borehole network confirms permafrost is>

Food and Freshwater

Food Scarcity Issues

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources: (Listed by month in reverse chronological order)

123 January 2011

Global Risk 2011

<http://riskreport.weforum.org/>

Extreme Weather Helps Drive Up Food Prices

<http://green.blogs.nytimes.com/2011/01/05/extreme-weather-sends-food-prices-soaring/?partner=rss&emc=rss>

Policy guide for countries hit hard by high food prices

<http://www.fao.org/news/story/en/item/49954/icode/>

Authoritarian governments start stockpiling food to fight public anger

<http://www.telegraph.co.uk/news/worldnews/middleeast/8288555/Authoritarian-governments-start-stockpiling-food-to-fight-public-anger.html>

Indonesia's President says food security must be G20 priority

<http://www.google.com/hostednews/afp/article/ALeqM5gmhg0nKzrqDTGK9ww6o9bUkohyGQ?docId=CNG.7cf561b86d25fb9fcfc035de4e9a829a.f1>

124 August 2010

African nations dominate Maplecroft's new Food Security Risk Index - China and Russia will face challenges

<http://www.maplecroft.com/about/news/food-security.html>

125 December 2010

Agriculture Must Play Key Role In Climate Solutions

<http://go.worldbank.org/3SYJZL2PN0>

World leaders announce roadmap for action on agriculture, food security and climate change

<http://www.agricultureday.org/blog/index.php?p=423>

African Farmers Displaced as Investors Move In

<http://www.nytimes.com/2010/12/22/world/africa/22mali.html?nl=todaysheadlines&emc=a22>

Africa mulls biofuels as land grab fears grow

<http://www.reuters.com/article/idUSTRE6AT3ZE20101130>

Food security, farming, and climate change to 2050

<http://www.ifpri.org/publication/food-security-farming-and-climate-change-2050>

126 November 2010

The United Nations had previously projected that grain yields would grow 1.2% this year.

Food Outlook report

<http://www.fao.org/docrep/013/al969e/al969e00.pdf> One trillion food import bill as prices rise

<http://www.fao.org/news/story/en/item/47733/icode/>

World 'Dangerously Close' to Food Crisis, U.N. Says

<http://green.blogs.nytimes.com/2010/11/24/world-dangerously-close-to-food-crisis-u-n-says/>

It's Down 2 Earth - Global Conference on Agriculture, Food Security and Climate Change

<http://www.iisd.ca/ymb/afcconference>

Global Conference on Agriculture, Food Security and Climate Change

<http://www.afccconference.com/>

Roadmap for Action

<http://www.afcconference.com/final-roadmap-for-action> FAO site on climate-smart agriculture

<http://www.fao.org/climatechange/climatesmart/en/>

127 October 2010

State of Food Insecurity in the World

<http://www.fao.org/publications/sofi/en/>

Long-term crises keep 22 nations in hunger trap - FAO

http://www.alertnet.org/db/an_art/57964/2010/09/7-120439-1.htm

Farmers Hurt As Pressure On Arable Land Grows: U.N.

<http://planetark.org/wen/59953>

128 September 2010

925 million in chronic hunger worldwide

<http://www.fao.org/news/story/en/item/45210/icode/>

Food price volatility a major threat to food security

<http://www.fao.org/news/story/en/item/45690/icode/>

Food Commodities Speculation and Food Price Crises

http://www.srfood.org/images/stories/pdf/otherdocuments/20102309_briefing_note_02_en.pdf ActionAid report

"Who's really fighting hunger?"

<http://www.actionaid.org/assets/pdf/ActionAid-scorecard-report-2010.pdf>

The UK Food Group meeting- Securing Future Food

[http://www.ukfg.org.uk/docs/Securing Future Food Draft Agenda.pdf](http://www.ukfg.org.uk/docs/Securing%20Future%20Food%20Draft%20Agenda.pdf)

UN warned of major new food crisis at emergency meeting in Rome

<http://www.guardian.co.uk/environment/2010/sep/24/food-crisis-un-emergency-meeting-rome>

As food prices jump, UN group tries to avoid fuelling new crisis

<http://www.theglobeandmail.com/globe-investor/potash/rising-food-prices-key-to-battle-for-potash-corp/article1697548/>

Rising Global Interest in Farmland: Can It Yield Sustainable and Equitable Benefits? Report

<http://siteresources.worldbank.org/INTARD/Resources/ESW Sept7 final final.pdf>

New World Bank Report Sees Growing Global Demand for Farmland. Risks and Opportunities for the Developing World

<http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22694767~pagePK:64257043~piPK:437376~theSitePK:4607,00.html>

Take Action to Stem Risks of Overseas Agriculture Investments, Warn Groups
<http://ictsd.org/i/news/biores/84541/>

129 August 2010

Hotter nights threaten food security - rice at risk

<http://www.fao.org/news/story/en/item/44618/icode/>

Chinese soil experts warn of massive threat to food security

<http://www.scidev.net/en/news/chinese-soil-experts-warn-of-massive-threat-to-food-security.html>

Russian Export Ban Raises Global Food Fears

<http://online.wsj.com/article/NA WSJ PUB:SB 100014240527487037489045754107406175125 92.html>

Putin bans Russia grain exports due to drought

<http://news.yahoo.com/s/afp/20100805/tsafp/russiaheatwavefiresfarmcropscommoditiesgrain 2 0100805162243>

The Food Security and Climate Change in Dry Areas meeting

<http://www.icarda.org/Announcement/2009/IntlConfrnc FoodSecurity/FoodSecurityAndClimate ChangeInDryAreas 2009.htm>

Food security and climate change in dry areas: Abstracts (En)

<http://icardablog.wordpress.com/2010/07/20/food-security-and-climate-change-in-dry-areas-abstracts-en/>

130 Food Security Threatened by Diminishing Low-Cost Phosphorus

Military Implications:

Phosphorus use, conservation, and long-term supply should be added to long-term strategic studies and programs for management of scarce materials and resources for conflict prevention.

Sources:

Elemental Shortage

<http://www.the-scientist.com/article/display/57777/>

The Story of Phosphorus: Sustainability implications of global phosphorus scarcity for food security

<http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-53430>

Freshwater Scarcity Issues

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources: (Listed by month in reverse chronological order)

132 December 2010

UAE-GCC SUMMIT: Abu Dhabi Water Declaration calls for adoption of modern farming technologies

http://ipsnotizie.it/wam_en/news.php?idnews=7963

UAE leads water security agenda

<http://www.thenational.ae/news/uae-news/environment/uae-leads-water-security-agenda>

Abu Dhabi Water Declaration calls for adoption of modern farming technologies

<http://www.uaeinteract.com/docs/Abu Dhabi Water Declaration calls for adoption of modern farming technologies/43642.htm>

Managing Blue Gold: New Perspectives on Water Security in the Levantine Middle East

<http://www.upi-fiaa.fi/en/publication/154/managing-blue-gold/>

Managing Blue Gold: New Perspectives on Water Security in the Levantine Middle East-Launching event highlight

<http://www.upi-fiaa.fi/en/event/317/>

Water as a Strategic Resource in the Middle East

<http://csis.org/publication/clear-gold>

133 November 2010

New atlas shows Africa's vulnerable water resources in striking detail

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=651&ArticleID=6843&l=en&t=long>

Africa Water Atlas

<http://na.unep.net/atlas/africaWater/book.php>

134 October 2010

ADB: Asia Needs \$8 Billion Annual Investment In Water

<http://planetark.org/wen/59839>

135 September 2010

The paper "Water Storage in an Era of Climate Change: Addressing the Challenge of Increasing Rainfall Variability"

[http://www.iwmi.cgiar.org/Publications/Blue Papers/PDF/Blue Paper 2010-final.pdf](http://www.iwmi.cgiar.org/Publications/Blue%20Papers/PDF/Blue%20Paper%202010-final.pdf)

136 July 2010

Water Issues between Nepal, India & Bangladesh.

IPCS paper

[http://www.ipcs.org/pdf file/issue/SR95.pdf](http://www.ipcs.org/pdf%20file/issue/SR95.pdf)

Water Dispute Increases India-Pakistan Tension

<http://www.nytimes.com/2010/07/21/world/asia/21kashmir.html>

India-Pakistan water treaty poised to burst

<http://www.theglobeandmail.com/news/world/asia-pacific/india-pakistan-water-treaty-poised-to-burst/article1652763/>

UN humanitarian chief: 10 million in Africa's drought-stricken Sahel hungry, need help

[http://www.google.com/hostednews/canadianpress/article/ALeqM5jeg5Eoxjn-ivdeZ-vjPDAla RTNA](http://www.google.com/hostednews/canadianpress/article/ALeqM5jeg5Eoxjn-ivdeZ-vjPDAlaRTNA)

Health

Potential Impacts of Climate Change

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources: (Listed by month in reverse chronological order)

139 January 2011

Animal Migration and Infectious Disease Risk. Science 331, 6015: pp. 296-302

<http://www.sciencemag.org/>

Changes in wildlife migration could alter disease risk

<http://www.scidev.net/en/agriculture-and-environment/news/changes-in-wildlife-migration-could-alter-disease-risk.html>

140 November 2010

Geneva consultation on Essential Public Health Package to Enhance Climate Resilience in Least Developed Countries

http://www.who.int/globalchange/mediacentre/events/2010/geneva_consultation_07092010/en/in dex.html

Essential Public Health Package, Consultation Report

http://www.who.int/globalchange/mediacentre/events/2010/EssentialPublicHealthPackage_September_2010_Consultation_Meeting_Report.pdf

141 August 2010

Country experiences of assessing health implications of climate change

<http://climatehealth.wordpress.com/2010/08/04/country-experiences-on-assessing-health-implications-of-climate-change/>

142 UNEP Study on Inter-Linkages of Climate Change, POPs, and Human Health

Military Implications:

The impact of climate change on releasing potentially toxic chemicals might trigger new international discussions on disclosure and accelerating the cleanup of POP sites, including military bases and/or abandoned weapons. [See CCW Protocol Von Explosive Remnants of War Entered into Force in November 2006 environmental security report.] Sources:

Climate change increases vulnerability of planet to Persistent Organic Pollutants

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=653&ArticleID=6862&l=en>

Climate Change Increases Planet's Vulnerability to Persistent Organic Pollutants

<http://chm.pops.int/Convention/Media/Pressreleases/UNFCCCOP16ClimateChangeCancun7Dec2010/tab id/1269/language/en-US/Default.aspx>

Energy Security

144 Scientists Create 20-Year Roadmap for Nuclear Energy

Military Implications:

Military and related security personnel should assess this nuclear roadmap for possible contributions to increasing and/or decreasing the potential for hijacking of nuclear material, as well as improved and safer recycling of nuclear waste and related security issues. A new regulation-inspection-compliance regime would be required and have to be enforced (involving national security decision-makers).

Sources:

Scientists call for a global nuclear renaissance in new study

<http://www.physorg.com/news200842486.html>

Experts say federal nuclear waste panel overlooks public mistrust

<http://www.physorg.com/news200842407.html>

145 World Energy Outlook 2010

Military Implications:

WEO-2010 deserves careful study because it provides insights into the potential evolution of the current energy system and thus world energy security, as well as policies and alternatives for a more energy-efficient society.

Source:

World Energy Outlook 2010

<http://www.worldenergyoutlook.org/>

146 China is Now the Largest Energy Consumer in the World

Military Implications:

This milestone in China's energy consumption is a warning to relevant military personal to explore a full range of military-to-military options with China for improved environmental security. Sources:

China overtakes the United States to become world's largest energy consumer

http://www.iea.org/index_info.asp?id=1479

Global carbon emissions steady for first time since 1992

<http://www.guardian.co.uk/environment/2010/jul/01/emissions-recession>

No growth in total global CO2 emissions in 2009

<http://www.pbl.nl/en/publications/2010/No-growth-in-total-global-CO2-emissions-in-2009.html>

Climate change biggest restriction on China's development -economist

http://www.alertnet.org/db/an_art/60714/2010/06/9-162342-1.htm

147 Nordic Countries to Support Mekong Energy and Environment Partnership

Military Implications:

The Energy and Environment Partnership can also be used for confidence building and conflict prevention in the vulnerable Mekong region. Although at present this is an exclusively Nordic project, U.S. environmental organizations should investigate to determine if they could usefully participate in this cooperative effort.

Source:

Finland to provide clean-up solutions for environment

<http://vietnamnews.vnagency.com.vn/Environment/203445/Finland-to-provide-clean-up-solutions-for-environment.html>

148 Coal-fired Power Plants under Fire

Military Implications:

Military bases dependent on coal-fired plants should review their energy requirements in light of these policy changes that could close coal plants earlier than expected and raise costs.

Sources:

Analysis: Toxic Fish Could Help Obama Hit 2020 Climate Goals

<http://planetark.org/wen/58929> (This site may require a subscription.)

Senator Milne said this could be achieved by 2030 with the right preparation and infrastructure. Greens say coal must go

<http://www.smh.com.au/federal-election/climate/greens-say-coal-must-go-20100724-10pmh.html>

Prevention and Adaptation

Military Implications:

[Same as other on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources: (Listed by month in reverse chronological order)

150 December 2010

Latin America and the Caribbean: Atlas of our Changing Environment

http://www.cathalac.org/lac_atlas/

New atlas maps future of the environment in Latin America and Caribbean

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=653&ArticleID=6867&l=en&t=long>

Economics of Climate Change in Latin America and the Caribbean

<http://www.eclac.cl/cgi-bin/getProd.asp?xml=/publicaciones/xml/9/41909/P41909.xml&xsl=/dmaah/tpl-i/p9f.xsl&base=/dmaah/tpl/top-bottom.xsl>

Climate Change Is Expected to Cost Latin American Countries at Least 1% of Annual GDP

<http://www.eclac.org/cgi-bin/getProd.asp?xml=/prensa/noticias/comunicados/7/41947/P41947.xml&xsl=/prensa/tpl-i/p6f.xsl&base=/tpl-i/top-bottom.xsl>

Climate change to trim Latin America growth: UN

<http://news.yahoo.com/s/afp/20101208/scafp/unclimatewarminglatam>

151 November 2010

Guiding principles for adaptation to climate change in Europe ETC/ACC Technical Paper 2010/6 <http://air-climate.eionet.europa.eu/reports/>

ITU Symposium on ICTs and the Environment & Climate Change

<http://www.itu.int/ITU-T/worksem/climatechange/201011/>

152 October 2010

UNISDR urges mayors and citizens to decrease disaster losses

http://www.unisdr.org/preventionweb/files/15810_2010no24.pdf

UN Secretary-General's Message on International Day for Disaster Reduction

<http://www.un.org/News/Press/docs/2010/sgsm13175.doc.htm>

Parliamentarians urged to take action on disaster reduction

<http://www.unisdr.org/news/v.php?id=15724>

UNECA Press Release on the Opening Plenary

http://unecea.org/eca/resources/Press Releases/2010_pressreleases/pressrelease7010.html

UNEP Press Release

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=649&ArticleID=6781&l=en&t=long>

UN Press Release

[http://www.un.org/apps/news/story.asp?NewsID=36467&Cr=climate+change&Cr1 =](http://www.un.org/apps/news/story.asp?NewsID=36467&Cr=climate+change&Cr1=)

Forum Website

<http://www.uneca.org/adfvii/>

153 September 2010

UNESCAP Press Release: <http://www.unescap.org/unis/press/2010/sep/g39.pdf> World Disasters Report 2010 - Is urban the new rural? <http://www.ifrc.org/publicat/wdr2010/index.asp>

154 August 2010

Economics of Adaptation to Climate Change

<http://beta.worldbank.org/content/economics-adaptation-climate-change-study-homepage>

Synthesis Report on the Economics of Adaptation to Climate Change Study

http://siteresources.worldbank.org/EXTCC/Resources/EACC_FinalSynthesisReport0803_2010.pdf

UN Decade for Deserts and the Fight Against Desertification Website

<http://unddd.unccd.int>

UN launches decade-long drive to combat desertification

[http://www.un.org/apps/news/story.asp?NewsID=35633&Cr=desert&Cr1 =](http://www.un.org/apps/news/story.asp?NewsID=35633&Cr=desert&Cr1=)

UN Secretary-General's High-level Panel on Global Sustainability

<http://www.un.org/wcm/content/site/climatechange/pages/gsp>

Pacific Platform 2010

<http://www.pacificdisaster.net:8080/Plone/pacific-platform-2010#section-2>

UNDP Pacific Centre Press Release

<http://www.undppc.org.fj/pages.cfm/newsroom/press-releases/2010/pacific-partnering-with-caribbean-better-mitigation-of-natural-disasters-climate-change-.html>

155 July 2010

World Investment Report 2010

<http://www.unctad.org/Templates/WebFlyer.asp?intItemID=5535&lang=1>

Reports on Sustainability and Climate Change

Military Implications:

Military personnel with sustainability and climate change responsibilities should review these reports for potential applications.

Sources:

157 July 2010

The Business of Sustainability

<http://sloanreview.mit.edu/special-report/the-business-of-sustainability/>

The Business of Sustainability - Findings from the first annual survey and interview project

<http://www.mitsmr-ezine.com./busofsustainability/2009#pg1>

Informing an Effective Response to Climate Change

http://www.nap.edu/catalog.php?record_id=12784

158 FAO Launches Global Fire Information Management System

Military Implications:

The GFIMS system could help save lives and livelihoods and reduce environmental disasters caused by fire, thus reducing factors that could lead to, or exacerbate conflict situations. Relevant military and security personnel involved in environmental security operations should ensure that they are making full use of GFIMS's capabilities. Sources:

Poor to benefit from global fire monitoring system

<http://www.scidev.net/en/news/poor-to-benefit-from-global-fire-monitoring-system.html>

GFIMS: <http://www.fao.org/nr/gfims/gf-home/en/>

159 New Global Land Cover Maps

Military implications:

These maps could be useful in identifying future environmental hotspots and other issues of environmental security.

Sources:

European Space Agency and the Belgian Universite Catholique de Louvain

<http://ionia1.esrin.esa.int/>

ESA's GlobCorine project

<http://ionia1.esrin.esa.int/globcorine/>

Atlas on the state of the environment in Latin America and the Caribbean

http://www.cathalac.org/lac_atlas/

on-line National Atlas of the U.S.

<http://nationalatlas.gov/>

Climate Modeling

Military Implications:

[Same for all on similar issues] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change. Sources:

161 January 2011

Climate change to Continue to Year 3000 in Best Case Scenarios, Research Predicts

<http://www.sciencedaily.com/releases/2011/01/110109184025.htm>

Ongoing climate change following a complete cessation of carbon dioxide emissions

<http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo1047.html>

162 July 2010

The Future Climate for Development

<http://www.forumforthefuture.org/projects/the-future-climate-for-development> Low carbon, high hopes

<http://blogs.dfid.gov.uk/2010/07/low-carbon-high-hopes/>

163 October 2010

Drought may threaten much of globe within decades

<http://www2.ucar.edu/news/climate-change-drought-may-threaten-much-globe-within-decades>

NOAA's Palmer Drought Severity Index

<http://www.drought.noaa.gov/palmer.html>

Scenarios

165 July 2010

The Future Climate for Development

<http://www.forumforthefuture.org/projects/the-future-climate-for-development>

C. Protecting the Environment Due to Its Inherent Moral Value

Environmental Security-Related International Regulations That Have Been or Are Close To Coming into Force since July 2010

Broad Environmental Aspects

169 Progress on International Environmental Governance

Military Implications:

Military personnel with international environmental responsibilities should seek collaboration with the Consultative Group to ensure that security concerns are included in the most effective way in the new international environmental governance reform proposals. Sources:

First Meeting of the Consultative Group, Nairobi 7-9 July 2010

<http://www.unep.org/environmentalgovernance/Introduction/GCfeb2010/tabid/4556/language/en-US/Default.aspx>

The Co-Chairs' Summary and Roadmap

<http://www.unep.org/environmentalgovernance/Introduction/GCfeb2010/tabid/4556/language/en-US/Default.aspx>

170 The Protocol on Strategic Environmental Assessment to the UNECE Espoo Convention Entered into Force on July 11, 2010

Military Implications:

Relevant military personnel stationed in Europe should review the new SEA Protocol requirements for specific implications for planning new activities and projects. Source:

Protocol on Strategic Environmental Assessment (Kyiv, 2003)

<http://www.unece.org/env/eia/sea protocol.htm>

1 Repository of Multilateral Environmental Agreements

Military Implications:

The book provides a comprehensive tool for legal practitioners and all those who are using MEAs in their work.

Sources:

Multilateral Environmental Agreements. State of Affairs and Developments 2010
<http://www.isbs.com/partnumber.asp?cid=28591&pnid=326458>

Biodiversity

173 New International Mechanisms Adopted for Protection of Biodiversity

Military Implications:

[Similar to previous on this issue] Increased coherence among biodiversity agreements, UN-related bodies, and capacity building should lead to greater attention being paid to biodiversity impacts of military training and other operations. Military liaisons should explore opportunities for cooperation and applications of the Army Strategy for the Environment as this integration evolves with monitoring and enforcement organizations. Also, military and other security personnel should anticipate increased international adherence to the concept of calculating the environmental footprint and an increased number of protected regions.

Sources:

COP 10 Outcomes

<http://www.cbd.int/nagoya/outcomes/>

Nagoya biopiracy agreement 'is unexpected success'

<http://www.scidev.net/en/agriculture-and-environment/indigenous-knowledge/news/nagoya-biopiracy-agreement-is-unexpected-success-.html>

No to Geo-Engineering: UN Issues a Moratorium on Efforts to Manipulate the Earth's Climate

[http://www.alternet.org/environment/148768/no to geo-engineering](http://www.alternet.org/environment/148768/no-to-geo-engineering) UN issues a moratorium on efforts to manipulate the earth's climate

Research into the possibility of engineering a better climate is progressing at an impressive rate—and meeting strong opposition

<http://www.economist.com/node/17414216>

Chemicals and other Hazardous Compounds

175 Amendments Adding Nine Chemicals to the Stockholm Convention Entered into Force

Military Implications:

[Similar to previous on this issue] Although the U.S. is not Party to the Stockholm Convention, since several of these POPs are widely used worldwide, it should be prepared to comply with the requirements when acting in countries Party. Thus, it should consider the military implications of the additional substance phaseouts and find replacements if necessary. Since interoperability among allies depends upon the harmony of acceptance of and compliance with international conventions, security organizations need to remain fully up-to-date on agreements on the status of chemicals, whether or not they or their state is Party to the Convention. Sources:

Entry into Force of the Amendments adding Nine Chemicals to the Stockholm Convention on Persistent Organic Pollutants on 26 August 2010

<http://chm.pops.int/default.aspx>

Amendments to global treaty launched to eliminate nine toxic chemicals

[http://www.pic.int/Press/Press release POPs Amendment EIF 2010.08.26 final.doc](http://www.pic.int/Press/Press%20release%20POPs%20Amendment%20EIF%202010.08.26%20final.doc)

176 Stockholm Convention on Persistent Organic Pollutants (POPs) Updated Military Implications:

The decisions from POPRC-6 should be studied by military and security personnel with responsibilities that include persistent organic pollutants in order to improvement their own procedures. [Similar to previous on this issue] Although the U.S. is not Party to the Stockholm Conventions, it should be prepared to comply with the requirements when acting in countries Party. Thus, such personnel should consider the implications of the new listing of these substances, and—if the cases require—find replacements.

Source:

Sixth Meeting of the Persistent Organic Pollutants Review Committee (POPRC6) to the Stockholm Convention on Persistent Organic Pollutants (POPs)

http://www.iisd.ca/vol_15/enb15176e.html

177 EU Parliament Adopts Restrictions on Nanoproducts

Military Implications:

Military operations in the EU area should be prepared to adjust procurement plans accordingly, to comply with the new decision. The EU decision could lead other countries to implement similar policies until health and environmental safety is assured.

Sources:

MEPs call for ban on food from cloned animals

http://www.europarl.europa.eu/news/expert/infopress_page/067-77912-186-07-28-911-20100706IPR77911-05-07-2010-2010-false/default_en.htm

European Environmental Bureau welcomes European Parliament's vote on nanofoods

http://www.nanowerk.com/news/newsid=17069.php?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+nanowerk%2FagWB+%28Nanowerk+Nanotechnology+News%29

178 Germany publishes criteria for substances of very high concern

Military Implications:

The military should familiarize itself with Germany's SVHC criteria to ensure Status of Forces Agreement compliance in Germany, while also continuing to monitor the European Chemicals Agency (ECHA) REACH SVHC authorization process, including prudent military procurement and R&D for safe substitutes.

Sources:

German risk institute publishes SVHC criteria

<http://chemi.calwatch.com/4742>

BfR criteria for the selection of candidate substances for the authorisation procedure under REACH

http://www.bfr.bund.de/cm/290/bfr_criteria_for_the_selection_of_candidate_substances_for_the_authorisation_procedure_under_reach.pdf

179 UN Resolution Acknowledges Access to Clean Water and Sanitation a Human Right

Military Implications:

Military-to-military personnel concerned with water-related causes of conflict should be made aware of this resolution to add justification to their continued or expanded operations. Although the resolution is voluntary, it gives a new rationale to all organizations, including peacekeeping and other military entities, to increase their efforts towards improving the water situation in the regions where they are stationed or are operating. The resolution increases the likelihood that actions by public and private security actors will be scrutinized more often and more thoroughly for their impact on water, up to and possibly including provoking charges of "aggression". Sources:

General Assembly Adopts Resolution Recognizing Access to Clean Water, Sanitation as Human Right, by Recorded Vote of 122 in Favor, None against, 41 Abstentions

<http://www.un.org/News/Press/docs/2010/ga10967.doc.htm>

General Assembly declares access to clean water and sanitation is a human right

<http://www.un.org/apps/news/story.asp?NewsID=35456&Cr=sanitation&Cr1>

180 UN Human Rights Council Affirms Right to Water as Legally-Binding

Military Implications:

Senior military personal should explore military roles in implementing this resolution to reduce water-related conflicts in the future. Military-to-military personnel concerned with water-related causes of conflict should be made aware of this resolution to add justification to their continued or expanded operations. Since the UN Human Rights Council resolution is binding, it gives a new rationale to all organizations, including peacekeeping and other military entities, to increase their efforts towards improving the water situation in the regions where they are stationed or are operating. The resolution increases the likelihood that actions by public and private security actors will be scrutinized more often and more thoroughly for their impact on water, up to and possibly including provoking charges of "aggression". Sources:

UN united to make the right to water and sanitation legally binding

<http://www.ohchr.org/en/NewsEvents/Pages/DisplayNews.aspx?NewsID=10403&LangID=E> 15/... Human rights and access to safe drinking water and sanitation. Human Rights Council Resolution A/HRC/15/L.14 (Sept. 24, 2010)

<http://daccess-dds-ny.un.org/doc/UNDOC/LTD/G10/163/09/PDF/G1016309.pdf?OpenElement> UN landmark decision: right to water and sanitation is legally binding <http://internationallawobserver.eu/2010/10/14/un-landmark-decision-right-to-water-and-sanitation-is-legally-binding>

181 European Parliament Resolution on Jordan River Water Management Reform

Military Implications:

Previous collaborations on water issues helped ameliorate conflict situations in several regions, including the Middle East. Environmental diplomacy and international military cooperation should be used to explore how to turn around the deterioration of the Jordan River and use this opportunity to further confidence and peace building. Additionally, military-civilian policy research is needed to clarify when intervention should be initiated to prevent or halt actions whose most likely result is inter-state or intra-state violence. Sources:

Situation of the Jordan River with special regard to the Lower Jordan River area:

<http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2010-0314&format=XML&language=EN>

European Parliament passes historic resolution in support of regional rehabilitation of the Lower Jordan River

http://foeme.org/www/?module=media_releases&record_id=85 Marine Environment

183 IMO MEPC Revises MARPOL, Addresses Emissions from Ships

Military Implications:

[Same as previous on this issue] Although emissions from military ships make up only a tiny fraction of this polluting source, the Navy should be prepared for new international anti-pollution regulations that may not exempt military craft.

Sources:

IMO Environment meeting discusses GHG measures for new ships

http://www5.imo.org/SharePoint/mainframe.asp?topic_id=1859&doc_id=13710 Revised

MARPOL Annex III adopted at IMO environment meeting

http://www5.imo.org/SharePoint/mainframe.asp?topic_id=1859&doc_id=13711

184 Chile Establishes 150,000 KM2 Protected Marine Reserve in Pacific

Military Implications:

Activities in and around the new reserve need to take pains to avoid infringing upon the sovereign waters and disturbing any of the local ecology.

Source:

Chile Creates Large Marine Reserve at Sala y Gomez Island

<http://blogs.nationalgeographic.com/blogs/news/chiefeditor/2010/10/chile-creates-large-marine-res.html>

185 Ecuador to Join the UN Convention on the Law of the Sea

Military Implications:

It is likely that Peru, another non-signatory of UNCLOS, will follow Ecuador regarding accession to the Convention, leaving only Venezuela in the Americas as a non-signatory, and making almost the entire Pacific coast Party to the Convention, with the exception of Colombia, El Salvador, and the U.S. Therefore, military organizations operating in this part of the Pacific should be prepared to comply with the UNCLOS requirements along the relevant coasts.

Source:

Ecuador anuncia adhesión a la Convemar (text in Spanish)

<http://andes.info.ec/politica/ecuador-anuncia-adhesion-a-la-convemar-23938.html>

New Technologies

187 Synthetic Biology Guidelines to Reduce Bioweapon Threats

Military Implications:

International military liaisons with security, health, and environmental responsibilities should be aware of these guidelines and share them with their counterparts to speed the day when international agreements are written to monitor and control synthetic biology.

Source:

Screening Framework Guidance for Providers of Synthetic Double-Stranded DNA

<http://www.phe.gov/Preparedness/legal/guidance/syndna/Documents/syndna-guidance.pdf>

188 The EU Strengthens Legislation to Counter Cybercrime

Military Implications:

Military personnel with cyber security expertise should be asked for their suggestions on creation of a global cybersecurity strategy, agreements, and enforcement measures. Such suggestions could be shared with military counterparts to begin the formulation of international military cybersecurity positions that could be used for future treaty negotiations.

Sources:

Commissioner concerned about cyber-attacks on WikiLeaks

<http://euobserver.com/9/31409/?rk=1>

Commission to boost Europe's defences against cyber-attacks

<http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/1239&format=HTML&aged=1&language=EN&guiLanguage=en>

For a more secure Europe

http://ec.europa.eu/news/external relations/101122_en.htm

Pollution

190 New EU Directive on Industrial Pollution

Military Implications:

Military and security personnel deployed in the EU and with work related to industrial plants should be prepared to comply with the new Directive within the provisions of Status of Forces Agreements. It is also fair to speculate that new regulations will be expanded to any relevant production areas. In the meantime, the BAT offers opportunities to introduce innovations in environmental technologies across operations and installations.

Sources:

EU adopts stricter rules on industrial emissions

[http://europa.eu/rapid/pressReleasesAction.do?
reference=IP/10/1477&format=HTML&aged=0&language=EN&guiLanguage=en](http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/1477&format=HTML&aged=0&language=EN&guiLanguage=en)

The IPPC Directive

<http://ec.europa.eu/environment/air/pollutants/stationary/ippc/summary.htm>

Waste Management

192 Kenya to Implement E-Waste Management Program

Military Implications:

AFRICOM should liaise with e-waste experts and this Kenyan initiative. It is reasonable to assume that Kenya's example will stimulate other African countries to create their own e-waste regulations; hence, military and security organizations along with their contractors should plan to have compatible e-waste procedures.

Source:

UNEP backs action on e-waste in East Africa

[http://www.unep.org/Documents.Multilingual/Default.Print.asp?
DocumentID=647&ArticleID=6744&l=en&WT.rssf=pr&WT.rssa=647-6744](http://www.unep.org/Documents.Multilingual/Default.Print.asp?DocumentID=647&ArticleID=6744&l=en&WT.rssf=pr&WT.rssa=647-6744)

Proposed Treaties and/or Changes to Existing Ones

Biological Diversity

195 Prosecution of Pillage of Natural Resources as War Crime

Military Implications:

Since "conflict minerals" pillage is more likely to occur in vulnerable or conflict areas, the military might be called upon to help enforce the relevant regulations locally, as well as to report and stop breaches. Additional training requirements should be explored for personnel likely to be deployed in such areas.

Sources:

Firms Linked to Conflict Minerals May Face Prosecution

['Conflict Mineral' Strategy Emerging
http://wardsauto.com/ar/conflict mineral strategy 101228/](http://www.ens-newswire.com/ens/jan2011/2011-01-03-02.html)

Digging In: Recent Developments on Conflict Minerals

<http://www.enoughproject.org/publications/digging-in-conflict-minerals>

Conflict minerals law could push prices higher - MSCI ESG

196 World's Humid Tropical Forests to Suffer Considerable Biodiversity Change by 2100

Military Implications:

The study might trigger new regional or international conservation regulations, as well as increased enforcement of the existing ones. In addition to preparedness, relevant military personnel should increasingly include biological diversity and conservation into construction, training, and operations planning and encourage military-to-military exchanges for the transfer of best practices in environmental sustainability. Security organizations, worldwide, should consider being ready to support calls for advice and assistance from countries with "humid tropical forests" which are unable to address threats to their biodiversity. Providing security aid in maintaining national sovereignty of the "forest state" may result in special challenges. Source:

Global Tropical Forests Threatened by 2100

http://carnegiescience.edu/news/global_tropical_forests_threatened_2100

197 Biosafety Regulations Reviewed in Context of Worrying Forecasts

Military Implications:

Increased coherence among biodiversity agreements, UN-related bodies, and capacity building should lead to greater attention being paid to biodiversity impacts of military training and other operations. Military liaisons should explore opportunities for cooperation and applications of the Army Strategy for the Environment as this integration evolves with monitoring and enforcement organizations. Also, military and other security personnel should anticipate increased adherence to the concept of calculating the environmental footprint internationally and an increased number of protected regions. Brazil and India have already stated they will integrate valuations of nature's services into their national economic frameworks, and the EU is prepared to support other developing nations who would like to do the same. Sources:

Fifth meeting of the Cartagena Protocol on Biosafety. 11-15 October, 2010

<http://www.iisd.ca/vol09/enb09528e.html>

Nagoya 2010: Report puts economic value of nature on the global political radar

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=649&ArticleID=6791&l=en>

Living Planet Report 2010

<http://www.footprintnetwork.org/press/LPR2010.pdf>

198 New Protected Areas Proposed in the Pacific

Military Implications:

Maps of these proposed areas should be reviewed for impacts on military operations.

Sources:

Blueprint to protect the future of Australia's oceans revealed

<http://www.physorg.com/news/2010-11-blueprint-future-australia-oceans-revealed.html>

Island nation announces Ukraine-sized sanctuary for whales and dolphins

[http://news.mongabay.com/2010/1024-hance mammal sanctuary.html](http://news.mongabay.com/2010/1024-hance-mammal-sanctuary.html)

Chemical and Biological Safety

200 International Biosecurity Initiative

Military Implications:

Military and security personnel with biosecurity-related responsibilities should review this legislation, follow its legislative progress, and explore its implications with their international counterparts for reducing the full range of international biosecurity threats and improving the use of nanosensor and other networks (some of which have been referenced in these monthly reports).

Sources:

Bill: To improve the international strategy of the United States for monitoring, reducing, and responding to biological risks, and for other purposes.

<http://www.govtrack.us/congress/bill.xpd?bill=h111-6297>

Bill Would Establish Global Biosecurity Body

http://gsn.nti.org/gsn/nw/20101005_4535.php

H.R. 5498: WMD Prevention and Preparedness Act of 2010

<http://www.govtrack.us/congress/bill.xpd?bill=h111-5498>

1 Synthetic Biology Guidelines to Reduce Bioweapon Threats

Military Implications:

International military liaisons with security, health, and environmental responsibilities should be aware of these guidelines and share them with their counterparts to speed the day when international agreements are written to monitor and control synthetic biology.

Source:

Screening Framework Guidance for Providers of Synthetic Double-Stranded DNA

<http://www.phe.gov/Preparedness/legal/guidance/syndna/Documents/syndna-guidance.pdf>

202 New Regulations for Chemicals in California

Military Implications:

It is fair to speculate that California's chemicals initiatives may set a precedent and be emulated by other states and at international levels. Military personnel with procurement responsibilities should monitor progress and

ensure compliance with pending regulations and be prepared for additional restrictions. Source:

California Issues New Green Chemistry Requirements for Consumer Products

<http://www.mofo.com/files/Uploads/Images/100915-Green-Chemistry-Requirements.pdf>

Copper in brake pads out to protect water, fish

<http://www.signonsandiego.com/news/2010/aug/28/copper-brake-pads-out-protect-water-fish/>

Greenhouse Gas Emissions

Post-Kyoto Protocol and Post-Copenhagen Negotiations

Military Implications:

[Same to all on this issue] The military should identify all resources and programs for reducing GHGs and responding to effects of climate change, update information continuously, forecast how it might be called upon for both mitigation and adaptation, and perform a gap analysis in anticipation of future requests. International discourse over climate change is increasing the development of international policies and strategies to mitigate and adapt to climate change.

Sources:

205 November 2010

Update on CO2 emissions. Nature Geoscience, 21 November 2010

doi:10.1038/ngeo1022

<http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo1022.html>

United Nations Climate Change Conference Cancun - COP 16 & CMP 6

<http://unfccc.int/2860.php>

206 October 2010

The current state of affairs in the climate change negotiations leading up to COP16

<http://www.jiqweb.org/images/stories/JIQmagazine/2010Oct.pdf>

International Climate Policy after Copenhagen: Towards a 'Building Blocks' Approach

<http://onlinelibrary.wiley.com/doi/10.1111/j.1758-5899.2010.00045.x/full>

World Gobbling Up Greenhouse Gas Budget: WWF

<http://planetark.org/wen/59777>

207 September 2010

Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol Fourteenth session, Tianjin, 4-9 October 2010

<http://unfccc.int/resource/docs/2010/awg14/eng/12.pdf>

208 August 2010

UNFCCC Executive Secretary: Governments make progress towards deciding shape of result at UN Climate Change Conference in Mexico, but need to narrow down number of negotiating options

http://unfccc.int/files/press/newsroom/press_releases_and_advisories/application/pdf/pr_20100_608_closing_awg_aug.pdf

Climate Change Dominates Pacific Island Forum Meeting

<http://climate-l.org/2010/08/04/climate-change-dominates-pacific-island-forum-meeting/?referrer=climate-l.org-daily-feed>

209 July 2010

World Investment Report 2010

<http://www.unctad.org/Templates/WebFlyer.asp?intItemID=5535&lang=1>

Environmental and economic effects of the Copenhagen pledges and more ambitious emission reduction targets

<http://www.uba.de/uba-info-medien/3998.html>

Study Warns that Decisions Made Today About Carbon Emissions Will Have Consequences "In the Coming Centuries and Millennia"

<http://www.wwfblogs.org/climate/content/nrc-climatereport-16july2010>

210 Cancun UN Climate Change Conference Consolidates Progress

Military Implications:

The Cancun Agreements set conditions for increased accountability concerning emission reductions and adaptation actions. Relevant military personnel should review the "Cancun Agreements" to identify opportunities for implementing the Army Strategy for the Environment, military-to-military activities to build adaptation capacities, and to ensure that units and contractors respect host countries' climate policies.

Sources:

The outcome documents of the COP16:

<http://unfccc.int/conference/documents/items/5776.php>

Back from the brink

<http://www.economist.com/node/17730564>

An Ethical Analysis of the Cancun Climate Negotiations Outcome.

<http://rockblogs.psu.edu/climate/2010/12/an-ethical-analysis-of-the-cancun-climate-negotiations-outcome.html>

211

International Civil Aviation Pact Cuts Climate Emissions from Aircraft

Military Implications:

Although the regulation concerns only civil aviation, military and security organizations should explore these conclusions as potentially leading to future impacts on their own operations. Sources:

ICAO Member States Agree to Historic Agreement on Aviation and Climate Change

<http://www2.icao.int/en/Assembly37newsroom-public/Documents/ICAO%20Member%20States%20Agree%20To%20Historic%20Agreement%20On%20Aviation%20And%20Climate%20Change.pdf>

Civil Aviation Pact Cuts Climate Emissions from Aircraft

<http://www.ens-newswire.com/ens/oct2010/2010-10-13 -02.html>

ICAO Environmental Report 2010

www.icao.int/icao/en/env2010/pubs/environmentreport 2010.pdf

212 More Aggressive Action Needed to Curb Ozone Depletions

Military Implications:

It is likely that the new Assessment will accelerate negotiations for a ban and implementation of regulations banning ozone-depleting chemicals. The military and its contractors should prepare to comply with new strictures and other chemicals' phase-outs.

Sources:

The 2010 Assessment of the Scientific Assessment Panel

<http://ozone.unep.org/Assessment Panels/SAP/Scientific Assessment 2010/index.shtml>

Ozone Secretariat Releases 2010 Scientific Assessment Report

<http://climate-l.iisd.org/news/ozone-secretariat-releases-2010-scientific-assessment-report/?referrer=climate-change-daily-feed>

New Technologies

214 Reports Assessing Several Nations' S&T Advances

Military Implications:

As the DIA requested and sponsored the NRC report, they should ensure it is widely disseminated throughout the military community, particularly to personnel with environmentally-specific, S&T or JBRICS duties.

Sources:

S&T Strategies of Six Countries: Implications for the United States

http://www.nap.edu/catalog.php?record_id=12920

U.S. Risks Losing Global Leadership in Nanotech

<http://www.kurzweilai.net/u-s-risks-losing-global-leadership-in-nanotech>

Nanotechnology

216 ISO Published Standard for Inhalation Toxicity Testing of Nanoparticles Military Implications:

This standard should be used in the planning and operation of systems for nanotech risk assessment and use.

Sources:

How toxic are nanoparticles? New ISO standard helps find out

<http://www.nanowerk.com/news/newsid=19862.php>

ISO 10808:2010 Nanotechnologies -- Characterization of nanoparticles in inhalation exposure chambers for inhalation toxicity testing

http://www.iso.org/iso/catalogue_detail?csnumber=46130

217 ISO Publishes Methodology for Nanomaterials Classification Military Implications:

Personnel concerned with nanotechnology should become familiar with this work, as it will presumably become a standard for communications in the field.

Source:

New ISO methodology demystifies nanomaterials

<http://www.nanowerk.com/news/newsid=17691.php>

218 The Geopolitics of Nanotech Military Implications:

The report might be a good source of information on the present worldwide state of affairs of nanotechnology.

Source:

The Big Downturn? Nanogeopolitics

<http://www.etcgroup.org/en/node/5245>

219

Organizations Address Key Issues For Nanomaterial Definition

Military Implications:

These guidelines are likely to have a substantial effect on the formulation of the nanomaterial definition used in future regulations, and should be taken into account in planning for such regulation.

Sources:

International Council of Chemical Associations addresses key issues for nanomaterial definition

<http://www.nanowerk.com/news/newsid=19145.php>

ICCA Core Elements of a Regulatory Definition of Manufactured Nanomaterials

<http://www.icca-chem.org/ICCADocs/Oct-2010>

ICCA-Core-Elements-of-a-Regulatory-Definition-of-Manufactured-Nanomaterials.pdf

Reply form for the public consultation on Proposal for a Commission definition of the term "nanomaterial"

http://www.ciel.org/Publications/Nanomaterials_ReplyForm_Nov10.pdf

220 EC Publishes Report on Definition of Nanomaterials For Regulatory Purposes Military Implications:

Military personnel concerned with nanotech regulation should follow the evolution of the European discourse on the definitional questions and eventually provide input. This process might set a precedent to be emulated worldwide, and trigger new regulations accordingly. Sources:

Considerations on a definition of nanomaterial for regulatory purposes

<http://publications.jrc.ec.europa.eu/repository/>

European Commission publishes reference report on definition of nanomaterials for regulatory purposes

<http://www.nanowerk.com/news/newsid=17008.php>

Document: Scientific Basis for the Definition of the Term "Nanomaterial"

http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_030.pdf

Public consultation on scientific basis for a definition of the term 'nanomaterial'

<http://www.nanowerk.com/news/newsid=17175.php>

221 EC Committee Presents Scientific Basis for the Definition of "nanomaterial"

Military Implications:

This definition is a difficult but key point that lies at the foundation of much nanotech regulatory activity. ES personnel concerned with this area should review the paper.

Sources:

EU scientific committee publishes opinion on definition of nanomaterials.

<http://www.nanowerk.com/news/newsid=19377.php>

Scientific Basis for the Definition of the Term "nanomaterial"

[http://ec.europa.eu/health/scientific committees/emerging/docs/scenihr_o_032.pdf](http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_032.pdf)

222 EU Gearing Up for Active Nanotech Regulatory Year in 2011

Military Implications:

Organizations concerned with nanotech EHS should be preparing for a large amount of regulatory study, discussion, and activity in Europe in 2011.

Source:

Regulation of products containing nanomaterial: Traceability, a pre-condition to acceptability

<http://www.nanowerk.com/news/newsid=18061.php>

223 EU Gearing Up for Active Nanotech Regulatory Year in 2011

Military Implications:

Organizations concerned with nanotech EHS should be preparing for a large amount of regulatory study, discussion, and activity in Europe in 2011.

Source:

Regulation of products containing nanomaterial: Traceability, a pre-condition to acceptability

<http://www.nanowerk.com/news/newsid=18061.php>

224

New Report Analyzes European Nanotech Issues

Military Implications:

This report provides a useful summary and analysis of a number of important nanotech issues from the European point of view.

Source:

NanoCode project published synthesis report on responsible development of nanotechnology

<http://www.nanowerk.com/news/newsid=18235.php>

225 New EU NanoSustain Project Aims for Sustainable Solutions for Nanotechnology Military Implications:

This project should make substantial contributions to the field of nanotech risk assessment, and should be closely followed by all personnel concerned with those issues.

Sources:

New EU-funded project to develop sustainable solutions for nanotechnology-based products based on hazard characterization

<http://www.nanowerk.com/news/newsid=17326.php>

NanoSustain Project

<http://www.nanosustain.eu/>

226 EU Launches Public Consultation on Risk Assessment of Nanomaterials in Food

Military Implications:

Because of the probable influence of this document on the future course of ENM regulation in the EU, appropriate nanotech risk assessment personnel should review it and, if warranted, submit comments on it by the deadline of 25 February 2011.

Source:

European Food Safety Authority launches public consultation on risk assessment of nanomaterials in food and feed

<http://nanotech.lawbc.com/2011/01/articles/international/efsa-begins-public-consultation-on-draft-guidance-on-risk-assessment-for-nanoscience-and-nanotechnologies/>

227 German Paint Association Issues Nanomaterials Workplace Guidance

Military Implications:

Although this is a highly specialized industrial application area, the guidelines document could offer useful insight into self-regulation in Europe of potentially hazardous nanomaterials workplace environments.

Sources:

German Paint and Printing Ink Association publishes guidance for workplace handling nanomaterials

<http://www.nanowerk.com/news/newsid=17345.php>

Guidance for the handling of nano-objects at the workplace

[http://www.lackindustrie.de/Default2.asp?
cmd=getdwld&docnr=127627&file=Nanoleitfaden+englisch%2Epdf](http://www.lackindustrie.de/Default2.asp?cmd=getdwld&docnr=127627&file=Nanoleitfaden+englisch%2Epdf)

228 EPA Issues Final Significant New Use Rules (SNUR) on Carbon Nanotubes Military Implications:

Organizations involved with nanotube environmental health and safety (EHS) should review these modified rules to determine their effects on R&D, procurement, and operations. The modifications provide clarifications on exemptions from applicability of the SNUR, and additional human health and environmental summary information to support EPA's findings.

Sources:

75 FR 56880 - Multi-Walled Carbon Nanotubes and Single-Walled Carbon Nanotubes; Significant New Use Rules

<http://www.gpo.gov/fdsys/granule/FR-2010-09-17/2010-23321>

EPA Issues Final SNURs for Carbon Nanotubes

<http://nanotech.lawbc.com/2010/09/articles/united-states/federal/epa-issues-final-snurs-for-carbon-nanotubes/>

229 GAO Tells EPA It Should Expand Nanomaterials Info and Regulatory Efforts Military Implications:

The military should be prepared for potential additional regulations on the use of nanomaterials.

Sources:

Nanotechnology: Nanomaterials Are Widely Used in Commerce, but EPA Faces Challenges in Regulating Risk

<http://www.gao.gov/products/GAO-10-549>

EPA Should Expand Efforts to Get Data On, Regulate Nanomaterials, GAO Says in Report

<http://www.merid.org/nanodev/more.php?articleID=2708>

1 Discussion on Federal/State Regulation of Nanotech Military Implications:

These discussions offer useful insights into the history, current state, and possible future course of state and federal regulation of nanotechnology.

Sources:

We Should Have Seen It Coming: States Regulating Nanotechnology

<http://www.nanotech-now.com/columns/?article=484>

State-level nano regulation: Yes, indeed, the industry "should have seen it coming" - it caused it!

<http://blogs.edf.org/nanotechnology/2010/09/10/state-level-nano-regulation-yes-indeed-the-industry-should-have-seen-it-coming-%E2%80%93-it-caused-it/>

231 California Asks Manufacturers for Nano Analytical Test Measures Military Implications:

The call is accompanied by a 102-page bibliography of chemical information on the nanomaterials of concern, which should be a very useful reference work for risk assessment.

Source:

CDTSC issues DCI for Nano Metals, Nano Metal Oxides, and Quantum Dots

<http://nanotech.lawbc.com/2010/12/articles/united-states/state/cdtsc-issues-dci-for-nano-metals-nano-metal-oxides-and-quantum-dots/>

Bibliography

[http://www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/upload/Round Two Biblio.pdf](http://www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/upload/Round%20Two%20Biblio.pdf)

232 Thailand Moves Toward Nanotechnology Safety and Ethics Strategy Plan

Military Implications:

Appropriate EHS personnel in the region should offer the benefit of their experience to assist the authorities in this work and also become prepared for its eventual regulatory results.

Source:

Thailand pushing forward on nanosafety regulations

<http://www.nanowerk.com/news/newsid=19736.php>

233 Thailand to Introduce New "NanoQ" Certification Mark Military Implications:

This move by Thailand may presage a wave of such efforts around the world to allay the fears of consumers regarding nanotech safety. (See related item Effort and Care Vital in Communicating Nanotech to the "Public", in this issue.) That raises the specter of future proliferation of different national standards/certifications, resulting in an impetus for an internationally coordinated system. (A foreshadowing of this kind of situation may be the current study by a Wisconsin Legislature committee of the possibility of state regulation of nanotech use.) ES personnel should also be considering the effect of such developments on the public's (including service members') attitudes toward nanotechnology in applications other than consumer products. Further, this field could become fertile ground for unscrupulous vendors who claim but fail to properly follow even the voluntary standards. Military organizations using nanotech products could become liable for suppliers' ethical and technical failures, unless safeguards are established.

Source:

Thailand's first NanoQ

<http://www.asia-anf.org/NewsDetails.php?NewsId=218>

234 India Soon to Have a National Regulatory Framework for Nanotechnology Military Implications:

The progress of this effort should be carefully monitored, since organizations working in India or cooperating with national enterprises will have to live with its results.

Source:

Soon, a national regulatory framework for nanotechnology

<http://timesofindia.indiatimes.com/city/pune/Soon-a-national-regulatory-framework-for-nanotechnology/articleshow/6750692.cms>

235 Pakistan Establishes National Nanotech Commission; Environment a Focus Military Implications:

This new initiative by the government of Pakistan may offer opportunities for military-to-military cooperation in methods for the management of applying new technology to environmental security.

Source:

Pakistan is striving to grow in Nano technology field

<http://regionaltimes.com/06aug2010/moneynews/pakistan.htm>

236 India Soon to Have a National Regulatory Framework for Nanotechnology

Military Implications:

The progress of this effort should be carefully monitored, since organizations working in India or cooperating with national enterprises will have to live with its results.

Source:

Soon, a national regulatory framework for nanotechnology

<http://timesofindia.indiatimes.com/city/pune/Soon-a-national-regulatory-framework-for-nanotechnology/articleshow/6750692.cms>

237 Study Analyzes Stakeholder Preferences in Regulating Nanotechnology

Military Implications:

The results of this study should be taken into account in planning regulatory measures, and, in particular, in presenting them, and their justifications, to the stakeholders.

Sources:

Stakeholder Preferences in Regulating Nanotechnology

<http://www.nanowerk.com/spotlight/spotid=17337.php>

Multicriteria mapping of stakeholder preferences in regulating nanotechnology

<http://www.springerlink.com/content/x82lt46t86514361/>

238 ASTM Forms New Subcommittee on Nano-Enabled Consumer Products Military Implications:

Appropriate environmental health and safety (ES) personnel should consider joining this subcommittee to lend their expertise to the effort and to keep abreast of developments in this standards area.

Source:

ASTM Nanotechnology Committee Creates Subcommittee on Nano-Enabled Consumer Products
<http://www.astmnewsroom.org/default.aspx?pageid=2270>

239 Nanotechnology Long-term Impacts and Research Directions: 2000-2020

Military Implications:

This material offers a comprehensive, forward-looking view of the entire field. Sources:

Nanotechnology Long-term Impacts and Research Directions: 2000-2020

<http://www.wtec.org/nano2/>

240 What Can Nanotechnology Learn from Biotechnology?

Military Implications:

Military personnel concerned with the relationship between nanotechnology and society, and setting policy and communicating with the public on such issues, should consider reviewing the paper and the book.

Sources:

In the footsteps of biotech

<http://www.nature.com/nnano/journal/v5/n7/full/nnano.2010.136.html> (Subscription or purchase required)

What Can Nanotechnology Learn From Biotechnology?

http://www.elsevier.com/wps/find/bookdescription.cws_home/713890/description#description

241 Report Outlines Nanotech Research Directions for Societal Needs in 2020

Military Implications:

This report, drawing on the opinions of leading experts from over 35 countries, should provide useful information for the long-range planning of nanotech assessment.

Sources:

Nanotechnology Research Directions for Societal Needs in 2020

<http://www.nanotechproject.org/events/archive/researchdirections/>

Nanotechnology Research Directions for Societal Needs in 2020

<http://sites.merid.org/nanodev/more.php?articleID=2986>

242 International Handbook on Regulating Nanotechnologies

Military Implications:

The Handbook could be a useful tool to those concerned with nano-related environmental health and safety regulatory issues, as well as effects of any restrictions on the materiel uses of nano-products.

Source:

International Handbook on Regulating Nanotechnologies

<http://2020science.org/international-handbook-on-regulating-nanotechnologies/>

243 Chemical Heritage Foundation Issues Two Reports on Nanotech Regulation

Military Implications:

The reports should provide useful summaries of the current state of these aspects of the regulatory process.

Sources:

Emerging Nanotechnologies and Life-Cycle Regulation: An Investigation of Federal Regulatory Oversight from Nanomaterial Production to End of Life

<http://issuu.com/chemheritage/docs/emerging-nanotechnologies?viewMode=presentation&mode=embed>

Nanotechnology Regulation: Policies Proposed by Three Organizations for the Reform of the Toxic Substances Control Act

<http://issuu.com/chemheritage/docs/nanotechnology-regulation?viewMode=presentation&mode=embed>

244 Regulation of Products Containing Nanoscale Materials

Military Implications:

This excellently detailed article provides a very useful summary of the course of nanotech regulation in the USA.

Sources:

Regulation of Products Containing Nanoscale Materials

<http://sites.merid.org/nanodev/more.php?articleID=2979>

Regulation of products containing nanoscale materials

<http://www.lexology.com/library/detail.aspx?g=4b460c16-b0cc-4c05-972d-c9b152cf3400>

245 Review of the Long History of Nanosilver Usage and Regulation, and Implications

Military Implications:

This point should be taken into account in considering regulatory actions on nanosilver, and reactions thereto.

Source:

Environmental Science & Technology Article Reviews History of Nanosilver and Policy Implications

<http://nanotech.lawbc.com/2011/01/articles/united-states/federal/environmental-science-technology-article-reviews-history-of-nanosilver-and-policy-implications/>

246 Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path

Military Implications:

The Project's five years of experience in the development of a number of voluntary initiatives in this area should ensure that this report offers valuable guidance to nanotech regulation planners.

Sources:

Voluntary Initiatives, Regulation, and Nanotechnology Oversight: Charting a Path

<http://www.nanotechproject.org/events/archive/voluntary/>

PEN 19 - Voluntary Initiatives, Regulation, and Nanotechnology Oversight

<http://www.nanotechproject.org/publications/archive/voluntary/>

247 Webinars on Nanotech Regulation Offered

Military Implications:

Relevant military personnel should consider subscribing to this offering.

Source:

Nanotechnology Today 2010 webinar

<http://www.khlaw.com/showevent.aspx?Show=3789>

248 New Book Addresses Nanotechnology Education and Workforce Training

Military implications:

This work may provide useful ideas on communicating nanotech knowledge and understanding to outside audiences.

Source:

New Book Addresses Nanotechnology Education and Workforce Training

<http://www.foresight.org/nanodot/>

249 Studies Discussing the Possibility of Understanding Nanotoxicology

Military Implication:

These studies provide valuable information to those planning nanomaterial development and risk assessment.

Sources:

Nanotoxicology myth buster

<http://www.nanowerk.com/spotlight/spotid=18774.php>

Debunking Some Misconceptions about Nanotoxicology. David B. Warheit, DOI: 10.1021/nl103432w

[http://pubs.acs.org/action/doSearch?
action=search&author=warheit&qsSearchArea=author&type=within&publication=40026042&](http://pubs.acs.org/action/doSearch?action=search&author=warheit&qsSearchArea=author&type=within&publication=40026042&) (Abstract)

"Study of nanoparticle emission of selected products during their life cycle" (English summary)

[http://www.umweltbundesamt.de/technik-verfahren-
sicherheite/publikationen/texte_52_2010_kurzfassunge.pdf](http://www.umweltbundesamt.de/technik-verfahren-sicherheite/publikationen/texte_52_2010_kurzfassunge.pdf)

250 Management of Nanomaterials Safety in Research Environment

Military Implications:

The article should offer insights into this institution's experience with this technique for risk management.

Source:

Management of Nanomaterials Safety in Research Environment

<http://sites.merid.org/nanodev/more.php?articleID=3034>

251 Bioethics Commission Calls for Enhanced Federal Oversight of Synthetic Biology

Military Implications:

Military personnel with research responsibilities that could be affected by synthetic biology should be given this document to study. Those with direct responsibilities for synthetic biology should give special consideration to the report's recommendations, especially the seven cited above (1, 3, 5, 9, 11, 12, and 17).

Sources:

Presidential Commission on Bioethics calls for enhanced federal oversight of synthetic biology

<http://www.nanowerk.com/news/newsid=19449.php>

NEW DIRECTIONS. The Ethics of Synthetic Biology and Emerging Technologies

<http://www.bioethics.gov/documents/synthetic-biology/PCSBI-Synthetic-Biology-Report-12-16-10.pdf>

252 NRC Committee Recommends Sequence-based Tracking of Possible Pathogens

Military Implications:

Those organizations with biological counter-warfare responsibilities should review this report for potential to improve policy and procedures.

Sources:

Sequence-Based Classification of Select Agents: A Brighter Line

http://www.nap.edu/catalog.php?record_id=12970

US report pins down future biosecurity. Committee recommends a sequence-based system for identifying pathogens

<http://www.nature.com/news/2010/100803/full/466678a.html>

253

India Urges Strengthening Outer Space Treaty

Military implications:

[Same as previous on similar issues] In addition to the DOD's Commercial and Foreign Entities program, the military should increase cooperation with military counterparts and civilian organizations around the world to explore joint research programs and design of a legal framework to increase space security.

Sources:

Plug holes in UN 'Outer Space Treaty', says former Air Chief

<http://news.oneindia.in/2011/01/19/plugholes-in-un-outer-space-treaty-says-former-airchief-aid0121.html>

Space, Science, and Security: The Role of Regional Expert Discussions New Delhi, January 19-21

<http://swfound.org/events/2011/space,-science,-and-security-the-role-of-regional-expert-discussions>

Improved Enforcement of Environmental Regulations

255 "Public Interest" Environmental Suits Increasing

Military Implications:

This is further evidence that military installation and training planners should increasingly consider public opinion on environmental issues before considering new projects, installations, training, etc. Source:

Activists in India cry foul over new rules regarding public interest litigation

<http://www.washingtonpost.com/wp-dyn/content/article/2010/07/25/AR2010072502773.html>

256 International Consortium Created to Curb Environmental Crime

Military Implications:

AFRICOM and military personnel in other regions working in countries with governments with weak local customs or security organizations should consider how they might conduct military-to-military activities to help implement the intentions of the Consortium and explore cooperation on the full range of international environmental crime-related activities with the Consortium.

Sources:

World's police at INTERPOL General Assembly rally against environmental crime

<http://www.interpol.int/Public/ICPO/PressReleases/PR2010/News20101110.asp>

Powerful alliance to fight wildlife crime comes into effect

<http://www.interpol.int/Public/ICPO/PressReleases/PR2010/PR098.asp>

AG-2010-RAP-08, Appendix.

Resolution: Subject: Sustainable Environmental Crime Programme

http://www.cites.org/eng/news/press/2010/20101108_Interpol_resolution.pdf

257 The ICC to Establish an Independent Oversight Mechanism

Military Implications:

Although the U.S. is not a State Party to the ICC, relevant military personnel should review the documents adopted by the 9th ASP, especially the ones specified above, which aim to strengthen the ICC and international criminal justice. They should be prepared to cooperate or comply, as required by status of forces agreements, in those countries that are States Party.

Sources:

9th Assembly of States Parties to the Rome Statute of the ICC, Official documents

<http://www.icc-cpi.int/nr/exeres/f16c9b3e-55a6-4989-8987-f57125a0d306.htm>

Assembly of States Parties concludes its ninth session

<http://www.icc-cpi.int/Menu/ASP/Press+Releases/Press+Releases+2010/Assembly+of+States+Parties+concludes+its+ninth+session.htm>

258 Strategic Plan for Biodiversity to Connect UN Conventions and UN Bodies

Military Implications:

Increased coherence among biodiversity agreements, UN-related bodies, and capacity building should lead to greater attention being paid to biodiversity impacts of military training and other operations. Military liaisons

should explore opportunities for cooperation and applications of the Army Strategy for the Environment as this integration evolves with monitoring and enforcement organizations. Sources:

First high level retreat among secretariats of biodiversity-related Conventions. 1 September 2010, Chateau de Bossey, Switzerland. Summary of the Retreat

<http://www.cbd.int/cooperation/doc/report-hlr-2010-09-01-en.pdf>

Ministerial forum calls for leadership for a new biodiversity vision for the twenty-first century
<http://www.cbd.int/doc/press/2010/pr-2010-09-03-minister-forum-geneva-en.pdf>

259 UN Review of Sustainable Development in Preparation for Rio+20 in 2012

Military Implications:

The Rio+20 conference could speed up some reforms of the UN system and raise environmental concerns on the international and national agendas, thus strengthening enforcement of environmental regulations. Military personnel involved in promoting the Army Strategy for the Environment should study the review of the implementations of Agenda 21 and the Barbados Programme of Action to identify potential applications for the Army Strategy for the Environment.

Sources:

The United Nations General Assembly advanced unedited copy of the Synthesis Report

<http://www.earthsummit2012.org/index.php/news/313-synthesis-report-231210>

First Intersessional Meeting for the UN Conference on Sustainable Development

<http://www.uncsd2012.org/index.php?option=comcontent&view=category&id=73&Itemid=124>

260 International Atomic Fuel Banks to Reduce Nuclear Proliferation

Military Implications:

The military should explore the use of the enriched uranium reserves along with other initiatives as part of the continual assistance to countries for advancing nuclear disarmament and facilitate NPT negotiations and improve global nuclear safety.

Sources:

IAEA approves global nuclear fuel bank

[http://www.world-nuclear-news.org/ENF-IAEA approves global nuclear fuel bank-0612105.html](http://www.world-nuclear-news.org/ENF-IAEA%20approves%20global%20nuclear%20fuel%20bank-0612105.html)

The first in the world guaranteed reserve of nuclear fuel has been set up in the Russian Federation

<http://www.rosatom.ru/wps/wcm/connect/rosatom/rosatomsite.eng/presscentre/news/6a376f8044e2e26db0bdfa6fd126209c>

Russia Inaugurates World's First Low Enriched Uranium Reserve

<http://www.iaea.org/newscenter/news/2010/leureserve.html>

261 Prosecution of Pillage of Natural Resources as War Crime

Military Implications:

Since "conflict minerals" pillage is more likely to occur in vulnerable or conflict areas, the military might be called upon to help enforce the relevant regulations locally, as well as to report and stop breaches. Additional training requirements should be explored for personnel likely to be deployed in such areas.

Sources:

Firms Linked to Conflict Minerals May Face Prosecution

<http://www.ens-newswire.com/ens/jan2011/2011-01-03-02.html>

'Conflict Mineral' Strategy Emerging

<http://wardsauto.com/ar/conflict mineral strategy 101228/>

Digging In: Recent Developments on Conflict Minerals

<http://www.enoughproject.org/publications/digging-in-conflict-minerals>

Conflict minerals law could push prices higher - MSCI ESG

<http://www.miningweekly.com/article/conflict-minerals-law-could-push-prices-higher—mcsi-esg-2011-01-21>

262 Regional Cooperation in Africa to Counter Wildlife Trafficking

Military Implications:

AFRICOM should explore how to assist such regional collaboration and build capacity to help enforcement of the Convention on International Trade in Endangered Species and the Convention against Transnational Organized Crime.

Sources:

Central Africa: four-nation 'sting' operation busts wildlife smuggling ring

<http://www.guardian.co.uk/environment/2010/dec/12/africa-wildlife-ivory-smuggling>

263 Hazardous E-waste Grows as Major Environmental Problem

Military Implications:

Military personnel and their civilian contractors with recycling and waste management responsibilities should review their classifications and operations to see if revisions are necessary. The reports of INECE should be circulated to these personnel. Sources:

Global Crackdown on Illegal Hazardous Waste Shipping Confirms Benefits of Cross-Border Cooperation

<http://inecesecretariat.wordpress.com/2010/11/02/global-crackdown-on-illegal-hazardous-waste-shipping-confirms-benefits-of-cross-border-cooperation/>

INECE Seaport Environmental Security Network

www.inece.org/seaport

264 Shipping Efficiency Database to Reduce Emissions from Maritime Transportation

Military Implications:

The military should consider the shippingefficiency.org database for selecting contractors as part of reducing the environmental footprint of the Army in general and from shipping specifically.

Sources:

Shippingefficiency.org website

<http://www.shippingefficiency.org/>

Cleaning up shipping. New database to rate energy efficiency of ocean-going vessels

<http://thechronicleherald.ca/Business/1218898.html>

International Standards With Environmental Security Implications

266 Revised Standards Proposed for Corporate Greenhouse Gas Reporting

Military Implications:

Military and their civilian contractors with GHG reporting responsibilities should review the revised standards and plan their appropriate compliance activities.

Sources:

New measures emerge for measuring carbon emissions, both corporate and municipal

<http://www.smartplanet.com/business/blog/business-brains/new-measures-emerge-for-measuring-carbon-emissions-both-corporate-and-municipal/11209/> The GHG Protocol Initiative

<http://www.ghgprotocol.org/standards/product-and-supply-chain-standard>

267 Comments Invited on EPA/DOT Proposed Heavy Truck Mileage/Emission Standards

Military Implications:

These standards would have major effects on vehicular procurement. The proposal should be reviewed for its probable consequences, so that adequate planning can be instituted. Comments are invited by January 3, 2011.

Sources:

New Truck Emission Standards and Controls

http://www.enn.com/top_stories/article/41927

EPA and NHTSA Propose First-Ever Program to Reduce Greenhouse Gas Emissions and Improve Fuel Efficiency of Medium- and Heavy-Duty Vehicles: Regulatory Announcement

<http://www.epa.gov/otaq/climate/regulations/420f10901.htm>

268 ISO Publishes Methodology for Nanomaterials Classification

Military Implications:

Personnel concerned with nanotechnology should become familiar with this work, as it will presumably become a standard for communications in the field.

Source:

New ISO methodology demystifies nanomaterials

<http://www.nanowerk.com/news/newsid=17691.php>

269 Fuel Efficiency Standards Are Changing around the World

Military Implications:

It is fair to speculate that the UN procurement guidelines might be expanded to peacekeeping operations and therefore affect the military and its contractors. At the same time, fuel efficiency standards are increasing around the world, which increases the likelihood of global standards with assessment methodologies eventually affecting the military. The opportunity for military-to-military programs in fuel efficiency should be explored.

Sources:

Buying Better Vehicles for the UN

<http://www.greeningtheblue.org/news/buying-better-vehicles-un>

New report gives green light to the feasibility of halving carbon emissions from new cars by 2030

http://www.iea.org/index_info.asp?id=1775

Clean Transport Systems

http://ec.europa.eu/transport/urban/vehicles/road/clean_transport_systems_en.htm

RAND study concludes use of alternative fuels by US military would convey no direct military benefit; recommends energy efficiency instead

<http://www.greencarcongress.com/2011/01/rand-20110125.html>

270 International Air Cargo Screening Cooperation Requested

Military Implications:

Where possible, relevant military entities should share multi-purpose sensors and related screening technology with negotiators to improve forthcoming international standards for air cargo screening.

Source:

TSA Wants Countries to Cooperate on Air Cargo Screening: Industry Official

http://gsn.nti.org/gsn/nw/20110124_5589.php

271 New Earth-Approaching Asteroid Discovered

Military Implications:

Space objects of approximately 150 ft. in diameter colliding with Earth can eliminate life within an 800-mile radius of impact. Continued vigilance and international cooperation regarding space security should remain a high priority for military and related security personnel.

Sources:

Pan-STARRS discovers its first potentially hazardous asteroid

<http://www.physorg.com/news204826766.html>

Pan-STARRS

<http://pan-starrs.ifa.hawaii.edu/public/>

272 Hungary Industrial Plant Spill Might Trigger Tougher Environmental Regulations

Military Implications:

The Ajka spill will probably raise questions regarding proper implementation and enforcement of Europe's Seveso II Directive that includes legislation on the storage of dangerous substances and chemical safety management systems. EUCOM and NATO personnel should consider supplementing the EU's inspection capability of industrial facilities in Europe both for assessing this instance's pollution rate, as well as to be prepared for likely tougher enforcement.

Sources:

The Danube's menacing industrial legacy

<http://www.theglobeandmail.com/news/world/europe/the-danubes-menacing-industrial-legacy/article1759897/>

Danube Largely Safe Despite Toxicity of Hungarian Spill

<http://www.spiegel.de/international/europe/0,1518,722100,00.html> UN sends experts to Hungary to help assess health impact of sludge spill <http://www.un.org/apps/news/story.asp?NewsID=36414&Cr=health&Cr1=>

273 Study Indicts Swimming Pool Disinfectants for Toxic Effects from Byproducts

Military Implications:

These results suggest a thorough reexamination by preventive health agencies of disinfection procedures for recreational facilities in installation environments.

Source:

Recreational Pool Disinfectants Linked to Health Problems

<http://www.sciencedaily.com/releases/2010/07/100721133213.htm>

Genotoxicity of Water Concentrates from Recreational Pools after Various Disinfection Methods

<http://pubs.acs.org/doi/abs/10.1021/es903593w>

274 Artificial Grass May Pose Threat of Lead Poisoning to Children

Military Implications:

Military installations with artificial turf should be notified to evaluate this problem and to institute remedial measures, if necessary.

Sources:

Warning of threat to children posed by artificial grass

<http://www.heraldscotland.com/news/health/warning-of-threat-to-children-posed-by-artificial-grass-1.1062033>

Evaluating and Regulating Lead in Synthetic Turf

<http://ehp03.niehs.nih.gov/article/fetchArticle.action;jsessionid=603B9732578818DD76D9060DCB31669A?articleURI=info%3Adoi%2F10.1289%2Fehp.1002239>

275 China to Expand Weather Control Program

Military Implications:

These activities will provide additional data on the consequences of such measures, and should be monitored, especially if they are a precursor to larger-scale geoengineering proposals and prove safe to apply to drought-prone areas that otherwise might force migrations that could lead to conflict.

Source:

China to step up efforts to control Mother Nature

<http://www.physorg.com/news/2010-12-china-efforts-mother-nature.html>

Nanotechnology--Potential Environmental and Health Implications

277 Study Raises Doubts on PEN Nano Consumer Products Inventory (CPI)

Military Implications:

Military personnel concerned with nanotech risk evaluation should examine the allegations in the article, and their stated justifications, including the authors' professional qualifications, and determine if any additional caution is needed in using data from the CPI. They should also consider the merits of the recommendation for a government-prepared inventory.

Source:

Project on Emerging Nanotechnologies - Consumer Product Inventory Evaluated Nanotechnology Law & Business (Volume 7, Issue 2)

<http://www.nanolabweb.com/index.cfm/action/main.default.viewArticle/articleID/330/CFID/4996510/CFTOKEN/43195139/index.html> (abstract; subscription or purchase required for full text)

278 Lack of Nanoparticle Characterization Obstructs Development of Nanomedicines

Military Implications:

The environmental security community should take very serious note of these opinions, as the negative consequences of these information gaps apply equally to the use of nanomaterials in products other than medicines. Every effort should be made to improve the states of characterization technology and nano/bio interaction studies.

Source:

Tiny traits cause big headaches. Nanotech medicines held up by lack of particle characterization.

<http://www.nature.com/news/2010/100914/full/467264b.html>

279 Structured Relationship Modeling Allows Prediction of Nanoparticle Properties Military Implications:

If this technique lives up to its promise, it should prove of considerable assistance in designing new nanoparticles and assessing their risks.

Sources:

Predicting the toxicological effects of nanomaterials with novel modeling approach

<http://www.nanowerk.com/spotlight/spotid=18875.php>

Quantitative Nanostructure-Activity Relationship Modeling

<http://dx.doi.org/doi:10.1021/nn1013484>

280 Sunscreens with ZnO, TiO₂ Nanoparticles May Pose Health Risk

Sources:

Toxicological Aspects of Long-Term Treatment of Keratinocytes with ZnO and TiO₂ Nanoparticles

<http://www.merid.org/nanodev/more.php?articleID=2889>

Toxicological Aspects of Long-Term Treatment of Keratinocytes with ZnO and TiO₂ Nanoparticles

<http://onlinelibrary.wiley.com/doi/10.1002/smll.201000032/abstract> (abstract)

1 Study Shows TiO₂ Nanoparticles Disrupt Aquatic Ecosystems

Military Implications:

These results should be taken into account in environmental risk assessments of the very wide range of products using TiO₂ nanoparticles. A review of the paper also points out that this toxicity, "...could have a potential application: Water purification processes based on nTiO₂ could limit growth of cyanobacteria in closed water systems, such as cooling towers and boilers."

Sources:

TiO₂ Nanoparticles in the Environment

<http://sites.merid.org/nanodev/more.php?articleID=2909>

TiO₂ Nanoparticles in the Environment (study)

<http://pubs.acs.org/cen/news/88/i40/8840news5.html>

282 New Model Predicts Nanoparticle Cellular Toxicity

Military Implications:

According to Meridian Nanotechnology and Development News, "The model could help regulators streamline and prioritize nanotoxicology testing, especially since nanoparticle use is growing faster than toxicology can keep up." It could also be a tool for military R&D agencies and preventive health organizations. Source:

Predicting Nanoparticle Toxicity

<http://www.rsc.org/chemistryworld/News/2010/July/26071001.asp>

283 Transatlantic Partners to Analyze Environmental Safety and health (EHS) for Manufactured Nanomaterials

Military Implications:

Components concerned with nanotech EHS should establish liaison with the institutions involved with this effort, to follow the results obtained.

Sources:

Transatlantic partners to analyse environment and health risks of manufactured nanomaterials

<http://www.nanowerk.com/news/newsid=19871.php>

284 Toxicity of Silver Nanoparticles Increases During Storage

Military Implications:

This line of research needs to be closely followed because of its consequences for the accuracy of nanotech risk assessment.

Sources:

Toxicity of Silver Nanoparticles Increases during Storage Because of Slow Dissolution under Release of Silver Ions

<http://pubs.acs.org/doi/abs/10.1021/cm100023p>

Toxicity of silver nanoparticles increases during storage

<http://www.nanowerk.com/spotlight/spotid=17687.php>

285 Some Types of Nanotubes Produce Harmful Oxygen in Sunlit Water

Military Implications:

These findings need to be taken into account in risk assessment of SWNTs, especially if there is a possibility of their appearance in sunlit aqueous environments.

Sources:

Photoreactivity of Carboxylated Single-Walled Carbon Nanotubes in Sunlight: Reactive Oxygen Species Production in Water

<http://pubs.acs.org/doi/abs/10.1021/es101073p> (Abstract; full text by subscription)

Shining A Light On Nanotoxicity <http://pubs.acs.org/cen/news/88/i33/8833news5.html>

286 Nanosilver Compound Turns Up in Municipal Wastewater

Military Implications:

These findings once again emphasize the requirement for extensive continuing research into the environmental connections in the life cycle of nanoproducts and derivatives, from original production through use, discard, and eventual disposal; as, for example, an ingredient in sludge used for agricultural fertilization. An indication of the uncertain situation in this regard is the recent appeal by the National Association of Clean Water Agencies asking the EPA not to conditionally approve the use of nanoscale silver as a preservative in textile products as it does not have the scientific basis to conclude the use would not cause harm.

Sources:

Sludging through the nano lifecycle: Caution ahead

<http://blogs.edf.org/nanotechnology/2010/09/23/sludging-through-the-nano-lifecycle-caution-ahead/>

Discovery and Characterization of Silver Sulfide Nanoparticles in Final Sewage Sludge Products

<http://pubs.acs.org/doi/abs/10.1021/es101565j>

287 French Lab to Be Set up for Study of Nanotube Toxicity in Aqueous Environments

Military Implications:

Components dealing with nanotech risk assessment should establish liaison with this laboratory after it begins operations, in order to be able to profit from the results of its research.

Source:

NAUTILE: the first research laboratory for the study of the ecotoxicity of carbon nanotubes in the aquatic environment

http://prodawl.arkema.com/sites/group/en/press/pr_detail.page?p_filepath=/templatedata/Content/PressRelease/data/en/2010/100910_nautile_the_first_research_laboratory_for_the_study_of_th_e_ecotoxicity_of_carbon_nanotubes.xml

1 Mouse Model Shows Reversible Reproductive Damage from Nanotubes

Military Implications:

The further research necessary in this area of nanotech EHS should be strongly encouraged.

Source:

No nanotube fertility risk

<http://www.rsc.org/chemistryworld/News/2010/August/08081002.asp>

289 Scientific Review on Using Nanomaterials in Construction Materials

Military Implications:

This report provides useful guidance for anyone dealing with the use of manufactured nanamaterials in construction.

Sources:

Nanomaterials in the construction industry and resulting health and safety issues

<http://www.nanowerk.com/spotlight/spotid=17138.php>

Nanomaterials in the Construction Industry: A Review of Their Applications and Environmental Health and Safety Considerations

<http://pubs.acs.org/doi/abs/10.1021/nn100866w>

290 Use of TiO₂ Nanoparticles in City Pavement Raises Risk Questions

Military Implications:

The use of TiO₂ nanoparticles should be viewed with extreme caution until their environmental risk is much better understood.

Source:

TiO₂ nanoparticles-containing materials in our cities: Impacts are difficult to predict

* * * * *

How Should the Department of Defense Approach Environmental Security Implications of Climate Change

ABSTRACT

Environmental Security (ES) is a process for analyzing and responding to those environmental issues caused by anthropogenically driven environmental degradation. Climate change is a major ES threat having the potential to affect U.S. national security and thus has significant impact for the military national defense mission. This paper considers the most up-to-date climate change projections published by the IPCC, NASA, and the U.S. Global Change Program along with the latest national strategic guidance in order to determine actions required by the DoD. An overwhelming number of greenhouse models indicate considerable changes will affect U.S. national security during the mid-21st century. In addition, the study shows the DoD is currently at the onset of strategically organizing itself to analyze climate change impacts, provide combatant commanders with relevant mission preparedness information, and assess impacts to U.S. military installations of rising sea level/extreme weather events. Therefore, this study makes the following four recommendations: (1) ES must be a national security component, (2) DoD must establish an activity dedicated to develop ES related strategy, (3) Climate change data should be incorporated into a yearly Intelligence Environmental Estimate, (4) USJFCOM should take the lead in developing climate change related training scenarios.

ACKNOWLEDGMENTS

An academic undertaking of this scale would not have been possible without the insight and dedication of my thesis committee. Their efforts challenged my assumptions and provided the needed guidance to complete this work.

I would first like to thank my thesis committee. Dr. King as committee chair helped focus my efforts and keep me on track throughout this process. His knowledge on environmental science ensured this work considered the latest scientific and policy information available. LTC Anderson was instrumental in helping me communicate effectively and structuring my argument logically. Mr. Boyce challenged my assumptions and provided an essential objective perspective in reviewing my research. Their efforts were vital to this study.

Secondly, thanks are owed to Dr. Constance Lowe who provided me crucial guidance and wisdom and whose inquisitive questions helped me select this topic. Finally, I would like to thank Ms. Cary Garcia who painstakingly edited my first draft. It is my hope that this product is worthy of their efforts.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Primary Research Question

Secondary Research Questions

Definitions

Limitations

Delimitations

Assumptions

Significance of the Study

Background

CHAPTER 2

LITERATURE REVIEW

Climate Change

Water Resources and Changes in Precipitation

Sea Level Rise and Ocean Acidification

Meridional Overturning Circulation

What Climate Change Does

IPCC Fourth Assessment Report

Global Climate Change Impacts in the United States

Strategic Guidance

The Obligation of the U.S

Summary

CHAPTER 3

ANALYTICAL RESEARCH METHODOLOGY

CHAPTER 4

ANALYSIS

Secondary Research Questions

Primary Research Question

CHAPTER 5

RECOMMENDATIONS

Recommendations

REFERENCE LIST

ACRONYMS

COCOM Combatant Command
DHS Department of Homeland Security
DIME Diplomatic, Informational, Military, and Economic
DoD Department of Defense
DoS Department of State
DSCA Defense Support to Civil Authorities
FEMA Federal Emergency Management Agency
GDP Gross Domestic Product
GHG Greenhouse Gas
IPCC Intergovernmental Panel on Climate Change
NASA National Aeronautics and Space Administration
NATO North Atlantic Treaty Organization
NIE National Intelligence Estimate
NOAA National Oceanic and Atmospheric Administration
OSD Office of the Secretary of Defense
PPM Parts Per Million
QDR Quadrennial Defense Review
UN United Nations
UNEP United Nations Environmental Program
USACE United States Army Corps of Engineers
USAF United States Air Force
USGCRP United States Global Change Research Program
USNORTHCOM United States Northern Command
USJFCOM United States Joint Forces Command
USPACOM United States Pacific Command

CHAPTER 1

INTRODUCTION

For a better part of the 20th century, issues relating to the environment, climate change, and environmental degradation were seen as abstract concepts far-off in a distant land. Many scientists and scientific publications considered global warming caused by the release of greenhouse gases, predominately carbon dioxide, as a slow developing concern that can be addressed in the future. During the last quarter of the 20th century, improved science and analysis techniques resulted in an enhanced understanding of climate change that sparked fierce debate among scientists and policy makers on whether global warming was occurring and on its long-term effects. In addition, a growing community began to realize a need to consider climate-induced change in national security planning. General Maxwell Taylor, who in 1974 suggested creating "an expanded National Security Council charged with dealing with all forms of security threats, military and nonmilitary, and having access to all elements of government and to all relevant resources capable of contributing to this broad task" (Campbell 2008, 3). Further, over the past two decades the concept of climate-induced change; how it should affect U.S. environmental security policy has generated significant discussion, especially given the growing awareness resource scarcity driven by climate change will have on violence, civil strife and regional destabilization.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) chartered under the United Nations Environmental Program issued their Fourth Assessment Report on Climate Change, providing the world with the most comprehensive and up-to-date scientific data on climate change. More recently, the U.S. Global Change Research Program released a report titled Global Climate Change Impacts in the United States. This report focuses on the U.S. regional effects of climate change now and in the future. While this research does spend a considerable amount of time in review and analysis of climate-induced change, the purpose is to demonstrate how climate-induced change will affect the nation. Much of the work performed by the IPCC and USGCRP is referenced in this report to project future climate.

The goal of this study is to make strategic recommendations on the direction the Department of Defense (DoD) should take to address environmental security to properly posture the department and effectively plan for climate related change, while also providing relevant information to combatant commanders and service components so they can adequately prepare the force. Within the many operational centers and organizations in the DoD, the concept of environmental security lacks a commonly accepted definition. For the purpose of this research, environmental security is "a process for responding to those environmental issues having the potential to affect U.S. national security has significant implications for the military national defense mission" (King 2000, 14). This definition sets the threshold for all of the work that will follow in this study. More broadly, this research paper intends to serve national security needs by providing an understanding of current climate-induced threats and identify actions necessary to better act upon environmental security risks.

This thesis compiles much research performed on climate change, its outcomes and analysis. Chapter 2 provides a literature review on relevant climate change studies, national security strategy, and DoD publications. Chapter 3 describes the thesis methodologies and analysis process. Chapter 4 analyzes and summarizes the findings of the literature review and applies security threat analysis to understanding the problem. Chapter 5 presents this paper's final conclusions.

Primary Research Question

How should the Department of Defense approach environmental security implications of climate change?

Secondary Research Questions

1. Does the Department of Defense have an environmental security direction?
2. What conditions of climate change are likely to provide security risks to the U.S. in the near term?

Definitions

Throughout this research, the term "Environmental Security" is used to describe a process for addressing climate induced environmental concerns that pose a threat to national security. Further, this paper uses the definition for environmental security as it is applied in this research:

Environmental security is a process for effectively responding to changing environmental conditions that have a potential to reduce peace and stability in the world and thus affect U.S. national security. U.S. environmental security involves accomplishment of the environmentally related actions specified in the National Security Strategy. Accomplishing U.S. national environmental security goals requires planning and execution of programs to prevent and/or mitigate anthropogenically induced adverse changes in the environment and minimize the impacts of the range of environmental disasters that could occur. (King 2000, 17)

This research paper is based on the most up-to-date scientific data relating to climate change and makes use of the latest national strategic documentation. The purpose of this study is not necessarily to describe climate change itself, but how those changes will refocus U.S. national security concerns. A cornerstone of the research paper is based on the United Nations IPCC research, specifically extracts from the IPCC Forth Assessment Report, which utilizes a scenario based approach to establish four plausible scenarios of future climate changes. The 2009 U.S. Global Change Research Program recently published report on Global Climate Change Impacts in the United States is utilized to demonstrate observed and expected climate change which poses national security threats. Throughout this research the author has taken a "middle of the road approach" in respect to selecting and presenting climate modeling data. Many of the contemporary (CY2006-09) climate models present ranges that vary from mild to catastrophic changes based mainly on the level of human use of fossil-based fuels such as oil and coal. Since there is a range of climate model results, this research paper uses the median (the middle value) result to illustrate future outcomes.

Within the content of this research paper several key terms are used, including:

Carbon Dioxide (CO₂). This gas is responsible for a majority of the human caused input of greenhouse gasses. Major sources include fossil-fuel burning and deforestation. CO₂ remains in the troposphere for approximately 500 years--20 percent lasts for a millennium.

Chlorofluorocarbons (CFCs). These gases are synthetic compounds used extensively for refrigeration and aerosol sprays. They have a dual effect of warming the atmosphere because they absorb thermal radiation and significantly reduce ozone. When released into the atmosphere they destroy ozone (O₃) by removing one "O" atom, thus turning the gas into O₂. CFCs remain in the atmosphere for 65 to 111 years, depending on the type. The Montreal Protocol agreement of 1987 is resulting in a reduction of CFC production.

Methane (CH₄). This gas is produced by bacteria that decompose organic matter in oxygen-poor environments such as landfills, materials left after deforestation, the digestive tracts of billions of cattle, sheep, pigs, other livestock, and humans. CH₄ remains in the troposphere for approximately seven to ten years and each molecule is 26 times more effective in warming the atmosphere than a molecule of carbon dioxide.

Nitrous Oxide (N₂O). This gas is released by the breakdown of nitrogen fertilizers in soil, livestock waste, nitrate-contaminated groundwater, and by biomass burning. N₂O remains in the troposphere for an average of 150 years and each molecule is 200 times more effective in warming the atmosphere than a molecule of carbon dioxide.

Greenhouse effect. The greenhouse effect is the raising of air temperature that occurs when the lower atmosphere (troposphere) traps and contributes to the buildup of heat near the earth's surface. Water vapor, carbon dioxide, methane, and several other gases in the atmosphere absorb a portion of the long-wave energy flowing back towards space from the earth's surface and redirects the energy back towards the earth's surface.

Climate change. Any systematic change in the long-term statistics of climate elements such as temperature, precipitation, and wind sustained over several decades or longer. Climate change may be due to natural external forcing, such as changes in solar emission; natural internal process of the climate system; or

anthropogenic forcing (American Meteorological Society 2009). Climate change and global warming are often used to describe the same effect.

Feedback effects. These are factors which can increase or decrease the rate of a process. For example, continued carbon dioxide loading through burning of fossil fuels can create a tipping-point where the northern tundra and underlying permafrost begin to melt, releasing tons of methane and carbon dioxide into the atmosphere. Carbon stored in the upper matter of permafrost is estimated at 700 billion metric tons. Feedback has a significant potential of creating a climate situation that will spiral out of control leaving humans little they can do to stop it.

Keeling Curve. A chart showing the variation in concentration of atmospheric carbon dioxide since 1958. It is based on continuous measurements taken at the Mauna Loa Observatory in Hawaii. Keeling's measurements showed the first significant evidence of rapidly increasing carbon dioxide levels in the atmosphere" (NOAA 2009). See figure 1.

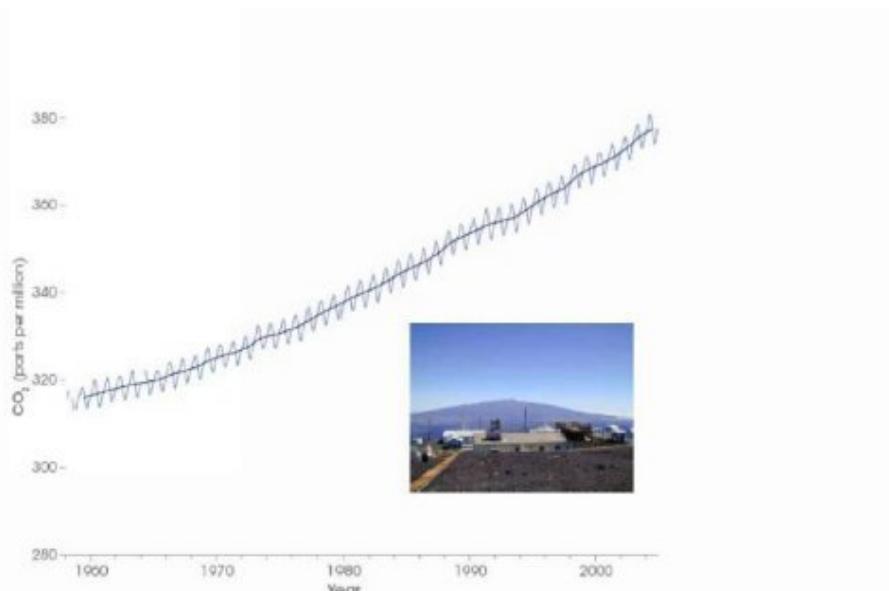


Figure 1. Atmospheric CO₂ concentration measured at Mauna Lab Observatory
Source: NOAA, Keeling Curve. <http://www.mlo.noaa.gov/home.html> (accessed August 24, 2009).

Limitations

Information for this research is limited to unclassified open source information found in the US Army's Fort Leavenworth Combined Arms Research Library, international government organizations, U.S. Government generated data, civilian institutions, World Wide Web, open source databases, and the author's education on the subject matter.

Delimitations

Information on environmental security concerns caused by climate change has a profound potential to reduce peace and stability. Relevant information should be available to Combatant Commanders and DoD strategic planners so that there is an improved understanding of the strategic environment. Relevant information containing projected regional security concerns such as conflicts due to water/resource scarcity or mass population movements into neighboring countries that pose a challenge to U.S. national security are considered. This research, while not a paper on climate change, does introduce the reader to environmental science data to establish a basis of understanding in order to analyze observed and future climate related changes. The goal of this research is to

illustrate near-term strategic challenges caused by climate change posing a significant threat to U.S. national security.

Assumptions

This paper makes three assumptions to establish a baseline for the research. First, issues relating to environmental security are not currently factored into strategic or service level organizations with enough specificity to provide Combatant Commanders and Service Chiefs with relevant information to prepare the force. Second, intelligence gathering does not account for near and long-term climate induced changes that pose a threat to U.S. national security. A yearly-publicized document such as an intelligence environmental security estimate similar to that proposed by Secretary of State Warren Christopher could provide DoD and interagency decision makers with needed specificity to help anticipate future hotspots. Finally, it is likely the strategic structure to address environmental security within the U.S. Government including the DoD is virtually nonexistent. A strategic structure or office can significantly contribute to an understand how decision makers can utilize available climate change data to adequately prepare the force, interagency, international community, and take advantage of synergistic effects realized from working in a combined team. The precedence set in many instances being the first to provide humanitarian/disaster aid along with its vast logistics capabilities, DoD with its expertise will play a lead role in climate related incidents by responding to disasters and civil unrest.

Significance of the Study

We are in a period where the window to take action to prevent climatic climate change is quickly narrowing. A growing number of estimates (Hansen 2008, 3) indicate we have less than a decade to take radical steps in order to significantly reduce the amount of greenhouse gases human activity release into the atmosphere. According to James Hansen, director of the NASA Goddard institute for space studies, "our home planet is dangerously near a tipping point at which human-made greenhouse gases reach a level where major climate changes can proceed mostly under their own momentum (Hansen 2008, 3). The Feedback effects James Hansen describes will cause unprecedented warming, shift the hydrological cycle thus causing massive human migration in a scale never before seen.

There are two goals to this study. First, this study identifies the likely effects climate change will cause over the next thirty years. It discusses how climate-induced change will exacerbate drought conditions, heat waves, and rising sea levels. The point of discussing expected change is to explore the actions the DoD should be taking to prepare the force to anticipate and react to serious threats to the homeland and mankind. Operation Iraqi Freedom and Operation Enduring Freedom have allowed the services to change doctrine and tactics from those adopted to fight a monolithic enemy to fighting irregular warfare wars. Yet it has taken a number of years to adapt intelligence gathering, tactics, and acquisition of systems to better fight irregular warfare. Unfortunately, time has become the most precious commodity; DoD has just a few years to prepare for massive-scale disaster relief operations at home and abroad. A second goal of this research is to take a look at the DoD's current progress in building awareness in those climate related changes that pose a threat to U.S. national security. Consideration of strategic documentation to include the National Security Strategy, National Defense Strategy, and National Military Strategy along with applicable Service doctrine is researched.

Background

Human awareness of anthropogenic induced climate change is a relatively recent discovery and the science is now mature enough where climate change can be projected within a reasonable range of certainty. Until fairly recently humans were not fully aware of threats to the environment caused by anthropogenic activity. In fact, American biologist Rachel Carson's seminal work *Silent Spring* released in 1962 was one of the first studies resulting in a book that identified food-chain poisoning caused by dichlorodiphenyl trichloroethane (DDT) used in pesticides and weed killer. Her book identified the effects of food-chain poisoning by tracing how DDT, once released into the environment makes its way through the food chain, killing or mutating vulnerable species. In another case, a small body of scientists, as early as the 1950s, hypothesized chlorofluorocarbons were likely depleting the ozone layer. NASA's Nimbus-7 satellite was the first satellite in 1980 to perform global ozone level measurements, thus proved their hypothesis correct by showing scientists ozone holes were indeed present at both

polar ends and adjoining lands (NASA 2009). Chlorofluorocarbons (CFCs) are entirely man-made; they are used in refrigeration and as a propellant in aerosol cans were the main culprits. The Montreal Protocol of 1987 called for the phase-out of CFC by 2010; however, the lingering effects of the gas will continue to degrade ozone for many decades to come. Now, newer models of meteorological satellites are sending imagery of increasing global heat patterns along with the capability to identify areas of thinning ozone. With the ability for satellites to collect weather data along with globally networked ground and oceanic monitoring devices, scientists began clearing-up lingering discrepancies in climate change data.

By the 1990s the science used to predict the effects of anthropogenic and naturally occurring greenhouse gases and aerosols matured to the point where a growing body of scientists acknowledged change was occurring. Meteorological satellites capable of measuring water vapor, global ozone levels, and temperature variances gave scientists the raw data needed to model global warming trends and its consequences. Further, a critical piece of data needed to reconstruct the planet's historical climate was locked deep in glacial ice sheets where air bubbles containing air and oxygen isotopes allowed scientists to recreate climate conditions present nearly a million years ago. In addition, during this period, the topic of environmental security began to gain traction in U.S. Government and DoD with the establishment of several key environmental security positions such as the National Security Council director for environmental affairs and the DoD's Deputy Undersecretary Defense for Environmental Security.

During the Clinton and George W. Bush administrations both presidents took the position the country was not going to be a signatory in the Kyoto Protocol. The Kyoto Protocol is an international agreement that sets binding targets for reducing greenhouse gas emissions. The U.S. is still the only major industrialized country refusing to implement provisions outlined in the Protocol. President Bush's "reservation echoed Clinton's--it might stall economic growth, and developing nations such as China and India were not required to comply--and cast a doubt on the scientific evidence that human activity drove climate change" (Campbell 2008, 10). As of February 2009, 183 states have signed and ratified the Kyoto Protocol. By not ratifying the Kyoto protocol the U.S. forfeited any ability to take a leadership role in developing climate change policy. Further, the U.S. sent a clear message to the world that as one of the largest (total and per-capita) contributor of greenhouse gases did not intend to alter its fossil fuel use. In retrospect, the US failed at an opportunity to lead the world out of the more serious effects of climate change that according to a growing body of scientific research is only a few decades away. In addition, as a leading per-capita greenhouse gases emitter, the U.S. will likely be asked with increasing frequency to assist governments not capable of handling large-scale relief operations for themselves.

According to climatologists at the NASA Goddard Institute for Space Studies (GISS), "2007 tied with 1998 for the Earth's second warmest year in a century" (NASA, 2009). See figure 2.

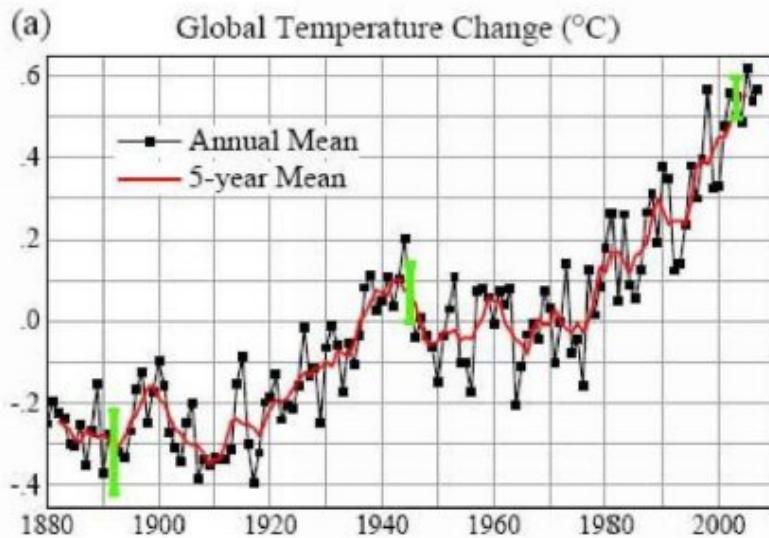


Figure 2. Global Annual Mean Surface Air Temperature Change

Source: NASA Goddard Institute for Space Studies. Datasets & Images.

<http://data.giss.nasa.gov/gistemp/graphs/> (accessed July 2, 2009).

In 2007 the IPCC released their Fourth Assessment Report (AR4), which was compiled by thousands of authors from dozens of United Nations (UN) member countries. AR4 confirmed what many U.S. scientists suspected for several decades, "most of the observed increase in global average temperatures since the mid-20th century is most likely due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC 2007f, 36).

It is evident with the Army's sponsorship of a conference on the National Security Implications of Global Climate Change and participation in the Center for Naval Analysis (CNA) conference on climate-induced challenges that the DoD in 2007 began to recognize that climate change has a significant potential to threaten national security. However, the lingering questions are how much warming will occur, how fast, and what areas will be affected? Surprisingly, the U.S. Government, almost two decades ago was better prepared to develop environmental security strategy than it is today. The DoD along with most U.S. Government agencies are in the process of determining how they will make institutional changes to better manage for climate change and develop an environmental security strategy. In March 2007, the U.S. Army War College sponsored a two-day conference on the topic "The National Security Implications of Global Climate Change." A major goal of the colloquium held in Chapel Hill, North Carolina was to provide insight to the consequences of climate change to military members, interagency, and academic researchers. General Weitz (Ret. USA) provided closing comments where he stated, 'it is now widely accepted that climate change can seriously threaten U.S. national security" (Pumphrey 2008, 408). In addition, on April 2007 the CNA issued a key report that received considerable press in the national security community because of its advisory board of retired senior general officers. General Zinni, one of CNA's climate change advisory board members speaking on issues relating the Middle East said, "you already have great tensions over water, it's not hard to make the connection between climate change and instability" (CNA 2007, 31).

Improvements in climatic science make it possible to predict with a high level of certainty the effects climate-induced change will have on earth. Models show which regions of the world will be impacted in the near future and demonstrate that the biggest security challenge confronting the U.S. is climate-induced change. Climate change is not an easy topic to understand and it is even harder to come up with mitigating factors to deal with the effects. The challenge now for the DoD is to act quickly at establishing an activity capable of analyzing all aspects of environmental security of climate change to properly prepare the force and provide policy makers with decision-making information that will lead to a comprehensive approach to national security implications resulting from climate change.

CHAPTER 2

LITERATURE REVIEW

The purpose of this research is to analyze existing open source U.S. Government documentation relating to climate change and national security. This chapter is divided into two broad topic areas that include climate science and strategic guidance which also include publications relating to climate change. Further, the paper reviews the latest available public accessible documentation, peer-reviewed research on national security impacts of global climate change. While many sources of information are used, the latest reports published by the Intergovernmental Panel on Climate Change (IPCC) assessments and the recently published Global Climate Change Impacts in the United States, by the U.S. Global Change Research Program were chosen because both research publications draw on a wide body of international, domestic, private and public sector experts. Both publications are cornerstone documents in this literature review. This chapter includes an introduction to climate change, impacts to the population from sea-level rise, ocean acidification, precipitation change, water availability, resource scarcity, national strategy, and other topics relevant to national security.

Climate change knowledge and disciplines such as meteorology and environmental science present humans with a relatively new understanding of how changes in climate will affect various regions around the globe. Looking back a few hundred years ago, recorded weather history in the U.S. dates back to the late 1700's when weather data was collected by Army Surgeons, Smithsonian observers, and the Naval Observatory until the mid-1800s (Grice 2005). In late 1870s the Army Signal Service began recording weather observations in Washington, D.C. until the U.S. Weather Bureau was established in 1891 as the office charged with observing and recording weather. The science of meteorology is also a recent practice dating back to 1861 when Francis Galton in his book *Meteographica* displayed weather charts showing areas of similar air pressure and interpreted weather data. In 1875, Galton published the first weather map in a London newspaper displaying regions of high and low pressure that forecasted weather conditions. Many of the meteorological methods established by Galton are still in use today to forecast the weather.

Until 1960, meteorologists relied on a network of over 1200 terrestrial climate-monitoring stations, aerial weather balloons, buoys, and weather reconnaissance aircrafts to make observations and forecast weather events. During this period, most weather stations were not networked and there were few timely systems in-place to give scientists and meteorologist a comprehensive global awareness of changing weather patterns. On April 1, 1960 NASA launched the world's first weather satellite. The Television Infrared Observation Satellite (TIROS-1) was a polar orbiting craft that sent thousands of images back to the ground station at Fort Monmouth, New Jersey (Alfred 2008). As recently as July 15, 2004, NASA launched Aura; dedicated to giving scientists greater ability to monitor complex interactions such as global ozone levels, ocean temperatures and polar ice melt trends.

Much of climate related science is new and there remains skeptics who challenge the accuracy of historical weather observation data. However, scientists do have 800,000 years of recorded carbon dioxide concentration data trapped in Antarctic ice core extractions. Like a buried time-capsule, the trapped air bubbles along with sediment deposits allows scientists to chart carbon dioxide levels which closely correlates to historical global temperatures. Another important discovery occurred in the mid-1950s when chemist Charles Keeling began taking air samples across the U.S. with the purpose of analyzing the amount of carbon dioxide gas present in his air samples. In his lab at the California Institute of Technology, he conducted precise measurements and discovered the level of carbon dioxide was nearly the same at every location sampled--310 to 315 parts per million (ppm). In 1958, Keeling began graphing levels of carbon dioxide taken at the Mauna Loa Observatory in Hawaii. The graph (figure 1), or Keeling Curve, helps anchor the debate about climate change in undisputable facts. As of August 2009, carbon dioxide measurements at the Mauna Loa Observatory registered at 385ppm--an increase of approximately 73ppm in half a century.

Climate Change

What is climate change? Simply stated, it refers to "any change over time, whether due to natural variability or as a result of human activity (IPCC 2007e, 26). This condition results in long-term, unbalanced weather cycles and shifts in hydrological patterns--ultimately leading to profound scarcity of resources. Scientists have known for

over a hundred years that adding significant quantities of carbon dioxide to the atmosphere raises the planet's temperature. This basic principle is known as the greenhouse effect and is caused by greenhouse gases, predominately carbon dioxide, but also chlorofluorocarbons, methane, nitrous oxides and an increase in water vapor. Scientists have also determined there is a correlation, between global temperatures and the level of carbon dioxide. In fact, 11 of the 12 warmest years on record have occurred since 1995 (NOAA 2009). Further, the authors of the recently released study from the U.S. Global Change Research Program attribute much of the warming due to burning fossil fuels. Below is an excerpt of their findings:

Observations show that warming of the climate is unequivocal. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. These emissions come mainly from the burning of fossil fuels (coal, oil, and gas), with important contributions from the clearing of forests, agricultural practices, and other activities. (USGCRP 2009, 13)

According to John Houghton in his book titled Global Warming, he attributes the main driver of climate change is human activity related to deforestation, transportation and in particular those activities that release carbon dioxide into the atmosphere. An increase in carbon dioxide acts like a blanket over the earth, keeping it warmer than it would otherwise be. As temperatures increase, so does the amount of evaporated water vapor in the atmosphere which causes a greater blanketing effect, thus causing temperatures to remain higher (Houghton 2004). One of the problems with the casual observation of climate change is that it is not obviously noticed because it is disguised by day-to-day weather fluctuations. To the casual observer it may seem that events such as heat waves, drought and more intense storms are anomalies. The fact is, in the decades to come climate-induced changes are expected to continue and will profoundly affect human health, water availability and agriculture.

Water Resources and Changes in Precipitation

A great deal of information is available on the topics of water resources and the changing cycles of precipitation. Lester Brown's Plan B 3.0 discusses how several regions around the world are in a state of "soaring demand for irrigation water coupled with declining rainfall" replenishing lakes and aquifers. According to Brown, water demand has tripled over the last half-century and demand for hydroelectric power has grown even faster (Brown 2008, 75). Already, water reservoirs around the planet are rapidly disappearing. Africa's Lake Chad bordered by Cameroon, Chad, Niger and Nigeria has receded to less than 20 percent of its former volume (BBC 2006). Global warming coupled with an unsustainable rate of water extraction required to provide drinking water and irrigation for the population surrounding Lake Chad is compounding the problem. In another example, the Jordan River, once a mighty river, provides much of the water used in Israel and Palestine. It is now a trickling stream during the summer months. Rapid population growth and drier summer months are contributing to decreased water availability. Water scarcity caused by climate change and higher than sustainable demand will be among the early climate related conflicts to take place in the 21st century. According to Brown, climate change is now affecting water supplies mainly because rising temperatures are increasing evaporation rates and altering earth's hydrological cycle. In a famous quote, Boutros Boutros-Ghali said: The next war in the Middle East will be fought over water and not politics."

As climate change progresses, warming will shift hydrologic cycles, affecting freshwater availability, reducing crop yields, ultimately leading to a scarcity of resources. Findings presented in State of the World 2009, indicate agriculture in the tropics, which are predominantly poor developing African countries are projected to be adversely affected even at low levels of warming. These findings are in agreement with those identified in the 2009 Global Climate Change Impacts in the United States, which point to prolonged drought periods in lower latitudes. Early evidence of climate change is being observed in many areas around the globe where water scarcity is quickly becoming a concern. Because water is intertwined with agriculture, water scarcity will also have a direct impact on food production. In addition, climate change along with higher population levels, are stressing aquifers, lakes, and rivers around the globe. According to findings published by the U.S. Global Change Research Program, changes in precipitation are consistent with the warming observed over the past several decades. The U.S. is already beginning to experience changing patterns and intensity in precipitation. This is because warmer global temperatures contribute to a greater rate of evaporation resulting in increased atmospheric water vapor. Increased atmospheric water vapor, along with the need to redistribute heat, is contributing to changes in atmospheric circulation that tend to move storm tracks northward resulting in dry areas becoming drier and wet areas wetter (USGCRP 2009, 42). In addition, several reports on the topic point to changes in precipitation will continue to become more regionally

concentrated as global temperatures rise and will be more intense with longer periods between rainfalls that will lead to increases in drought and desertification. When rain does occur, the intensity will cause flooding, leading to soil saturation and runoff. In the U.S. alone, the combination of longer dry periods and heavier rain conditions will significantly reduce existing crop yields, shift northward in growing zones, and decrease fresh water supplies.

Sea Level Rise and Ocean Acidification

During the twentieth century, recorded data show that the average sea-level rose by between 10 and 20 cm (Church 2006). The largest contribution during this period was from thermal expansion of ocean water; as oceans warm the water expands which in-turn cause sea-levels to rise (Houghton 2005). Melting of glaciers is another significant contributor to sea-level rise. Rising sea-levels have a significant potential of displacing tens of millions of people in the Caribbean, Pacific islands and along the U.S. coasts predominately the Atlantic which in some areas have experienced over eight inches of observed sea-level rise in the last fifty years. "Coastal water temperatures have also risen by about 2 degrees Fahrenheit in several regions, and the geographic distributions of marine species have shifted (USGCRP 2009, 149). According to the Intergovernmental Panel on Climate Change (IPCC) baseline global greenhouse emission model show sea level rise is "expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities" (IPCC 2007b, 15). Currently, models used to predict sea-level rise provide a moderate level of accuracy mainly because many factors such as the amount of deglaciation of Greenland and West Antarctic ice sheets, feedback, and amount of heat the oceans can store before significant thermal expansion occurs, presents a large range of variables. For example, the IPCC Special Report on Emissions Scenarios (SRES) predicts a range of sea-level rise between 13 and 20 feet over the next few centuries (IPCC 2007d, 17). The amount of sea-level rise mainly correlates with continued greenhouse gas emission at or above current rates, which will accelerate climate change, causing acceleration in sea level rise. During this century, models show the potential of a 6.6 to 9.8 feet sea level rise towards the end of the 21st century (Campbell 2008, 160). In addition, by "mid-century, climate change is expected to reduce water resources in many small islands, for example in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods (IPCC 2007b, 16). Rising sea levels caused by climate change has the significant potential of displacing approximately a third of Americans who live in areas immediately bordering the coasts (Crowell 2007, 23) and populations of the Pacific and Caribbean islands. Together, these populations total more than 40 million people (USGCRP 2009, 145).

Equally as serious as sea-level rise is ocean acidification. Of the total amount of human generated greenhouse gases, approximately half is absorbed by the oceans, making them more acidic. Higher levels of absorbed carbon dioxide cause carbonic acid to form contributing to a decrease in ocean pH level by 0.1 unit. A decrease in pH produces an increase in acidity while an increase in pH produces an increase in alkalinity. This situation has made the oceans more acidic than pre-industrial times (State of the World 2009, 69) (pH is a numeric value that indicates the relative acidity or alkalinity of a substance on a scale of 0 to 14. Since pH is a logarithmic scale, a decrease of 0.1 unit is an approximate increase of 30 percent more acid) (Kleypas 2005). An increase in acidity has a direct impact on thousands of marine species that depend on calcium carbonate to build shells and skeletons, thus decreasing the ability of marine species such as corals, crabs and lobsters to use available calcium carbonate, to survive. A lower pH level also has a diminishing effect on tiny plankton organisms which serve as the base of marine food chains. Lower yields of crab and fish is already being detected at the base of food chains off Alaska and in the North Atlantic (State of the World 2009, 69).

Meridional Overturning Circulation

According to IPCC models, it is very likely that the slowing of the Meridional Overturning Circulation (MOC) will occur during this century. The MOC moves warm upper waters into northern latitudes via the Gulf Stream and returns colder waters deep across the equator. The MOC is also responsible for moving heat across the Atlantic Ocean contributing to the moderate climate of maritime and continental Europe.

Introducing high quantities of fresh water from polar ice melt or shifts in planet heat distribution can disrupt or slow the MOC, resulting in changes to "marine ecosystem productivity, fisheries, ocean carbon dioxide uptake, oceanic oxygen concentration and terrestrial vegetation" (IPCC 2007b, 17). In general, modeling shows that MOC changes will contribute to an increase of warming in select global regions because redistribution of surface heat

into deep oceans will diminish. Changes to the MOC will cause global precipitation patterns to decrease in certain areas, with changes more noticeable in "North Africa, the Middle East, Central America, the Caribbean, and northeast South America, including Amazonia" (Campbell 2008, 79). Climate models show increased precipitation will occur in the "eastern U.S., Canada, East Africa, northern eastern Asia, and southeast Asia" (Campbell 2008, 79). Finally, a MOC disruption, slowing, or collapse will contribute to an increase in sea-level in the north Atlantic region. The amount of sea-level increase is tied to the percentage of the MOC's capability to transport heat. For example, a slowing of 10 percent may have an effect of a few inches of sea level rise, while a MOC slowing of 60 percent or greater may contribute up to three feet of sea level rise in the north Atlantic. Several IPCC climate scenarios indicate it is unlikely that the MOC will "undergo a large abrupt transition during the twenty-first century" (IPCC 2007b, 17). Modeling in this area is still evolving and it is likely climate scientists will be able to develop MOC models which provide tighter timelines and impacts in the near future.

What Climate Change Does

Climate change will increase the acreage of heat-stressed forests, which are quickly becoming vulnerable to pest infestation such as the pine beetle epidemic in the Rocky mountain region. According to a top U.S. Forest officials, "The pine beetle epidemic chewing through forests in Wyoming and Colorado could endanger roads, power lines and other infrastructure as millions of acres of trees fall to the ground" (Joyce 2009). Further, higher temperatures and a growing population is projected to increase water demands over most of the U.S., leading to a dramatic decrease in water supplies especially in west and southeastern regions of the country. The countries' population carrying capacity will significantly decrease.

In his Tipping Point paper, Dr. James Hansen, director of the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies warns of a potential climate change tipping point where greenhouse gases reach a level where major climate changes occur under their own momentum. According to Hansen, at the current rate of greenhouse gas emissions, a tipping point where the earth's climate goes into a fast feedback where changes occur quickly in response to temperature change can happen in two to three decades (Hansen 2009, 13). One example of feedback cited by Hansen and other scientists is the thawing of huge quantities of organic material locked in frozen tundra such as in northern Canada or northern Russia, which has the potential of releasing billions of metric tons of methane into the atmosphere. Molecule for molecule, methane traps 26 times more heat than carbon dioxide and is persistent for a much longer period of time. How far are we from reaching a tipping point? A wide and growing body of scientists from the IPCC and NASA believe we are at the threshold of entering a climate change feedback cycle where change will begin feeding on itself and there would be little humans could do to stop runaway climate change from occurring. There appears to be growing consensus that reaching 450ppm carbon dioxide is the maximum allowable carbon dioxide level before a runaway climate change feedback begins to occur. As of August 2009, atmospheric carbon dioxide levels were recorded at 385ppm--two years ago, carbon dioxide levels were recorded at 381ppm. At current global greenhouse gases emission trend, we will reach a climate change tipping point where runaway feedback will occur by the year 2050. Yet there are signs the planet is already heading to a tipping point and the threshold of 450ppm may actually be lower, causing runaway climate change to come sooner than projected. James Hanson has written extensively on this topic, here's a quote from a recent writing:

The warming that has already occurred, the positive feedbacks that have been set in motion, and the additional warming in the pipeline together have brought us to the precipice of a planetary tipping point. We are at the tipping point because the climate state includes large, ready positive feedbacks provided by the Arctic sea ice, the West Antarctic ice sheet, and much of Greenland's ice. Little additional forcing is needed to trigger these feedback and magnify global warming. If we go over the edge, we will transition to an environment far outside the range that has been experienced by humanity, and there will be no return within any foreseeable future generation. (Hansen 2008, 4)

IPCC Fourth Assessment Report

A literature review on climate change impacts to national security would not be complete without covering the landmark IPCC Fourth Assessment Report (AR4) released to the public in February 2007. The organization's AR4 builds on the 2001 released Third Assessment Report and benefits from improved science, observation techniques and a more mature team organization. Al Gore used much of the data from AR4 in his book and the

documentary movie on climate change An Inconvenient Truth. In December 2007, both the IPCC and Al Gore were awarded the Nobel Peace Prize "for their efforts to build and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change"(Nobel Foundation, 2007).

The AR4 is based on observed climate change and develops a series of models to illustrate trending levels of greenhouse gases emissions that will impact global climate change. The IPCC is the United Nations' leading body for the assessment of climate change; composed of more than 800 contributing authors, 2,500 scientific experts from 130 countries. In their report, the IPCC concluded that human activity has increased global atmospheric concentrations of greenhouse gases and concludes that "warming of the climate system is unequivocal." Several climatologists and authors believe IPCC's findings may be too conservative and do not reflect the true severity of the problem. For example, James Hansen believes we may have a decade or two before we reach a tipping point of where climate change begins feeding on itself, while IPCC general findings tend to place severe climate change towards mid-21st century. A review of IPCC's administrative function points to the fact that the organization does tend to be a conservative body, which can only make a statement by unanimous consent of all the scientific representatives of the world's participating governments.

In order to produce AR4, the IPCC divided the team into three Working Groups and a Synthesis Report group tasked to develop the IPCC report released to the public and policy makers. Working Group-1 published the Physical Science Basis report, Working Group-2 published Impacts, Adaptations and Vulnerability report, Working Group-3 published Mitigations of Climate Change report, and the Synthesis Group published the Summary for Policymakers.

The Physical Science Basis report builds on IPCC Third Assessment Report findings by using improved modeling techniques and a wider range of observable data. Vast improvements in computing power coupled with a better understanding of environmental and climate science allowed for greater sophisticated analysis of data and extensive exploration of environmental uncertainty ranges. Figure 3 is a product from AR4 that displays a comparison of global and continental temperature change in surface temperatures with results simulated by climate models using natural and anthropogenic forcing (IPCC 2007d, 11). This shows that the models do replicate the historical records over the period of large-scale carbon dioxide increases and that natural causes do not account for the increase of temperatures for this period.

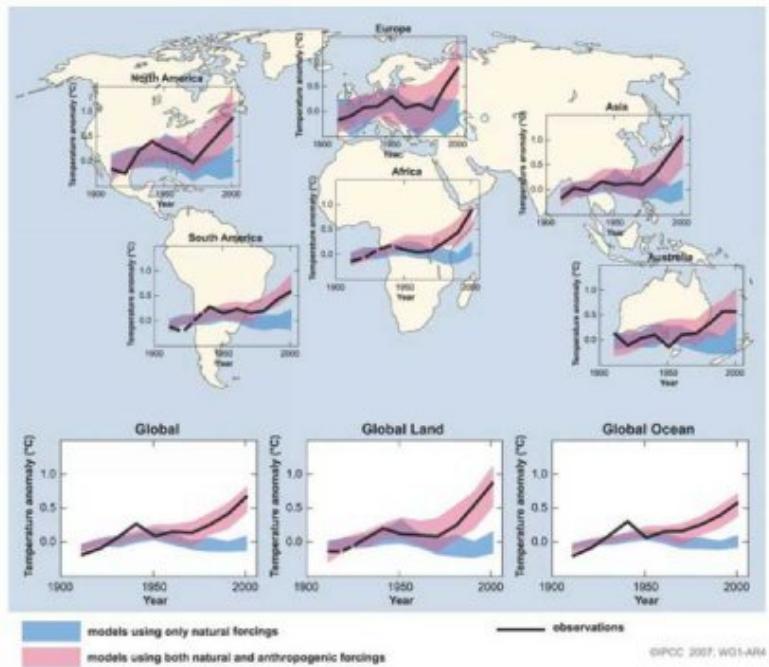


Figure 3. Comparison of Observed Continental and Global-Scale Changes in Surface Temperature

Source: IPCC, Synthesis Report, *Climate Change 2007*, Contribution of Synthesis Working Group to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (New York: Cambridge University Press, 2007), 40.

The Impacts, Adaptations and Vulnerability report builds on the findings of WG-2 along with a larger amount of evidence that has accumulated between CY 2002-2007 to project future environmental changes based on climate change trends. Further, the report's purpose is to assess studies of observed changes related to recent regional climate change. Several of WG-2 findings show that at current emission levels, recent climate change and climate variations such as sea-level rise, melting glaciers, flooding, drought, wildfires, growing insect populations, and ocean acidification will have an unprecedented effect on people and the environment this century. The "magnitude and timing of impacts will vary with the amount and timing of climate change" and, in some cases the capacity for ecosystems to adapt will likely be exceeded (IPCC 2007b, 11). Further, the Impacts, Adaptations and Vulnerability report provides specific information across the regions of the world on the nature and future impacts of climate change. Following is a limited summary of expected climate changes in North America through the 21st century:

1. The vulnerability of North America depends on the effectiveness and timing of adaptation and distribution of coping capacity. Adapting infrastructure to cope with altered water levels and achieving exiting water quality goals will be difficult and expensive (IPCC 2007a, 629).
2. Sea-level is rising along much of the coast, and the rate of change will increase in the future, exacerbating the impacts of progressive inundation, storm-surge flooding and shoreline erosion. Impacts on coastal communities and ecosystems will become more severe (IPCC 2007a, 619).
3. Climate change will further constrain North America's over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses. (IPCC 2007a, 619)
4. Climate trends and modeling indicate that by "the 2010 to 2039 time slice, year-round temperatures across North America will be outside the range of present-day natural variability." Areas that currently experience

heat waves are expected to experience an increase in intensity and duration of these events (IPCC 2007a, 626).

5. Disturbances such as, wildfire and insect outbreaks as well as the incidence of infectious diseases are increasing and are likely to intensify in the warmer future. Further, the report observes a rapidly growing trend in forested areas burned in the western U.S. From 1987 to 2003 forest fires have burned 6.7 times the area burned from 1970 to 1986 (IPCC 2007a, 623).

The Mitigations of Climate Change report published by WG-3 concentrates on the scientific, technological, environmental, economic, and social aspects of mitigating climate change. This report introduces four (A1, A2, B1, B2) plausible emissions, economic and population based scenarios groups while introducing policy considerations that can be adopted in order to maintain a modern standard of living in tandem with controlling greenhouse gasses released into the atmosphere. The report takes a multifaceted approach of industrial and lifestyle change along with implementation of the latest efficiency technology and strong governmental regulatory policies to control emission of greenhouse gases.

Finally, the Synthesis Report is grounded in research and assessments developed by the three working groups. It provides an integrated and comprehensive summary of the scientific, economic and technical studies presented in the three reports. While the Synthesis Report does not present new findings, it provides the reader with upfront facts without the voluminous references provided in the three working group reports. The figure below shows the distribution of regional per capita greenhouse gases emission. The U.S., with one of the smaller populations, is among the leading countries emitting greenhouse gases.

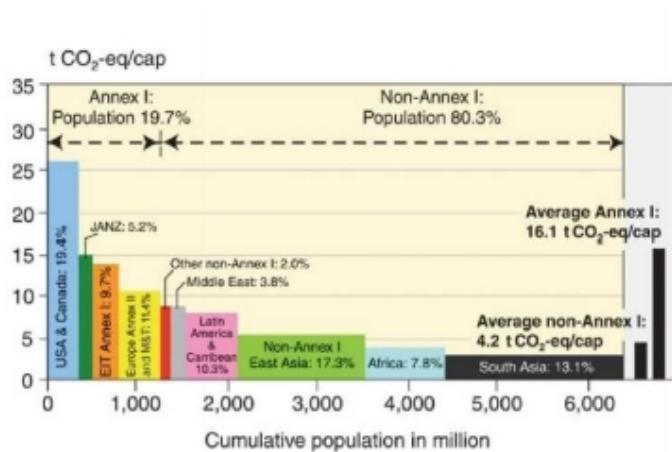


Figure 4. Regional Distribution of GHG Emissions by Population and GDP.
Source: IPCC, Synthesis Report, *Climate Change 2007*, Contribution of Synthesis Working Group to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (New York: Cambridge University Press, 2007), 37.

Global Climate Change Impacts in the United States

In 2009, the U.S. Global Change Research Program published their findings and projections in their Global Climate Change Impacts in the United States report. The purpose of the report is to use recent scientific climate change data along with observed trends to determine how the U.S. will be impacted. In its opening executive summary, the authors point to the fact, "Observations show that warming of the climate is unequivocal" (USGCRP 2009, 9).

One significant finding in the report is conclusive data that shows U.S. average temperature have risen more than 2 degrees Fahrenheit over the past 50 years (USGCRP 2009, 28). To help determine impacts of future temperature increase, the study team developed two greenhouse gases emission scenarios, partly based on the

IPCC Special Report on Emissions Scenarios (SRES) B1 (lower emissions (LES)) and A2 (Higher emissions (HES)). The HES is based on current global output of greenhouse gases. Under the HES, projected temperatures will average 7 degrees Fahrenheit by mid-century (2040-2060) and 11 degrees Fahrenheit by end-of-century (2080-2099) (USGCRP 2009, 29).

Even under a concerted global effort to reduce greenhouse gases, data shows that under LES, projected temperatures will average 5 degrees Fahrenheit by mid-century (2040-2060) and 7 degrees Fahrenheit by end-of-century (2080-2099) (USGCRP 2009, 29). By 2025 a combination of population increase and higher temperatures caused by climate change will lead to water supply conflicts in the west and southeastern U.S. (USGCRP 2009, 48). Moreover, in the near-term, increasing temperatures will accelerate forest fires in the west requiring military assistance in the form manpower and aerial assets. The report by the U.S. Global Change Research Program on Global Climate Change Impacts in the United States is considered the most up-to-date and authoritative document on climate impacts in the U.S. While the report bases estimates on IPCC AR4, it combines this data with recent information from 13 U.S. Government science, policy, energy agencies and 21 scientific groups to include US universities, the private sector and representatives from Canada. The report's ten key findings are:

1. Global warming is unequivocal and primarily human-induced.
2. Climate changes are underway in the U.S. and are projected to grow.
3. Widespread climate-related impacts are occurring now and are expected to increase.
4. Climate change will stress water resources.
5. Crops and livestock will be increasingly challenged.
6. Coastal areas are at increasing risk from sea-level rise and storm surge.
7. Risk to human health will increase.
8. Climate change will interact with many social and environmental stresses.
9. Thresholds will be crossed, leading to large changes in ecosystems.
10. Future climate change and its impacts depend on choices made today.

Strategic Guidance

Given IPCC observed trends and the current knowledge on future impact, climate change is rapidly becoming a matter of national security. Projected effects of climate change pose a dangerous threat to U.S. national security and life, as we know it. Disappointingly, today the DoD and U.S. government is less prepared to collect and analyze data relating to climate change trends that threaten national security than it was almost two decades ago. By contrast, in the early 1990s the DoD and several key government agencies had dedicated personnel to analyze climate change threats. For example, the National Security Council had a director for environmental affairs and the DoD had a deputy undersecretary defense for environmental security--both positions were eliminated. As of this writing, the DoD does not appear to have a strategic framework in place to analyze potential climate change related threats to national security.

Prior to SECDEF releasing the 2008 National Defense Strategy, much of the available national strategy reveals a mixed trend in giving environmental security significant consideration. Starting with policy set by the executive branch, the U.S. National Security Strategy (NSS) is a document prepared periodically by the executive branch, which outlines major security concerns and serves as a guide for all areas of national government to align their internal strategic direction with those of the President's vision. One of the important national interests identified in the December 1999 NSS is "protecting the global environment from severe harm" (NSS 1999, 1). Six

years later, the March 2006 NSS signed by President George W. Bush again makes mention of climate related events. Chapter 6 states that the U.S. has "joined with Australia, Japan, and the ROK in forming the Asia-Pacific partnership for clean development and climate to accelerate development of clean technologies to enhance energy security, reduce poverty, and reduce pollution." Further, the 2006 NSS in chapter 10 begins to acknowledge environmental destruction caused by human behavior and cites the environment as an opportunity to engage the global community. Between 1999 and 2006 the environment, along with climate change impacts to national security, took a back seat to more pressing issues such as combating terrorism, the Bush doctrine of preemptive war, Operation Enduring Freedom in Afghanistan, and Operation Iraqi Freedom.

The National Military Strategy (NMS), which is derived from the NSS, addresses the application of military power to help attain national objectives. The Joint Chiefs of Staff in consultation with Unified Combatant Commands, and the Office of the Secretary of Defense produce the document; final release authority is the Chairman of the Joint Chiefs of Staff (CJCS). The Chairman determines when to revise the NMS. The 2004 NMS released by CJCS General Richard B. Myers makes no mention of environmental security relating to climate change. The same is true for the National Military Strategic Plan for the War on Terrorism released 1 February 2006 by CJCS Gen Peter Pace, which mainly focuses on threats posed by terrorism, weapons of mass destruction, and other asymmetric threats.

Looking at the science and policy writings relating to climate change and national security reviles that the periods between the 1990s and halfway through the first decade of the twenty-first century have several vicissitudes in respect to administrative positions taken on climate change science. In addition, that period shows a mixed trend in the importance policy makers were willing to take action on reducing greenhouse gases. Part of the reason for the discrepancy is because climate change is going to affect different nations to different degrees, however, in the end will affect every nation. Furthermore, "special interests have undue sway with our governments and have effectively promoted minimalist actions and growth in fossil fuels, rather than making the scale of investment necessary" (Hansen 2008, 13).

As with all subject matters, there are the contrarians or skeptics such as Dr. Richard S. Lindzen, a professor of meteorology at the Massachusetts Institute of Technology who has been a critic of several global warming theories. In his May 2001 testimony to the U.S. Senate Commerce Committee, Dr. Lindzen told Senator McCain and other members regarding climate science that, "much of what informed scientists agree upon is barely quantitative at all" and "that man, like the butterfly, has some impact on climate" (john-daly). He further told the committee that the "IPCC was created to support the negotiations concerning carbon dioxide reductions" (john-daly).

While the 1990s through late 2005 may have been the period of uncertainty concerning climate change, 2007 was the year of awakening. A number of events and information helped solidify climate change is occurring and it is mostly due to the burning of fossil fuels and it poses a profound threat to national security. Much of the literature published after 2006 on climate change and threats to national security demonstrate a significantly improved understanding of climate science and the implications continued trend of greenhouse gases will result in. In 2007, Senators Richard J. Durbin (D-IL) and Chuck Hagel (R-NE) introduced a bill requesting a National Intelligence Estimate produced by the Central Intelligence Agency and the Pentagon to assess national security implications of climate change (Busby 2007, 1). Also in 2007, NASA's Goddard Institute for Space Studies announced global average surface temperature in 2007 tied those of 1998 as the warmest instrumental recorded year dating back to 1880. According to NASA, the record for the warmest recorded year is 2005, which also brought Hurricane Katrina, one of the five most costly and deadliest in U.S. history. Hurricane Katrina devastated Mississippi coastal cities of Pascagoula where one the U.S. Navy's main shipyard is located costing over 1 billion dollars to restore and Biloxi, where Keesler AFB saw water levels rise six feet in a few locations. The Air Force spent hundreds of million to restore the base's operational capability. Hurricane Katrina however, is best known for the major damage caused by several breaks in the city's intricate levy system. In some ways, Hurricane Katrina gave the U.S. Government a small glimpse into what future impacts from climate change will look like. For the DoD, Hurricane Katrina should have raised the question of how the Department will select future placement of key infrastructure. The Quadrennial Defense Review (QDR), along with the Base Realignment and Closure process are good policy documents to administer execution. In respect to climate change, the department does not have a long-term vision document such as the JCS Joint Vision 2020 to help the Department forecast climate change trends, especially those that threaten infrastructure.

In third place, for the warmest recorded year is 2003 which brought about many strange weather occurrences, including a blistering heat wave that swept across much of Europe, resulting in a French death toll of 14,802 and an overall European death toll of over 19,000 (USA Today 2003).

In late March 2007, the U.S. Army War College sponsored a multiday conference at the Triangle Institute for Security Studies on the topic of National Security Implications of Global Change. The main purpose of the conference was to consider how climate change would create new implications for national security and policy (Pumphrey 2007, 4). Participants included professors, research fellows, government representatives, active-duty and retired military officers who presented on a wide range of topics touching on the consequence of climate change, threats and concerns for the U.S. national security. Among topics discussed was the military's role in environmental security and disaster prevention, response and recovery. Several presenters touched on this topic noting how it is becoming an acceptable military mission and an essential element of regional stability (Pumphrey 2007, 9). A review of the U.S. Army Operations doctrinal publication introduces the operational environment and discusses how climate change and natural disasters will compound already difficult conditions in developing countries while causing humanitarian crisis and destabilize regions (FM 3-0 2008,1-7). Colloquium attendees stressed that to have an effective response in the environmental security arena it will likely require multiagency cooperation especially for domestic emergency management and multinational action (Campbell 2008, 16). There are several advocates for military-to-military cooperation and a multinational approach to environmental security. Among them is Dr. Busby, a member of the Council on Foreign Relations, who is a proponent for the U.S. government to develop a "multiyear program with militaries from Africa, Central Asia, South Asia, Latin America, and the Middle East to help facilitate efforts between militaries, thus creating better mutual understandings and cooperation (Busby 2007, 12).

In April 2007, the Center for Naval Analysis (CNA) Corporation released their report, which takes a top-level approach to national security consequences of climate change. The study included a military advisory board to answer how climate change could affect national security over the next 30 to 40 years. The period of 30 to 40 years was selected because that is roughly the amount of time it takes to acquire and build major weapon systems. Specifically the authors, supported by twelve well known retired flag and general officers, set out to answer three questions; What conditions are climate change likely to produce around the world that represent a security risk, What conditions may affect America's security interests, and what actions should the nation take to address national security consequences of climate change? Much of the science and conclusive information published by the authors is similar to conclusions published by the IPCC and NASA's Goddard Institute for Space Studies. For example, the authors acknowledged the effects of climate change over the coming decades include extreme weather events, droughts, flooding, sea-level rise, habitat shift, and life-threatening disease. Scientific data was used to determine under what conditions the nation will be asked to, with allies or unilaterally, aid in the restoration of weakened and failing governments. In considering all of the challenges, the CNA panel made the five recommendations:

- 1. The national security consequences of climate change should be fully integrated into national security and national defense strategy and require the intelligence community to incorporate climate consequences into its National Intelligence Estimate.**
- 2. "The U.S. should commit to a stronger national and international role to help stabilize climate change at levels that will avoid significant disruptions to global security and stability.**
- 3. The U.S. government should use its many instruments of national influence, including regional commanders to build partnerships that help less developed nations build the capacity and better manage climate change.**
- 4. "The DoD should enhance its operational capability by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power through energy efficiency."**
- 5. "The DoD should conduct an assessment of the impact on U.S. military installations worldwide of rising sea-level, extreme weather events, and other projected climate change impacts over the next 30 to 40**

years."

It is unknown what influence the IPCC, and various DoD sponsored colloquiums had on the National Defense Strategy (NDS) approved by Secretary of Defense Robert M. Gates, but the NDS represents a transformation in the department's traditional stance in environmental security and climate change. The 2008 NDS takes inputs from the President's 2006 NSS, results from the 2006 Quadrennial Defense Review and lessons learned from on-going operations to develop the NDS, which serves as the Department's strategic blueprint. The latest NDS acknowledges the effects of climate change over the next twenty years in addition to population-pressure, resource, energy, and the environment could combine with rapid social, cultural, technological and geopolitical change to create greater uncertainty (NDS 2008, 4). The NDS further states that environment and climate pressures may generate new security challenges, such future challenges require the Department to begin planning and prepare for climate related changes with existing and future resource. This document is an important step in shaping the Department's mindset. Moreover, it considers future effects of climate change in many aspects of operations from intelligence gathering, planning, and acquisitions of major weapon systems. Clearly, the NDS promotes developing partnerships for new situations to assist other countries in improving their security. Placed in the context of environmental security missions, future humanitarian aid and security cooperation missions will most likely occur in southern Asia, Africa, and the Middle East in order to help governments build management capacity. Many of the governments in this region do not have the resources or training to cope with resource scarcity or mass population movements resulting from climate change. By working with governments who are vulnerable to climate change, the U.S. and its allies can help stem much of the violence and disruptions that will occur.

The Obligation of the U.S.

An underlining theme not fully explored in much of the literature is the obligation of the U.S. to respond to environmental degradation. Domestically, the U.S. military is already responding to threats to the homeland in the form of assisting California and other state firefighters combat intense wildfires which every year burn more acreage than the previous. U.S service members also assist the Border Patrol and provide reconnaissance assistance to the U.S. Coast Guard to help protect our maritime borders. However, internationally the U.S has "incurred an obligation to sustain the global environment that supplies the resources this country thrives on" (King 2000, 6). The U.S has also incurred a responsibility to provide aid because historically it is the largest emitter of greenhouse gases. There are greenhouse gasses in the atmosphere dating back to the industrial revolution, which the U.S. greatly contributed. Internationally, the U.S. is already seen as a climate-villain and the data is widely available to back-up those claims. Finally, the U.S. historically has set precedence for providing aid to countries that have suffered from a natural disaster. The aid-provider precedence is already established and the international communities along with our allies will look to us for assistance and leadership--it is unequivocal.

Summary

In summary, this literature review demonstrates that humans recently became aware of the effect on climate. Climate change science along with the instruments to measure, collect and analyze data began maturing in the 1980s with advent of sophisticated satellites, globally networked sensors and computers capable of producing more realistic global climate models. Environmental Security in the 1990s began to gain traction, however during the George W. Bush administration environmental security along with implications of climate change on national security did not place high on the list of priorities. As such, much of the organizational structure required today to access climate based threats is not in place. The period after 2006 brought with it results of years and in some cases decades of work with the release of the IPCC AR4 findings in 2007 and the 2009 Global Climate Change Impacts in the U.S. study. Both studies, which are brilliant combinations of science and collaboration, confirm the planet is headed for a warming trend induced by an unprecedented levels of greenhouse gas emissions. We are at the point where we know enough to act even within the range of uncertainty that still exists. Some of the variations that do exist are in the areas population growth, utilization of resources and most important release of greenhouse gases. All models do indicate if the governments of the world take little or no action to curb greenhouse gases emission in this coming decade the planet as James Hansen predicts, will reach a tipping point where climate change begins feeding on itself. Such a scenario has a real potential to wipeout a majority of the population and species on the planet. On the opposite end, an aggressive move to stabilize and begin reducing greenhouse emissions will slow the effects of climate change allowing governments and population greater time to adjust. The military will be

called-up with increasing frequency. The latest version of the NDS clearly demonstrates a transformation in the Department's strategic thinking. In a number of NDS chapters the Secretary of Defense clearly sends a message that the Department needs to begin preparing for environmental security related missions. That preparation includes working with our allies to begin building governmental capacity to those nations most vulnerable to climate change induced events. At this point, what appears to be lacking is a strategic will in the executive branch and DoD so that clear planning guidance from the top can be disseminated the strategic planning staff.

CHAPTER 3

ANALYTICAL RESEARCH METHODOLOGY

This thesis attempts to answer the primary research question: How should the Department of Defense approach environmental security implications of climate change? The primary question is supported by the two following questions: (1) Does the Department have an environmental security direction? (2) What conditions of climate change are likely to provide security risks to the U.S. in the near term? The answers to the secondary questions assist to adequately frame the problem, explore variables, and develop a proposed response to the primary research question.

The literature review focused on three broad category of documentation, which are: Climate/Science/Environment, Strategic Guidance, and Current DoD publications. To determine the magnitude of security challenges that may result from climate related changes, the literature on the most up-to-date climate related science published by the international and domestic community was reviewed thoroughly. This is essential in order to ascertain the Department's priority in dedicating resources or incorporating environmental security into the planning process. A review of strategic level documentation to include the National Security Strategy, National Defense Strategy, and National Military Strategy assisted the researcher to establish a historical trend and determine whether the Department has a position on environmental security. The third category of information reviewed is service level documentation such as field manuals along with studies published by the Army Environmental Policy Institute. Further, information presented at colloquiums and publications from private and public institutions are considered.

The methodology selected for this paper is analytical research, which is best suited for topics that attempt to explain why and how. The topic on environmental security and climate change lends itself well to an analytical research method because much of the scientific data deals with cause-and-effect relations among variables.

A systematic process of input followed by Analysis and resulting in a Recommendation is used; see figure 5. This three step approach is direct and applicable to variables involved in analyzing climate related data and environmental security policy. The process accepts various inputs, such as, but not limited to variables in greenhouse gases emission that will produce a conclusive result. The researcher performs a trend analysis and compares the inputs against similar studies produced by different organizations or groups in order to validate or makes adjustments for inconsistent data. The process of analyzing and synthesizing is performed on all data categories.

The outcome of this process is made available in chapter 4 where the analytical methodology is applied to answer the primary and secondary research questions. The analytical framework along with the three stage systematic approach to data analysis provides ample amount of process rigor.

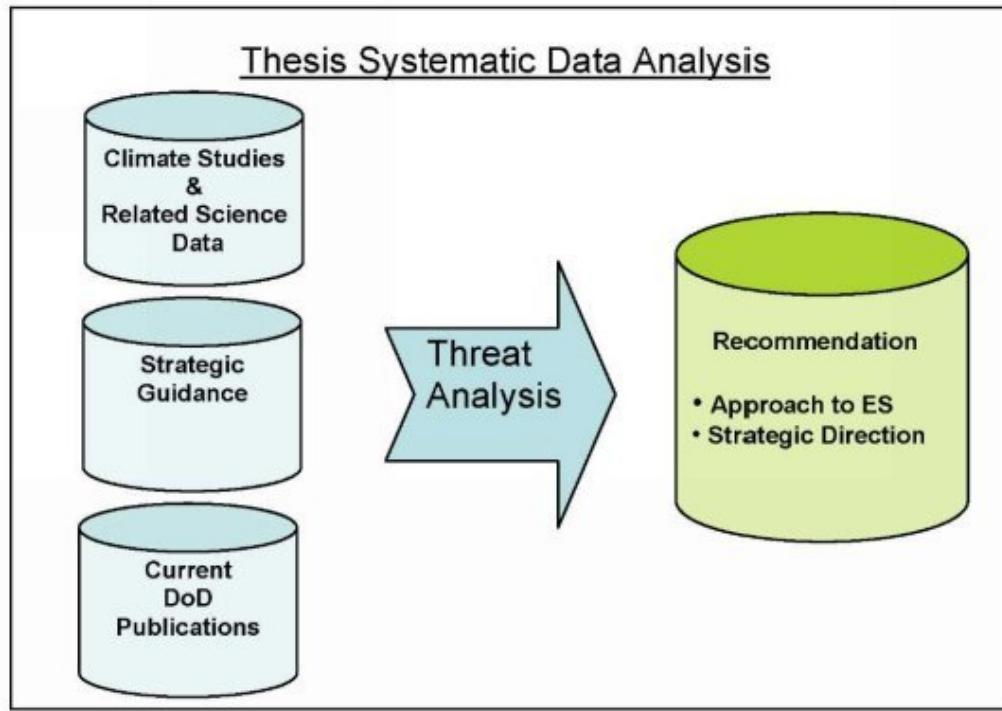


Figure 5. Thesis Systematic Data Analysis

Source: Created by author.

CHAPTER 4

ANALYSIS

As the U.S. maintains a focused approach on irregular warfare in Iraq and Afghanistan, the reality of environmental security risks brought upon by climate change is a distant priority. However, the DoD has a small window of time to organize itself in order to better plan and execute a projected increase in humanitarian and disaster response missions around the globe. This chapter will take a bottoms-up approach by first answering the secondary questions: (1) What condition of climate change are likely to provide security risks to the U.S. in the near term? and (2) Does the Department of Defense have an environmental security direction? which will be followed by the answering the primary question: How should DoD approach environmental security implications of climate change?

Secondary Research Questions

1. What conditions of climate change are likely to provide security risks to the U.S. in the near term?

For the purpose of this question, near term is defined as any impact predicted to occur in the next thirty years. A majority of recently published literature that was reviewed for this report shows a clear indication that climate change is occurring and at current greenhouse gas emission rates, the change is expected to accelerate. The contemporary question surrounding climate change is not if but when and where. The main factor that will determine the severity of climate change is directly related to emissions of greenhouse gas caused by burning fossil fuels. At current greenhouse gas emissions, all climate models show a significant increase in surface temperatures which will have a direct effect on the planet's precipitation cycles. Largely, precipitation frequency and locations will increasingly change which will reduce overall quality and quantity of available water resources used for

drinking, sanitation, and agriculture across many regions. It is estimated that by 2025, 40 percent of the world's population will be living in countries experiencing significant water shortages (CNA 2007). In the near-term, effects of climate change will be more severe in the tropics and gradually impacting the temperate zones.

Of the countries and regions that will begin showing early signs of climate-induced stress, three areas pose near-term national security risks to the U.S. They are; Middle East, Africa, and the Western Hemisphere (tropical zone). Other areas such as southern Asia and the Arctic will be stressed and will experience population shifts and regional disturbances.

The Middle East has some of the world's largest natural gas and oil reserves, which are vital to continued world economic growth. Today, the region controls 66 percent of the world's proven oil reserves (IAGS 2009), yet by some accounts the region is already water stressed. According to the UN at least 23 Middle Eastern countries will suffer significant water shortages by 2025 (Water Wars 1994). Climate change in the form of reduced precipitation coupled with decreasing arable land will limit the area's population carrying capacity. Further, water scarcity together with increasing surface temperature will lower soil moisture contributing to a reduction in crop yields. It will not take long for conditions such as economic disruptions, fighting, mass migration, and the collapse of weak governments to occur due to increased rates of global warming increasing. All Middle Eastern countries will be affected in one form or the other. However, those countries with significant energy reserves and ocean water access (Saudi Arabia, Iraq, Iran, UAE, Kuwait, and Libya) will have the advantage of building additional desalination plants to counter reduced precipitation, thus making water available for municipal purposes. Constructing desalination plants for agricultural needs is not likely to occur. According to the UN, as of 1995, 1,483 desalination plants were operating in the Arabian Gulf with a combined output estimated at 5.76 million square meters. People living in Israel, Yemen, Oman, and Afghanistan will likely experience unprecedented disruptions, fighting, and begin large migrations to other countries. Mass migrations pose the greatest challenge to Middle Eastern peace. One just needs to look at the decades of persistent fighting between the Israelis and Palestinians over land to get a glimpse of the potential turmoil the region will likely experience in several decades from climate-induced water wars. Based on past and current military engagements along with expected climate induced change, the Middle East poses one of the most serious near-term security challenges to the U.S.

The African continent is both a strategic and humanitarian interest to the U.S. Strategically, the U.S. relies on Africa for key industrial minerals such as bauxite, manganese, platinum, titanium, and uranium. Projections indicate Africa will supply 25 to 40 percent of U.S. oil consumption by 2015 (CNA 2007, 22). Historically, the U.S. has funded a large number of humanitarian and disaster support missions ranging from providing food to curbing the spread of HIV. Like the Middle East, the African continent is showing unequivocal signs of water stress. Lake Chad, which is an important water source for the countries of Chad, Cameroon, Niger, and Nigeria, is rapidly disappearing; by some estimates, it will disappear in less than ten years (BBC 2006). In addition, since a majority of the African continent falls within the tropic zone boundaries, climate change will continue to alter the continent's water cycle, affecting where and how much water is available. Water change cycles will likely result in water scarcity, increasing fires that contribute to desertification, and a reduction in arable land. There will be an increased reliance on a dwindling supply of water from lakes and aquifers. Because many of the countries on the African continent are developing or poor and the governments lack resources to counter the effects of climate change, the governments of several countries could collapse. Climate change will force populations to migrate in search of water, food, and shelter. It is likely populations will begin to migrate to the more temperate zones within the continent and a significant number will seek refuge in the countries of the European Union. The U.S. and allies will face an extremely difficult set of circumstances ranging from genocide to mass population migration management in the African continent.

The Western Hemisphere presents its own set of challenges in the homeland and throughout the Americas. The areas that will experience near-term effects of climate change include the following: Southwest and Southeastern U.S., Central America, and the Caribbean islands.

According to the U.S. Global Change Research Project, "human-induced climate change appears to be well underway in the Southwest" (UGCRP 2009, 133). Recent warming in the region is among the most rapid in the nation and is significantly more than the global average in some areas (UGCRP 2009, 133). In the Southwest, water scarcity is already an issue of concern that many states are finding more difficult to manage, in part because of prolonged drought and increasing population. Climate change will exacerbate an already difficult water resource

situation in the region. Several models show higher surface temperatures and decreasing precipitation will lead to crop failures and a decreasing yield. The models conclude that arable land, temperate crops, and species will begin shifting their habitat northward. Further, western wildfires particularly in California and in the Rocky Mountains will increase in frequency and intensity. The Southeast will experience reduced precipitation pattern similar to the Southwest. The Gulf Cost and Atlantic bordering states will face an increasing trend of tropical storm and hurricane activity. Since the 1970s, the destructive potential of Atlantic hurricanes has increased; such an increase correlates with an increase in sea surface temperatures (Hoyos 2006). Further, studies of the Atlantic and Gulf Cost conclude that because temperatures are increasing, causing greater water evaporation into the atmosphere, there is a growing trend of stronger hurricanes that have the capability to cause more destruction and flooding. With the exception of South Florida, which has some of the country's strictest structural building codes, the vast majority of homes and infrastructure bordering the Atlantic and Gulf Coast are not designed to withstand higher category storms. There is a real potential for future storms to cause devastating damage similar to what was experienced with Hurricane Andrew in 1992 and Hurricane Katrina in 2005. Hurricane Andrew caused over \$40 billion in property damage mostly in south Miami and Homestead. Hurricane Katrina is the costliest hurricane in U.S. history—over \$90 billion in property damage mainly in New Orleans.

Climate-induced conditions in the Southwest and Southeast will require greater DoD commitment. Already the DoD is involved with the Department of Homeland Security (DHS) and provides response forces to assist local, state and Federal Emergency Management Agency (FEMA) during periods of disaster. The military will be tasked to assist with disaster and humanitarian response missions along with a growing requirement to support the Forestry Service fight fires. Organizations such as Army Corps of Engineers will be required to assist in a growing trend of civil engineering projects as the country takes proactive measures to limit the effects of climate change and make adjustments to existing infrastructure in order to accommodate population shifts within the country.

As temperatures rise and precipitation patterns change, several Central American countries will experience climatic stress similar to those conditions that the southern U.S. is expected to undergo. Most Central American countries do not have the resources or governmental capacity to address the stress of higher temperatures, reduced water, and an increase in infrastructure damage caused by hurricanes. Of particular concern to the U.S. is Mexico because of its proximity and a population of over 111 million residents, some who currently migrate to the U.S. in search of a better economic situation. Climate change will cause scarcity of water and food. These conditions will cause a steep increase in Mexican migration to the U.S. and South America. Many areas in Mexico are already water stressed, in fact, Mexico City is sinking several centimeters a year due to over extraction of groundwater. Water availability and a decrease in arable land will cause increased political instability in Mexico. In addition to Mexico, the smaller countries that makeup Central America such as Belize or El Salvador for example, presents a security concern because it is probable civil strife and destabilization caused by climate-induced have a potential to destabilize the region.

Security concerns presented by the Central American region will require DoD involvement in the areas of border security, stability operations, capacity building, and humanitarian aid. Further, the Department will require support from interagency and allies to provide the necessary manpower and resource to effectively manage regional change.

The third region in the Western Hemisphere that will experience climate-induced change is the Caribbean. Of all the countries in the Western Hemisphere, the 40 island nations in the Caribbean, home to approximately 38 million people (USGCRP 2009, 145) are the most vulnerable to climate change because of limited terrain, infrastructure, and economic capability. Like many of the countries located in the tropics, models indicate precipitation patterns will shift to temperate zones. An aggregate reduction in rain alone is enough to devastate living conditions on most islands, especially smaller islands which solely rely on precipitation to recharge their lakes and aquifers. In addition to reduced precipitation, the islands will experience a growing number of storms and hurricanes, which will devastate aging infrastructure. In some countries such as Cuba, the current operating infrastructure dates back to the 1930s.

Alterations of ocean ecosystems caused by climate change will play an increasing role in decreasing availability of marine species that serve as a vital source of food needed to feed island inhabitants. As Caribbean ocean waters warm, marine species will gradually move northward. Further, according to models produced by the U.S. Global Research Program, sea level rise will play a huge factor in the second half of the 21st century. Rising

sea levels will exacerbate the other effects of climate change on the Caribbean islands. The compounding effect of impaired food availability and water scarcity will likely destabilize the region as refugees from ecological devastation migrate in search of resources. The greatest threat to U.S. national security lies in accommodating millions of ecological refugees from neighboring Caribbean islands, while simultaneously, the U.S. deals with climate-induced change within its own borders.

2. The second supporting question this paper answers is: Does the Defense Department have an environmental security direction? The answer to this supporting question helps frame the analysis required to answer the primary thesis question.

Based on national strategic literature and select service documents reviewed for this paper, the DoD does not have a comprehensive environmental security direction capable of uniting the various services and agencies required to characterize and operationalize environmental security within the Department. Moreover, the department does not appear to have an agreed upon definition of environmental security along with a process to determine how climate change will affect environmental security. Further, it is evident from the literature review that each service appears to be following their own policy of discovery when it comes to environmental security.

Over the past two decades, environmental security issues of climate-induced change have generated significant discussion throughout the DoD and most U.S. government agencies. However, there definitely appears to be a fast-moving realization within the DoD, and for that matter throughout the federal government, that climate-induced change is a reality which the country will have to deal with much sooner than later. Progress on identifying environmental risks to national security slowed down because since September 11, 2001, the U.S. has focused its efforts on homeland security and the war on terrorism. Both Operation Enduring Freedom and Iraqi Freedom have significantly contributed to the Department's sluggishness in developing environmental security strategy. However, it is evident by a growing number of service sponsored symposiums and colloquiums that the DoD does have a reasonable level of resident expertise needed to operationalize environmental security within the department. Further, the 2008 NDS sends a clear message throughout the Department that climate-induced change will continue to be a growing concern and the DoD needs to begin making internal changes in how it looks and addresses overall environmental security with special focus on climate change.

The Department can learn a few valuable lessons by analyzing the approach NOAA took as lead agency for the U.S. Global Research Program which brought together thirteen separate government agencies along with a number of institutions tasked to analyze climate change and its effects on the U.S. The results of their efforts produced a first of its kind document titled, *Global Climate Change Impacts in the United States*. This keynote publication is one example of synergistic effects the DoD can gain by bringing together organizations such as the Army Environmental Policy Institute, Air Force Air Combat Command and other DoD agencies to help the Department develop climate change strategy.

Primary Research Question

Given the increasing discussions and publication centered on climate change and its effects on national security, this research paper's primary goal is to analyze the DoD's current efforts in addressing the environmental security aspects of climate change. The thesis research question addressed is: How should DoD approach environmental security implications of climate change? Four recommendations are presented to address the multifaceted approach required to properly develop environmental security strategy. They are:

1. Environmental security must be a component of the national security strategy and national defense strategy.
2. DoD must establish an activity dedicated to develop environmental security and climate change related strategy.
3. Climate change data should be incorporated into a yearly Intelligence Environmental Estimate.

4. Training organizations such as U.S. Joint Forces Command (USJFCOM) should take the lead in developing climate change related training scenarios.

Primarily climate change as an environmental security issue starts at the top in the executive branch. Through the NSS, the office of Science and Technology Policy, and Office of Management and Budget, the President sets the Nation's security priority and allocates required resources to ensure those priorities are met. For the defense threats from climate change to be given appropriate priority and for it to take root, the upper levels of the federal government will need to use the four instruments of national power; Diplomatic, Informational, Military, and Economic (DIME). Climate change cannot be dealt with effectively once climate-induced changes are indisputably noticeable--by then it will be too late. Therefore, a DIME approach is required. Starting with diplomacy, the U.S. should change its approach from a country that has taken a minimalist approach on climate related issues to one that takes a lead in developing policy and curbing greenhouse gas emissions. Results of this action alone will provide the DoD with added time; perhaps decades to help counter the effects of climate change and develop environmental security strategy and tactics. What's more, overall reductions in greenhouse emissions will help produce milder climate change effects, giving Federal agencies and departments more time to adjust to changes. In addition, the U.S. should engage with its allies and foster new relationships to work together on developing solutions and foster international discussions focused on which countries will provide support in the form of aid and personnel to the various regions, particularly those located in the tropics that will experience the initial brunt of climate-induced change.

The informational instrument of national power, perhaps need to be focused internally more so than externally. As James Hansen mentions in his Tipping Point paper, that special interest in the U.S. has played a pivotal role in swaying government to take little action to stem growth in fossil fuels. Interestingly, the vast majority of key U.S. departments and agencies have an in-depth understanding of how future climate-induced change will affect the U.S. Unfortunately, climate related information does not appear to effectively be making its way to the public media. Information needs to flow from creditable channels to provide Americans and international partners with the most accurate and latest science. According to a poll conducted by the Pew Research Center in 2009, "only 57 percent of Americans now believe there is strong scientific evidence for global warming, down from 77 percent in 2006." The federal government needs to develop a credible information campaign to inform Americans the dangers climate-induced change presents to the U.S.

The U.S. military will make-up a significant piece of the Nation's environmental and climate change security approach. The DoD along with other key departments will be asked to develop environmental security strategy and policy with the purpose of identifying limited resources to address national security concerns. Keep in mind that the U.S. will have its own set of climate-induced change issues to deal with, which the military will be required to address by providing support in the form of manpower, equipment, and expertise. The faster environmental security becomes a component of national security, the quicker the DoD can begin analyzing future requirements to determine training and equipping needs. Further, DoD can begin engaging allies such as China's military to develop operations and tactics which specifically address the kinds of missions militaries around the world will encounter as a result of climate-induced change--humanitarian, disaster relief, security cooperation, capacity building and water resource development. Future climate-induced challenges will require DoD to open the aperture and expanded its definition of full spectrum operations.

There is a saying within the DoD acquisition community that an acquisition plan without funding is considered a dream. The same analogy can be drawn in the case of environmental security. Polices at various levels need to have the appropriate funding in order to set priority and allocate resources to cause change. The economic instrument of national power can be used in several areas; one possibility is the area of domestic technology development. The executive branch realizes a need to develop new technology that produces clean energy. President Obama, in a speech given at the Massachusetts Institute of Technology on October 23, 2009, spoke on the need to develop clean-energy alternatives and called on Congress to write legislation to curb climate change. He further told the audience that "the nation that wins this competition is going to be the nation that leads the world" (Boston Globe 2009).

The literature review conducted for this paper reveals a growing trend in an improved understanding of the climate change problem. However, there is a deficit in a clear direction from the Office of the Secretary of Defense (OSD) to provide planning, direction and resources required to develop environmental security strategy. Therefore,

the DoD must establish an activity dedicated to creating environmental security related strategy. An activity, which focuses on national security implications of climate change, will go a long way at integrating intelligence and science to gain a better understanding of the cause-and-effect relationship between climate-induced change and social upheavals. For example, the OSD can consider implanting within the DoD an Office of Environmental Security Strategy. See figure 6 for a notional make-up of this organization:

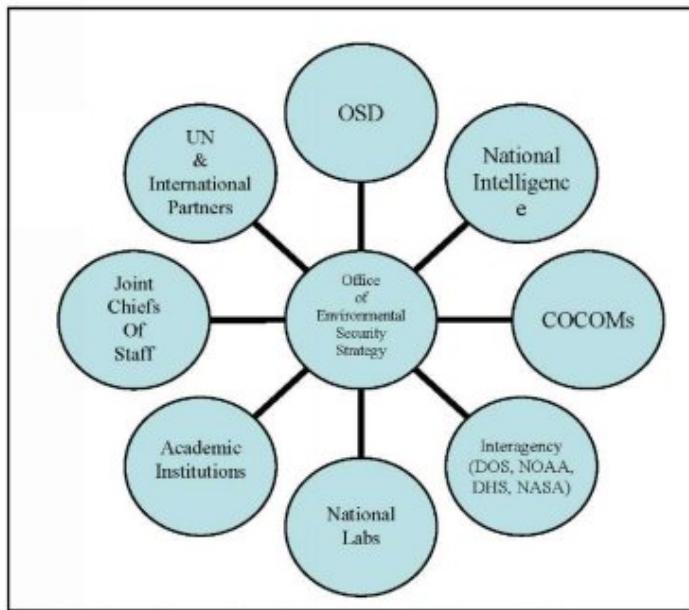


Figure 6. Notional Organization of the Office of Environmental Security Strategy
Source: Created by author.

The purpose of such an organization is to bring together a number of DoD activities exploring climate change implications to national security and join them with other government and institutional activities to expand knowledge and determine options for responding to those climate-induced changes, which threaten national security. The organizational makeup shown in figure 6 is an example of the type of organizations that should form a habitual relationship. It brings together key organizations, which are currently performing climate change related analysis to develop strategy and help operationalize environmental security.

The organization should take its overall strategic direction from OSD; conceptually an Office of Environmental Security and Strategy would operate in a collaborative organizational design. As shown in figure 6 the organization is composed of several independent organizations that include the United Nations, interagency, academic institutions, and the National Intelligence Agency. Suggested independent organizations are currently stakeholders in developing climate change studies and analysis at various levels and geographic regions. Further, independent organizations such as Lawrence Livermore National Lab and/or select academic institutions can perform peer-review studies on a proposed DoD strategy. A peer-review process will not only strengthen policies and strategies produced by the organization, but it will also lend more credibility to it. Inclusion of the Joint Chiefs of Staff and Combatant Command Commanders, allow both the joint community and the Service components to participate in analysis and strategy development.

Resulting strategy from the Office of Environmental Security Strategy will help shape National Military Strategy policy as well as the Department's own position on how it will handle future missions connected to climate-induced change. The organization will open dialog with interagency and international actors to promote environmental engagement missions and exercises. Such an engagement mission will help the U.S. and allies gauge levels of preparedness of governments in the areas of providing humanitarian relief, disaster response and mitigating civil strife. Take China for example, the DoD spends a great deal of resources evaluating China's national security threat; however, the two countries do not participate in unified military exercises. Considering how economically dependent both countries are to one another and the high level of industrial technological

transfer that occurs, both governments should actively participate in military exercises. Environmental engagement is one non-threatening form both militaries can cooperate to gauge their level of humanitarian and disaster response readiness. This knowledge will allow the DoD to determine the areas in the USPACOM AOR that present national security concerns from climate change. Finally, an organization dedicated to producing environmental strategy will help the Department prioritize by providing guidance to Service chiefs and COCOMS on future expected requirements and provide QDR input. Service chiefs and joint commanders will be able to anticipate and prepare the force for an increase in stability and humanitarian type missions. The strategic organization will provide the DoD with a long-range view (at least 20 years) on future national security implication from climate change. This long-range approach can feed into key capability policy documents such the QDR and other joint capability documents to better help the DoD select the right systems and infrastructure for future needs. For example, it is highly likely Diego Garcia, an island located approximately 1000 miles south of India will be inundated by rising sea-levels by mid-century. The island is home to a key air base used by the U.S. Air Force to support forward staging B-1 and B-52 bomber aircrafts. The air base supported aerial bombardment, refueling, and maintenance operations during the 1991 Gulf War and more recently Operation Enduring and Iraqi Freedom. In addition, the island serves as a key communication hub for the U.S. Navy and several DoD satellite systems. An organization such as an office of Environmental Security Strategy can play a vital role in assuring the DoD takes future sea-level rise along with other climate change factors into consideration when selecting or rebuilding infrastructure. Diego Garcia is just one example, there are dozens of key military bases such as MacDill AFB in Tampa, FL, Norfolk Naval Base in Hampton Roads, VA, and Langley AFB in Hampton, VA which will be threatened by rising sea-levels before the end of this century.

Analysis conducted for this chapter recommends that climate change data should be incorporated into a yearly Intelligence Environmental Estimate. This is not a new concept. In 1974, General Maxwell Taylor suggested creating "an expanded National Security Council charged with dealing with all forms of security threats, military and nonmilitary, and having access to all elements of government and to all relevant resources capable of contributing to this broad task" (Campbell 2008, 3). More recently, in 2007, Senators Richard J. Durbin (D-IL) and Chuck Hagel (R-NE) introduced a bill requesting a National Intelligence Estimate produced by the Central Intelligence Agency and the Pentagon to assess national security implications of climate change (Busby 2007, 1).

Just as the current National Intelligence Estimate (NIE) provides decision makers with a coordinated multi-intelligence agency position on potential future events, an Intelligence Environmental Estimate can help identify areas where climate-induced change will present a likelihood of violence, civil strife, or regional disruption. Analysis by OSD Environmental Security office should analyze the questions of when and what actions should be taken. The author believes it will take several years for many different organizations to normalize and for bureaucratic procedures to conform before comprehensive products to policymakers are made available. For DoD, the main purpose of such an estimate should be to provide actionable intelligence similar to the current NIE, but with the inclusion of how climate-induced change will affect a combatant commanders AOR. This will bring more depth to the analysis and provide commanders with a better understanding of the full-range of missions that his command will be required to accomplish. For example, the Army Operations Field Manual (FM) 3.0 dated February 27, 2008 provides an introductory description of how climate change will compound and influence operations in the battle-space. It further describes how climate change will lead to humanitarian crisis and regional destabilization. The problem is FM 3-0 is similar to a number of DoD published documents in that it provides little specificity on what regions will be affected first and what kind of events commanders need to begin training and preparing the force for. More broadly, such an estimate which reaches out to interagency and nongovernment experts can provide the DoD and other key federal government department and agencies with a deep perspective of the areas that pose a near-term risk to national security. While no single set of analysis can precisely describe the future environment, a document such as a yearly Intelligence Environmental Estimate will help ensure the U.S. and its allies are not caught off guard by climate-induced changes that will act as a threat multiplier.

The final analysis conducted in this chapter answers the primary question which results in recommending that training organizations, such as JFCOM, should take the lead in developing climate change related training scenarios. The Joint Warfighting Center (JWFC), which comes under JFCOM maintains resident experts in conducting joint, interagency, and combined exercises. The Center is organized to provide trained, capable, and interoperable forces to the combatant commander. This is accomplished by assisting combatant commanders in conducting mission rehearsal exercises in order to ready the joint forces prior to departing to an AOR.

The training approach required to prepare for future environmental engagements will require a broader partnership with interagency, allies and focus on those likely events to occur from climate-induced change--humanitarian and disaster relief, capacity building, and security cooperation. An example of the kind of interagency and international training required in greater frequency is U.S. Northern Command's Exercise Vigilant Shield conducted with the assistance of JWFC. While this exercise does focus on Homeland Security, it brings together international, interagency and local state authorities to counter threats against the homeland. The kind of environmental engagement missions combatant commanders will execute will require a high degree of coordination with interagency and international partners. Such engagements require the force to maintain a broader understanding of organizations such as DOS, FEMA, NATO, and the UN, just to name a few. Therefore, JFCOM with its vast knowledge in organizing mission rehearsal exercises for all combatant commanders, its close ties with NATO Allied Command for Transformation, and interagency partners should have the lead in environmental engagement exercises that will keep the joint force attuned to evolving global threats.

In summary, this chapter analyzed a number of findings derived from the literature review; providing answers and recommendation to both secondary questions and the primary question. The science is overwhelmingly clear that climate change is unequivocal and the effects of such changes are but a few decades away. The regions impacted first are those that lie in the tropic zone, in part because this is where most of the sunlight is absorbed. Among those regions, the Middle East, Africa, and the Western Hemisphere pose national security concerns to the U.S. At this point in time, the DoD does not have a focused effort dedicated to analyzing climate-induced change and the implications to national security. However, there are several activities within the DoD that tackle climate-change related issues. One key finding is that priority by the executive branch needs to be placed on environmental security. Within the DoD there needs to be a mechanism that provides the Department with long-range strategic guidance regarding climate change. Long-range environmental related guidance will be included in key planning documents such as the QDR and factor in to acquisition and infrastructure decisions. Shorter-range information should be included in a National Intelligence and Environment document. This document will provide combatant commanders with information available in the NIE, but will also identify environmental hot spots, where resource scarcity will play a significant role in violence, civil strife, or mass-migration. Finally, combatant commanders need to begin training for the types of environmental engagement missions the force will need to respond. Today, USJFCOM, as the joint trainer, is best positioned to help combatant commanders conduct such rehearsal exercises.

CHAPTER 5

RECOMMENDATIONS

Recommendations

This research highlighted the scope and scale of climate change and how national security will be impacted. The IPCC Fourth Assessment Report and U.S. Global Change Research Program Global Climate Change Impacts in the United States present unequivocal evidence that climate-induced change is the single most significant national security challenge facing the world.

Both reports clearly demonstrate human-induced climate change is occurring and the impacts are already apparent. Greater impacts are projected if greenhouse gases emission goes unabated.

This research further highlighted the various DoD communities and organizations at work on the topic of climate change and national security. However, based on national strategic literature and select service documents reviewed, the DoD does not have a comprehensive environmental security direction capable of uniting the various services and agencies required to characterize and operationalize environmental security within the DoD.

The next step DoD needs to take is establish an activity dedicated to analyzing and creating environmental security related strategy. This study recommends DoD should establish an Office of Environmental Security Strategy to help unify the Department's actions. Further the office will provide direction for systematic gathering of climate related information that can be used supplement intelligence and provide guidance in the areas of future engagement areas, training and acquisition.

REFERENCE LIST

- Ailworth, Erin. 2009. Obama hails state of innovation. Technology. The Boston Globe. October 24.
- Alfred, Randy. 2008. "April 1, 1960: First weather satellite launched." Science. WIRED Magazine.
- Associated Press. 2003. France heat wave death toll set at 14,802. USA Today, Weather. September 25.
- Bomford, Andrew. 2006. "Slow death of Africa's Lake Chad." BBC News. April 14.
- Brown, Lester R. 2008. Plan B 3.0, mobilizing to save civilization. New York: W. W. Norton and Company, Inc.
- Busby, Joshua W. 2007. Climate change and national security. New York: Council on Foreign Relations.
- Campbell, Kurt M. 2008. Climatic cataclysm. Washington, DC: Brookings Institution Press.
- Church, John A., Neil J. White, P.J., and John R. Hunter. 2006. "Sea-level rise at tropical Pacific and Indian Ocean islands." ScienceDirect 53 (April): 155-168.
- Crowell, Mark, Scott Edelman, Kevin Coulton, and Scott McAfee. 2007. "How many people live in coastal areas?" Journal of Coastal Research (September).
- Engelman, Robert, Michael Renner, Janet Sawin, Ambika Chawla, and Linda Strke. 2009. 2009 state of the world. New York: W.W. Norton and Company, Inc.
- Galton, Francis. 1861. Meteorographica: The weather of a large part of Europe. London: Macmillan and Co.
- Goodman, Sherri. 2007. National security and the threat of climate change. Alexandria: The CNA Corporation.
- Grice, Gary K. 2005. History of weather observing in Washington, D.C. 1821-1950. Asheville: Midwestern Regional Climate Center.
- Hansen, James. 2008. Tipping point: Perspective of a climatologist. Washington, DC: Island Press.
- Hoekstra, Peter. 2007. "Environmental intelligence" The Wall Street Journal, Opinion. May 10.
- Homer-Dixon, Thomas. 2009. Carbon shift, how the twin crisis of oil depletion and climate change will define the future. Canada: Random House Canada.
- Houghton, John. 2004. Global warming, the complete briefing. Cambridge: Cambridge University Press.
- Institute for the Analysis of Global Security (IAGS). "Future of Oil." <http://www.iags.org/futureoil.html> (accessed October 19, 2009).
- Intergovernmental Panel on Climate Change (IPCC). 2007a. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.

- . 2007b. Climate Change 2007: Impacts, adaptation and vulnerability. Summary for Policymakers. Contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.
 - . 2007c. Climate change 2007: Mitigation. Summary for Policymakers. Contribution of Working Group 3 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.
 - . 2007d. Climate change 2007: The physical basis. Summary for Policymakers. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.
 - . 2007e. Synthesis Report. Climate Change 2007. Contribution of Synthesis Working Group to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.
- Joyce, Matt. 2009. "Forest official: Beetle-killed trees a future in Wyoming, Colorado." *The Aspen Times*. January 15.
- Karl, Thomas R., Jerry M. Melillo, and Thomas C. Peterson, U.S. Global Change Research Program. 2009. Global climate change impacts in the United States. New York: Cambridge University Press.
- King, W. Chris, Colonel. 2000. Understanding international environmental security: A strategic military perspective. Atlanta: Army Environmental Policy Institute.
- Kleypas, J. A. 2005. Impacts of ocean acidification on coral reefs and other marine calcifiers. Report sponsored by the National Science Foundation, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey. April.
- Mabey, Nick. 2008. Delivering climate security. Philadelphia: Routledge. Mideast News Portal. Water Wars. <http://www.mideastnews.com/WaterWars.htm> (accessed October 19, 2009).
- National Aeronautics and Space Administration (NASA). "News & Features." http://www.nasa.gov/topics/earth/features/earth_temp.html (accessed July 17, 2009).
- . "Overview." <http://nssdc.gsfc.nasa.gov/earth/nimbus.html> (accessed July 8, 2009).
- National Intelligence Council. 2009. China: Impact of climate change to 2030. Washington, DC: Government Printing Office.
- Pumphrey, Carolyn. 2008. Global climate change: National security implications. Carlisle: U.S. Army War College.
- Turabian, Kate L. 2007. A manual for writers. 7th ed. Chicago: University of Chicago Press.
- U.S. Army. 2008. Field Manual 3-0. Washington, DC: Government Printing Office.
- . Command and General Staff College. 2008. ST 20-10, Master of military art and science (MMAS) research and thesis. Ft. Leavenworth, KS: USA CGSC, July.
- U.S. Department of Defense. 2004. National military strategy. Washington, DC: Government Printing Office.
- . 2006. Quadrennial defense review report. Washington, DC: Government Printing Office.

- . 2008. National defense strategy. Washington, DC: Government Printing Office.

U.S. Executive Office. 1999. The National Security Strategy of the United States of America. Washington, DC: Government Printing Office.

- . 2006. The National security strategy of the United States of America. Washington, DC: Government Printing Office.

U.S. Global Change Research Program (USGCRP). 2009. Global Climate Change impacts in the United States. New York: Cambridge University Press.

U.S. Joint Forces Command. 2008. The joint operating environment: Changes and implications for the future joint force. Norfolk: Government Printing Office.

U.S. Senate. 2000. Testimony of Richard S. Lindzen before the U.S. Senate Commerce Committee. <http://www.john-daly.com/TAR2000/lindzen.htm> (accessed October 17, 2009).

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

EMANUEL J. COHAN

MAJOR, USAF

B.A., Florida International University, Miami, Florida, 1995

M.S., California State University, Long Beach, California, 1998

U.S. Army Command and General Staff College

Fort Leavenworth, Kansas 2009

Approved for public release; distribution is unlimited.

* * * * *

Report of the Defense Science Board Task Force on Trends and Implications of Climate Change for National and International Security

October 2011

Office of the Under Secretary of Defense

For Acquisition, Technology, and Logistics

Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB)

The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense (DOD). The Defense Science Board Task Force on Trends and Implications of Climate Change for National and International Security completed its information-gathering in May 2011. The report was cleared for open publication by the DOD Office of Security Review on 4 August 2011.

This report is unclassified and cleared for public release.

OFFICE OF THE SECRETARY OF DEFENSE

3140 DEFENSE PENTAGON

WASHINGTON, DC 20301-3140

October 4, 2011

**MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION,
TECHNOLOGY AND LOGISTICS**

**SUBJECT: Report of the Defense Science Board Task Force on Trends and Implications of Climate
Change on National and International Security**

I am pleased to forward the final report of the Defense Science Board Task Force on Trends and Implications of Climate Change on National and International Security. The report offers important considerations for the Department of Defense related to this subject.

The task force examined the implications of climate change from a global perspective, with a special focus on the African continent, and makes recommendations that can improve the U.S. approach to addressing the many challenges of climate change. First, they identified a need for a strong climate information system database, managed by the Department of Defense. Second, the task force recommends a whole of government approach to mitigating the effects of climate change and highlights the importance of engaging with international leaders in identifying global solutions.

Climate change will only grow in concern for the United States and its security interests. This report offers guidance to the Department of Defense on how to become a leader in mitigating and adapting to its growing effects.

I endorse all of the study recommendations and urge you to adopt them into your operations.

Dr. Paul G. Kaminski

Chairman

OFFICE OF THE SECRETARY OF DEFENSE

3140 DEFENSE PENTAGON

WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

MEMORANDUM TO THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Trends and Implications of Climate Change on National and International Security

Changes in climate patterns and their impact on the physical environment can create profound effects on populations in parts of the world and present new challenges to global security and stability. Failure to anticipate and mitigate these changes increases the threat of more failed states with the instabilities and potential for conflict inherent in such failures.

Because of the increasing importance of climate change on US security, the Defense Science Board was charged with examining the need to adapt, manage, and mitigate the consequences of climate change.

This report begins with an overview of the impacts of climate change over recent decades while recognizing uncertainty about the pace of future changes. It examines the political consequences of climate change as it relates to national and international security, with special attention to the African continent due to the vulnerability of African nations with high potential to intersect with United States national interests. Within this context, the study examined the roles of the Department of Defense and the national security community writ large in responding to effects of climate change in both the United States and in key areas of the globe.

The deliberations of the task force identified the urgent need for clear roles and policies throughout the US government addressing the consequences of climate change and produced a set of recommendations on how the US government can manage the near-term effects on populations and the longer-term need for adaptation that impacts US and international security interests. The recommendations include specific roles for the Department of Defense in helping both the United States and U.S. Africa Command address these challenges. The recommendations fall into five main areas:

- The need for developing a robust climate information system
- Instituting water security as a core element of DOD strategy
- Roles of the national security community, including the intelligence community, the Department of State, and the White House
- Guidance and DOD organization to address the full range of international climate change-related issues and their impact on the evolution of DOD's missions
- Combatant command roles, responsibilities, and capacities.

The report emphasizes that the United States cannot enter into an open-ended commitment to dealing with the need to address the near term consequences of climate change or the longer term need for adapting to the change. The United States can provide needed expertise, leadership, and some level of resources where it is in the national interest to do so. To be effective, Department of Defense actions must be part of a comprehensive multi-department approach and in coordination with international efforts.

Gen. Larry Welch

Co-Chair

Dr. William Howard

Co-Chair

Table of Contents

Executive Summary

Chapter 1

Current Observation, Model, and Climate Projection Capabilities

Climate Prediction, Forecast, and Projection Methods

Climate Models

Chapter 2

Current Climate Change Situation and Trends

Global Climate Change Trends

Current Trends and Projections for Africa

Chapter 3

Potential Consequences of Climate Change

Impacts of Climate Change on Water

Transboundary Issues

Consequences for National Security

Addressing Climate Change Effects on African Populations

Chapter 4

Roles of the National Security Community

Strategic Concepts for Addressing the Challenges

Whole of Government

Chapter 5

Role of the Department of Defense

Guidance Shaping Department of Defense Efforts and Activities

Combatant Command Roles, Responsibilities, and Capacity

Appendix A

Climate Information System Needs

Climate Change Risk Management

Climate Information Systems

Climate Data Record Production

Overarching Barriers for Climate Information Systems

Summary

Appendix B

Special Topics

Tipping Points

Geoengineering

Terms of Reference

Task Force Membership

Presentations to the Task Force

Glossary

Executive Summary

Purpose

This report describes observable climate change and its consequences. It does not attempt to address the complex and controversial set of causes, nor does it offer recommendations on the possibility of changing the pace or scope of climate change. Instead, the focus is on the need to manage consequences. To that end, this report describes evidence of impacts over recent decades while recognizing uncertainty about the pace of future changes. It discusses the shortfalls in climate information, climate science, and climate models and the resulting scope of the uncertainties in projections. At the same time, it provides compelling evidence that climate impacts are observable, measurable, real, and having both near and long-term consequences. It recognizes that changes already underway are having, and will continue to have, major consequences for the political, economic, and geographic world as we know it. This report provides a set of recommendations on approaches to adaptation and dealing with the near-term effects on populations that impact US and international security interests.

While the effects of climate change are uneven and subject to a complex set of influences, some long-term trends seem clear. For example, to the extent that greenhouse gases are causing land and sea surface warming, the long life of some greenhouse gases in the atmosphere mean that effects will continue to increase and will be long lasting, even with no further addition to the concentration of greenhouse gases (e.g., water vapor (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), and ozone (O₃)). Hence, this is a challenge that cannot be "solved". Instead, it must be managed for the long-term. This report addresses the need and prospects for approaches to address the near-term impact on human populations and longer-term adaptation to climate change. The impact on human populations, near- and long-term, translates to impact on national and international security.

Cycles of climate change are not new to the planet. But, an important difference today is that effects are exacerbated by the increased density of populations, particularly in those areas most vulnerable to climate change.

The effects can be further exacerbated by the nature of the human response or the lack of response.

While adaptation approaches must cover a wide spectrum of effects and consequences, the challenges associated with climate change generally fall into three interrelated classes of needs each with several

subcomponents:

- Population support system resiliency
 - Water and food security
 - Health
 - Energy
- Human security
 - Population dislocation
 - Armed conflict
- Political continuity
 - Continuity of governance
 - Economic viability

Although recent data demonstrate an accelerating rate of climate change, the uncertainties about continued changes and populations' capabilities to adjust to those changes have led this report to a hedge strategy that recognizes the wide range of potential scenarios about the scope and rate of change. It focuses on climate related actions that will be beneficial to national and international security, regardless of the rate of climate change. This report places particularly strong emphasis on the need for programs and activities that provide better and more credible information to decision makers.

Climate Observation, Modeling, and Projection Needs

This report uses data and projections from a wide variety of sources to discuss trends and consequences. While this data comes from credible sources, climate information systems and climate modeling fidelity leave room for wide variances in projections. Hence, while the historical and recent trends seem clear, and consequences are visible in many parts of the world today, projections for future rates of change and impacts are far less clear.

Decision-making support demands a responsive, comprehensive, and informative climate information system. The system will need to include extensive, credible reporting and better science to predict the long-term implications of impacts and demand for adaptability. Progress towards producing such a system will require a systematic effort to define requirements, architecture, and implementation plans.

Currently no coherent, integrated climate information system capable of generating reliable, sustained, and actionable climate data and projections exists. Today's climate observations and models exist only as a loose federation of programs at many government agencies, academia, industry, and nongovernmental organizations (NGOs). While some of these assets are operational systems, the majority of observational assets and many of the modeling assets, are intended primarily for exploratory science rather than for supporting operational, long-term climate assessments. Many observations are intended to help improve basic climate process understanding, such as closing global-scale energy, carbon, and water budgets. They do not offer the space and time resolution, completeness, or accuracy to support needed improvements in, or validation of, regional climate models, particularly in developing countries.

The plethora of climate models present their own risk management challenges. Some of the models purport to provide highly accurate, long-term predictions (forty to one hundred years). For these predictions, there is a need for validation and verification standards. Also needed are clear uncertainty bounds and attention to the

unpredictable variables that impact climate in the near-term. Few of the models purport to provide accurate predictions that cover the planning time frame typical of most government activity.

The observational systems that provide the needed climate data are deployed in the four traditional physical domains—land, sea, air, and space. Space-based systems that are funded, developed, deployed, and operated by multiple agencies will play a major role because they provide the real-time, continuous observational data required to monitor changes in the climate system. Given the need for comprehensive global data to understand current conditions and make better predictions about future changes, there is a need for a comprehensive approach to space-based systems and systems operating in other domains.

While this report approaches climate change from a global perspective, it places special emphasis on Africa. The combination of existing climate change and the vulnerability of African nations to such change warrants special attention. African vulnerabilities are the result of widespread subsistence farming, fragile governance, economic shortfalls, ethnic tensions, and other factors.

Neither the needs of the Department of Defense (DOD) for climate information systems and assessment processes, nor gaps relative to current capabilities and planned future capabilities have been rigorously studied to date. The US government needs a scientifically robust, sustained, and actionable climate information system that addresses these and other issues. The details on the needs of such a system, and key barriers to its establishment are described in Appendix A of this report

Trends

This report addresses observed trends and some predictions based on these trends. It does not attempt to address the causes of climate change. The observable trends over multiple decades include:

- Increasing land and sea surface temperatures
- Changing ocean temperature
- Changing ocean chemistry (acidity and salinity-impact on ecosystems and circulation)
- Declining mass of Greenland and Antarctic ice sheets
- Declining glaciers and snow cover
- Decreasing and thinning Arctic sea ice
- More frequent and longer droughts
- Increased frequency of heavy precipitation events, flooding and landslides
- Increased cyclone intensity
- Rising sea level

There is a complex set of factors influencing atmospheric circulation, cyclone activity and other phenomena impacting the climate that are not well understood. The changes and consequences will present both near and long-term challenges. Some greenhouse gases are long-lived. Even with no addition of these gases to current levels, it will require hundreds of years to see significant reductions in the level in the atmosphere. Current estimates are that if all of the measures currently recommended to reduce emissions from human activity are implemented, the predicted temperature rise will vary from a minimum of 2°C to as much as 7°C by the end of the 21st century. A rise of more than 2°C is likely to have serious consequences for the human habitat. Current projections explicitly

exclude feedback cycles, such as those involving the release of methane and nitrous oxide which have the potential to further accelerate surface warming.

Consequences

The long-term trends in the release of the variety of greenhouse gases into the atmosphere are complex and controversial. Further, the prospects for significantly changing those trends are equally complex and controversial but are not central to the purpose of this report.

Climate change is likely to have the greatest impact on security through its indirect effects on conflict and vulnerability. Many developing countries are unable to provide basic services and improvements, much less cope with repeated, sudden onset shocks and accumulating, slow onset stresses. These effects span the spectrum from the basic necessities of livelihood to social conflict, including protests, strikes, riots, inter-communal violence, and conflict between nations. Climate change is more likely to be an exacerbating factor for failure to meet basic human needs and for social conflict, rather than the root cause. Climate change is already intensifying environmental and resource problems that communities are facing. In recent decades, social conflict has been particularly prevalent in Africa. According to the Climate Change and African Political Stability (CCAPS) program at the Strauss Center, during 2000-2008, over twenty thousand deaths were recorded in Africa during violent, politically destabilizing episodes outside of insurgencies and civil wars.¹ The Department of Defense and the combatant commanders recognize these issues, and to varying degrees, have established initiatives that incorporate environmental security and disaster preparedness into their security cooperation programs.

The single greatest direct driver of impact on the human habitat is water—too much or too little. Water and water management are key factors to food, health, energy, and economic development. Regional variability in rainfall is an underlying cause, but there is a range of exacerbating factors that are both cause and effect, e.g., population migration, agricultural methods that are no longer sustainable, lack of sanitation and the effect on health and productivity. Population increases demand an increase in agricultural productivity. At the same time, the combination of climate change, unsuitable agriculture practices, poor management of fisheries, and lack of development and management of water resources, particularly in Africa, are obstacles to the needed progress. Over the past half century, the renewable water resource per capita in Africa has decreased by a factor of three.

Water management is essential to sustaining populations. Energy and water are also essential to economic progress. However, a lack of economic resources is a formidable obstacle to water management. For example, in Africa, 95 percent of agriculture is rain-fed with little or no capability for storing or transporting water to deal with the variability in rainfall. Systems to store and transport water are a feature of wealthier nations. Further, given that river basins encompass multiple nations, the mechanisms to manage water across a viable area can, in themselves, cause conflict and population migration.

Roles of the National Security Community

Climate change has the potential for significant impacts on all three of the basic elements important to national and international security—defense, diplomacy, and economics. Dealing with these impacts by mitigating the effects on populations and adapting to change will demand the attention of a broad spectrum of agencies in the national government. This will include the Department of Defense, in support of lead US government agencies. While there will be direct effects on the United States from aspects of climate change to include sea level rise and dramatic changes in weather patterns, the most immediate effects with the highest potential for instability will come from the most vulnerable regions of the world where the United States obtains vital fuel and strategic mineral imports and combats terrorism. To deal with these issues, the Department of Defense, the Department of State, and the United States Agency for International Development (USAID) will be particularly challenged.

The United States has neither the resources nor the influence for an open-ended commitment to addressing the world's challenges related to the consequences of climate change. The United States does have a vital interest in promoting stability in areas of strategic interest. A key to success will be extensive advanced planning and collaboration with others most influenced by the impacts. Near-term work to deal with the immediate basic needs of populations will demand a multiagency and multinational response. Lasting progress will come from longer-

term adaptation to climate change. Adaptation will inevitably include more effective water management, population migration, changes in agricultural practices, and approaches to dealing with hydrometeorological disasters resulting from extreme changes in weather patterns. The effectiveness of adaptation will have significant national and international security implications.

The most extreme effects will be in areas with limited expertise and financial resources. The United States will need to collaborate with the political, economic, and military leadership in these regions to develop the needed expertise in civil engineering, hydrology, energy, agriculture, land use, and infrastructure planning. The long-term stability of these regions will depend on progress in all of these activities, even with no further climate change.

The United States has a long history of effective response to disasters with both the capability and commitment to respond quickly and effectively, often including a significant role for the military, and in particular the National Guard, in support of civil authorities. The US also has a history of successfully dealing with the need to adapt with a long-term focus. Examples include one hundred years of the Agricultural Extension Program that led a farm revolution and the Public Health Service that fostered changes in sanitation and food and water processing that virtually eradicated a set of debilitating childhood diseases. Similarly, the Army Corps of Engineers and the Bureau of Reclamation have dealt effectively with water transportation needs and flood control. This kind of sustained attention will be required to deal with near-term needs and adaptation to climate change.

There is existing structure and activity across the whole of government that can provide much needed expertise. A management and cooperation structure is needed to focus increased attention to assisting vulnerable regions in adapting to climate change. Examples of existing activities include:

- United States Global Change Research Program
- Climate Change Adaptation Interagency Task Force
- Department of State Special Envoy for Climate Change
- Department of State Regional Environmental Hub Program
- DOD Environmental International Cooperation Program
- DOD Minerva Initiative: The Climate Change and African Political Stability program
- Central Intelligence Agency Center for Climate Change
- Department of Agriculture Foreign Agricultural Service
- Environmental Protection Agency Climate Program Office
- National Oceanic and Atmospheric Administration Tsunami Resilient Communities concept work
 - Geographic combatant commanders theater security cooperation plans, supported by environmental security engagement activities
- United States Geological Survey
 - Military support for civil authority activities with various partnerships with USAID, the US Geological Society, Environmental Protection Agency, and the Department of the Interior
- United States Pacific Command Center of Excellence for Disaster Management and Humanitarian Assistance

- US Bureau of Reclamation
- Department of Defense Strategic Environmental Research and Development Program
- Department of Defense, Office of Naval Research Multidisciplinary University Research Initiative on socioeconomic-political driven migratory response of populations affected by rising sea levels

As suggested earlier, while these activities are important, their potential will be significantly enhanced with a structure and process for coordination to more effectively leverage the efforts to address global problems. These efforts need to include better insights into what other countries and international organizations are doing.

Role of the Department of Defense

The Department of Defense will inevitably be a part of approaches to adapt and respond to climate changes in both the United States and in key areas of the globe. Building regional capabilities and alliances to create climate change resilience will be an important contribution to regional stability. To be effective, DOD activities will need to be part of a comprehensive multi-department effort and in coordination with international efforts. DOD will play an important role in dealing with the potential for armed conflict driven by climate-driven population migration. There are existing examples of the potential for conflict generated by drought induced changes in farming and grazing practices in the Darfur region of Sudan, the margins of the Sahel, and southern Africa. The most effective influence of climate-related security issues will come from attention well before the situation deteriorates to the conflict stage.

The Department of Defense has demonstrated capabilities to respond to natural disasters. Much of this experience is applicable to dealing with the near-term effects of climate change. Still, there is a major difference. The traditional objective of disaster relief is a return, as quickly and as practical, to the condition of life as it existed before the disaster. In the case of climate change, there will be no return to the preexisting life's condition. Instead, near-term solutions need to be on the path to adaptation. DOD experience and capabilities include sustained attention to large-scale, long-term challenges. The Department is frequently called on to serve that purpose. DOD routinely conducts contingency planning across a wide spectrum and executes its plans in cooperation with other departments. The objective in Africa and elsewhere should continue to be sustainable political stability where civilian governments, supported by defense cooperation among militaries capable of supporting civil authority, promote resilience to the effects of climate change. The bulk of effort and influence must come from the affected region. Still, the Department can play an important role by providing climate change data and warning, and can help formulate programs to assist foreign militaries to understand the effects of climate change on their force structure, installations, and their country's security situation; and, training countries on how to build their capacity to provide effective mitigation and adaptation in support of civil authority.

Summary of Recommendations

RECOMMENDATIONS ON THE CLIMATE INFORMATION AND MODELING NEEDS

The President's Office of Science and Technology Policy should expand on the Roundtable for Climate Information Services to:

- Define requirements for information systems, catalog existing resources relevant to those requirements, identify gaps, and produce a conceptual roadmap for addressing those gaps.
- Identify obstacles to sustained availability of climate information with international scope.
- Define an operational framework for sustained translation of climate data records and other geophysical information into societal benefit metrics.

- Identify approaches and mechanisms for providing sustained, timely, and actionable synthesis assessments focused on developing regions and locales beyond the current US focus, including options for growing in-country capacity.

The Administrator of the National Oceanic and Atmospheric Administration should:

- Work with the National Aeronautics and Space Administration to conduct a renewed study of options for increasing the availability of low-cost, high-reliability launch vehicles for civil science satellites critical for climate observations.

- Establish a mechanism for frequent reassessment (annual vs. decadal) of observational needs responsive to changing scientific understanding and impacts due to failures or funding, including an evaluation of impacts of such developments to the operational needs of the DOD.

The President's Office of Science and Technology Policy should work with DOD, Department of State, and USAID to identify priorities for operational (distinct from research) climate data in priority regions.

RECOMMENDATIONS ON ROLES OF THE NATIONAL SECURITY COMMUNITY

The Director of National Intelligence should:

- Establish, within an appropriate agency of the Intelligence Community, an intelligence group to concentrate on the effects of climate change on political and economic developments and their implications for US national security.

— An important focus of this effort should be to project human security changes that could develop into national security issues.

— This group should make extensive use of open sources, seek to cooperate with other domestic and international intelligence efforts, and report most of its products broadly within government and nongovernmental communities.

- The intelligence group should commission the Central Intelligence Agency's (CIA) Center for Climate Change and Security to produce an assessment of regional climate change hotspots that threaten human security and governmental legitimacy and exacerbate existing tensions. They should use this assessment as a confidence-building measure to promote communication between antagonistic peoples or states. This document should be the basis for interagency cooperation at the strategic and regional levels.

The President's National Security Advisor, in conjunction with the Council on Environmental Quality, should establish an interagency working group to develop:

- Coordinated climate change policies and actions across US government entities.
- A whole of government approach on regional climate change adaptation with a focus on promoting climate change resilience and maintaining regional stability.

The President's National Security Advisor should continue to emphasize strategic interagency documents, such as the guidance to the combatant commanders which details the link between climate change effects and the underlying conditions that terrorists seek to exploit and should direct relevant organizations to consider this relationship in developing their regional plans.

The Deputy Secretary of State and the Deputy Secretary of Defense should:

- Follow the example of the successful foreign military training assistance program to fashion education and training programs in the fields most relevant to adapting to climate change, e.g., hydrology, civil engineering, construction, agriculture, biology, and public health.
- Make conflict avoidance a priority in foreign assistance (including security assistance and foreign military sales), development, and defense concept development and planning.
- Develop a strategic communication message that links water and food security and increased storm intensity to regional stability and US national security.

RECOMMENDATIONS ON THE ROLE OF THE DEPARTMENT OF DEFENSE

The Deputy Secretary of Defense should:

- Establish a DOD-wide coordinating policy board for climate change impacts on national security. This board's functions should include:
 - A coordinating role on climate change information from the strategic and operational perspective. This would include assessing implications for the force structure, deployment options, etc.
 - Compiling and assessing climate change effects information across the geographic combatant commands to identify implications for regional stability and the development of global and regional foreign military assistance programs.
 - DOD's interagency representative for climate change adaptation matters.
 - Serving as the focal point for information, web-enabled, that can be accessed by other Office of the Secretary of Defense (OSD) offices as well as the Joint Staff, Services, and combatant commands.
- Expand the authorities of the Operational Energy Plans and Programs Office to include operational climate change issues.
- Direct the establishment of a program of climate change adaptation pilot projects in concert with related programs at USAID and other agencies to identify, solicit, and fund pilot projects focused on specific adaptation sectors and locales (e.g., management of regions or villages in Africa and Central Asia). Examples of pilot projects and suggested activities might include, but not limited, to:
 - Embrace and augment the World Climate Research Program Coordinated Regional Climate Downscaling Experiment (CORDEX) for one of the sub-regions in Africa. Apply CORDEX in concert with an assessment activity similar to the Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects (PRUDENCE) project.
 - Extend the observational, modeling, and synthesis assessment capabilities applied today in the United States in the Upper Colorado River Basin to a priority water resource district in Africa, perhaps linked with the Nile Basin initiative.
 - Apply coastal hot spot pilot projects focused on offering local-scale risk assessment and planning for integrated sea level and storm impacts on the coupled water-energy-waste resources and physical infrastructures for megacities such as Lagos, Karachi, and Daka.
 - Engage the United States Global Change Research Program (USGCRP) international research programs, DOD commands and their in-country security partners, and international aid agencies such as USAID in identifying opportunities to share climate change-related information and bringing more visibility into stakeholders' activities.

— Focus on near-term, achievable, and measurable goals to develop and demonstrate end-to-end threads of core information systems while incrementally building in-country capacity and competence.

Office of the Secretary of Defense, Office of the Under Secretary of Defense for Policy and the Director, Joint Staff should direct development of a DOD strategic roadmap for climate change-related efforts that builds on the framework laid out in the US Navy Climate Change Roadmap to:

- Ensure that the guidance to the combatant commanders, once signed, is considered to be adequate by the Services and combatant commands for translating the broad-level guidance offered in the Quadrennial Defense Review into actionable requirements.
- Direct that combatant command missions include non-combat support to address serious climate change-induced US national security vulnerabilities.

The Deputy Under Secretary of Defense for Installations and Environment should assemble an inventory of critical facilities and infrastructure to include an assessment of vulnerability to climate change effects and the means to adapt.

The Director, Joint Staff should:

- Create a holistic approach to climate change, integrating efforts of its relevant directorates: J2 (Intelligence), J4 (Logistics), J5 (Strategic Plans and Policy), and J8 (Force Structure, Resources, and Assessment Directorate).
- Require that climate change and disaster risk reduction be integrated into training and exercises.

The Secretaries, Chiefs of the Services, and heads of defense agencies should:

- Better integrate climate change and disaster risk reduction considerations into exercises, training, and educational materials.
- Establish metrics focused on risk reduction to minimize the impact of climate change on military and support operations, forces, programs, and facilities.
- Develop guidance to ensure climate change resilience in DOD project designs and construction by incorporating climate change risk into design standards for facilities and installations, with emphasis on the elements related to energy intensive and water intensive uses.

The Secretaries and Chiefs of the Services should:

- Assess the Services' engineering organizations and the cost-benefits of using them in assisting climate change adaptation.
- Utilize military to military engagement opportunities with coalition partners to enhance resilience to climate change impacts and disaster risk reduction capacities. In so doing, they should expand consideration of roles for the National Guard and reserves. (For example, knowledge of traditionally non-military skills needed to respond to climate change threats is often found in the reserves.)
- Examine tasking authorities for domestic and international response to natural disaster or other disaster risk response situations. For example, the National Guard could bring important assets to an international disaster, as it already does in responding to domestic disasters.

United States Northern Command, with support from the Navy and Coast Guard, should identify the assets that will be needed to operate in the Arctic to include communication assets, personnel training, ice breakers, and

other equipment.

The geographic combatant commands should:

- Identify early warning indicators for those areas critical to DOD's mission set.
- Incorporate the guidance from the Quadrennial Defense Review and DOD Strategic Guidance on energy, security, and climate change into theater campaign plans.
- Create a demand signal by articulating the need to understand the implications of climate change and resource scarcities in their region to support their campaign plans.
- Include in their theater campaign plans energy, food, water, and disaster risk reduction strategies and plans for reducing vulnerabilities within their respective areas of responsibility.
- Harness more systematically resources beyond the traditional combatant command structure, to include the National Guard, and its State Partnership Program, service engineering units such as the US Army Corps of Engineers and Naval Facilities Command, and OSD-led programs such as the Defense Environmental International Cooperation Program and the Strategic Environmental Research and Development Program.
- Conduct systematic regional or even more localized impact assessments to identify trends and where their resources should be focused. To this end, each should request that the CIA Climate Change and Security Center provide a report on climate change effects and hot spots in their respective areas of responsibility. Programs such as DOD's Climate Change and African Stability Project (Minerva Initiative) could also be utilized in such undertakings.
- Include as a Tier 1 objective enhancing the capacity of host nation militaries and civil response readiness groups to plan for, and respond to, natural disasters (e.g., floods, coastal storm surges, and droughts).
- Integrate into their humanitarian assistance/disaster relief and other exercise plans additional climate change-related aspects. These exercises should include interagency activity.
- Promote the concept of coordinated management of shared natural resources like water.

Chapter 1

Current Observation, Model, and Climate Projection Capabilities

To be effective, actions by the United States addressing the impacts of climate change that are potentially important to national security require extensive advanced planning and interaction with others' interests in advance of significant effects. This requires the ability to assess potential future environmental effects of climate change and their political, economic, and geographic impacts years or decades before those effects appear. Generating such assessments involves the synthesis of observations of the current and past climate system, numerical models and their predictions and projections, non-climatic information, and expert judgment.

Assessments of past and current climate conditions are largely based on observational data with well-quantified uncertainties. Assessments of future climate variability and change are more complex and the needed understanding of the nature and limitations of assessment capabilities are often not available to decision makers. The words prediction, forecast, and projections are frequently used, often interchangeably, in assessments of potential future climate change impacts following the familiar paradigm of weather forecasts, with an assumption that predictions, forecasts, and projections use the same methods and produce equivalent information. However, there are important differences between these assessment methods. The differences are relevant for understanding the capabilities and limitations of present-day climate information. This chapter begins with an overview of these methods, followed by a review of current climate observation and modeling capabilities.

Climate Prediction, Forecast, and Projection Methods

To start with familiar territory, weather forecasts are currently produced by Numerical Weather Prediction (NWP) systems. These systems are made up of four principal components:

- Wide variety of observations (e.g., balloon soundings, surface measurements, satellite measurements, and ocean buoy measurements)
- Numerical/computer forecast models
- A data assimilation system
- Expert interpretation

Observations provide an initial condition for the forecast model that supports a physically-based weather prediction projected for five to fifteen days. For the next forecast, the data assimilation system is used to produce a new initial condition valid for that time by incorporating the new observations that have become available with the model forecast applicable to that time. The latter provides dynamical constraints and fills in the gaps where observations are inadequate. Finally, the results of this forecast are interpreted by meteorologists who apply expert judgment to the final products released to end users. This is a rigorous procedure continually exercised by operational weather services every day.

A close analogy, sometimes referred to as seasonal climate prediction (e.g., one to six month lead time), uses essentially the same tools, resources, and general methods applied in weather forecasting, albeit on longer timescales. Currently, seasonal climate prediction is primarily limited to features such as the El Niño Southern Oscillation (ENSO) or the Indian and Asian monsoons. In contrast to weather forecasts, the longer timescales of climate require consideration of additional physical factors and processes that do not change appreciably over the course of a weather forecast:

Examples of such factors and processes impacting climate include soil moisture, sea ice, biogeochemistry, and in particular the interaction with the near surface layer of the ocean. Such models need to be more comprehensive and less detailed because of computational limitations. Moreover, the observational needs are far more demanding, requiring measurements of a wider set of physical factors and processes. Despite this, there are currently a number of successful, skillful, operational, and seasonal climate prediction efforts for seasonal forecasting, but these are mostly associated with predicting ENSO impacts on global weather and climate patterns. A key limitation of these seasonal climate predictions is that they are currently designed to forecast the large-scale pattern, general character, and statistics of tropical Pacific sea surface temperatures but not the specific evolution of the weather patterns within the affected area.

Two extensions of the weather and seasonal climate forecasting paradigms are relevant to assessments of longer-term climate change. The first, decadal climate prediction, attempts to start from an observed initial condition of the climate state and then models the evolution of the larger-slower scale climate patterns (e.g., ENSO, meridional overturning circulation in the Atlantic Ocean, potential greenhouse gas-related warming over the decade), followed by quantifying the statistics (but not detailed behavior) of the weather associated with these changes. One aspect of the upcoming Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) will employ this method to assess nearer-term impacts (e.g., through 2035).

The second extension is often associated with the term "climate projections." This terminology generally applies to century-scale models, typically through the year 2100. The word projection, rather than the words prediction or forecast, highlights that a climate projection is meant to represent the expected evolution and character of the most general features of climate (e.g., global mean and large-scale temperatures, snow and ice cover, sea level rise). The projection includes the statistics of weather, its extremes (e.g., heat waves, droughts, and hurricanes), and the character and changes in modes of weather and climate variability.

For climate projection, the role of observations shifts from providing initial conditions to supporting model development and model validation by comparing the results of climate simulations to past observed climate over a relevant period. Such information is not yet comprehensive in terms of a variety of physical processes that come into play over long timescales. Climate data records need to be sufficiently long to capture the variability and trends over the course of the projected lead time, which may be decades or a century. Finally, climate projections often include a range of potential future physical actions affecting the emission and removal of climate-forcing greenhouse gases.

With the above clarifications in mind, it is evident that both observations and models of the Earth system form the foundation for climate assessments. Hence, the fidelity and utility of climate assessments are directly related to the capability and limitations of existing observations and models. Given the need to explore a broad range of potential future changes in the environment, coupled with socioeconomic drivers and impacts, Earth system observations and models are needed to quantify and understand the past and present climate and to provide objective and physically-based inferences on future climate and its associated impacts. The model results need to include rigorous quantification of the associated uncertainties.

Climate observations

Comprehensive observations of the Earth system—the atmosphere, hydrosphere, cryosphere, and biosphere—are foundational to assessing past and present climate conditions and supporting efforts to forecast and project future conditions. Their relevance and importance to projecting future conditions derives mainly from their usefulness in supporting climate model development, validation, and evaluation. Climate models are the only means to obtain objective and physically-based projections of future climate. To be useful in serving that purpose, it is essential that observations are well-designed, calibrated, and maintained over time. Models offer mathematical representations of the Earth system with uncertainties limited by the validity of the underlying assumptions and the spatial, temporal resolutions afforded by the available computational resources. In contrast, observational uncertainties are limited principally by temporal and spatial sampling biases, the systematic errors (e.g., bias) associated with the measurement technology, and the random measurement error (i.e., noise) that can arise from both of the above.

Figure 1-1 presents an example of the differences in fidelity that can occur between observations and model simulations.² In this case, the model significantly underestimates the observed information.³ This is not to suggest that observations are always better than models or sufficient alone. Both are needed. Observational data in the absence of models can be noisy and of limited use without the essential link to physical processes. Models without grounding in observations can be fantasy. Observations complement and support models by facilitating study of key processes towards better models, by offering a benchmark to validate and guide refinement in models, and by integration with models through data assimilation. Data assimilation provides the means to produce retrospective reanalysis utilizing as many observations and model constraints as possible.

Observations of the current Earth system state are conducted from a range of vantage points using different measurement techniques. Observational vantage points include the surface and subsurface of land and oceans (e.g., buoys, drifters and ships of opportunity), airborne platforms (e.g., research and commercial aircraft), and satellites in a variety of orbits. Measurement techniques include sample collection for laboratory analysis, in situ measurements, and remote sensing techniques spanning the electromagnetic spectrum. A subset of these techniques is employed to study proxies for past climatic conditions (e.g., analysis of air and water stored in ice cores).

Many observational systems today are focused on addressing fundamental questions in climate process understanding—for example, the global radiation budget, the hydrologic, carbon, and nitrogen cycles, and other feedback processes. Such research is critical to improving the quality of global climate models but often the question being asked can be addressed with global-scale information using sparse observations, so not necessarily providing the denser sampling and regional or local scale information relevant to decision-making.

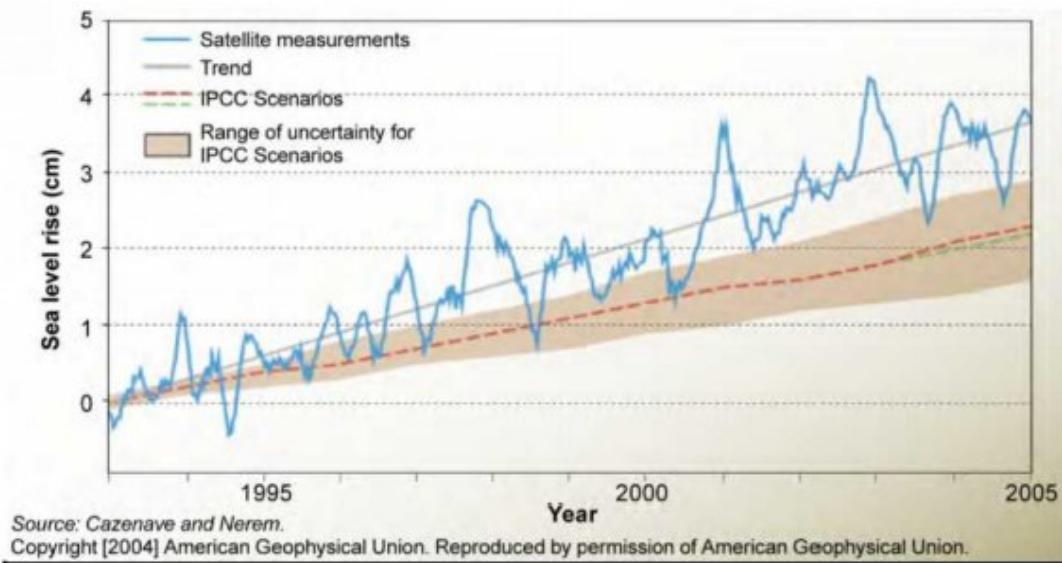


Figure 1-1. Global sea level rise as recorded by satellite measurements

Essential Climate Variables (ECVs), listed in Table 1-1, have been defined by the Global Climate Observing System⁴ in an effort to prioritize observations and close gaps. Assessment of ECV collection status is an ongoing effort, without clear consensus on the current state of completeness. For example, some assessments show fairly complete ECV data collection but only for global scale assessments. An assessment of ECVs providing higher resolution information needed to support regional assessment and downscaling of climate models offers a less optimistic picture.

Table 1-1. Essential Climate Variables

Domain	GCOS Essential Climate Variables	
Atmospheric (over land, sea, and ice)	Surface:	Air temperature, Wind speed and direction [over the oceans], Water vapour, Pressure, Precipitation , Surface radiation budget
	Upper air:	Temperature, Wind speed and direction , Water vapour, Cloud properties , Earth radiation budget (including solar irradiance)
	Composition:	Carbon dioxide, Methane, and other long-lived greenhouse gases, Ozone and Aerosol, supported by their precursors.
Oceanic	Surface:	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour , Carbon dioxide partial pressure, Ocean acidity, Phytoplankton
	Subsurface:	Temperature, Salinity , Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers
Terrestrial	River discharge, Water use, Groundwater, Lakes , Snow cover , Glaciers and ice caps , Ice sheets , Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture	

Note: Bold font indicates ECVs primarily provided by satellite observations.

Source: Committee on Earth Observation Satellites (CEOS) 2011

For example, observationally derived estimates of global mean sea level, an ECV, are generally considered well established. However, shifts in wind, rain, evaporation, and land ice volume can result in local-scale variations in sea level that can be an order of magnitude larger than the global mean increase projected from thermal expansion of the ocean and land surface melt-water runoff.⁵

Comprehensive assessments of the completeness of climate observations are not readily available. To some extent, this is a moving target given ongoing developments in various development programs and national budgets. However, some insight can be gleaned by considering specific examples.

Examining the evolution of Numerical Weather Prediction over the past several decades is instructive. NWP is the foundation of the weather forecasts generated by national weather services. As noted in the opening of this section, NWP uses data assimilation to ingest a variety of in-situ and satellite observations for the purpose of generating the accurate initial conditions for their weather forecasts. Figure 1-2 illustrates a tenfold improvement in spatial resolution in short-term weather forecasting between 1980 and 2005 for the National Centers for Environmental Prediction (NCEP) in the United States and the European Center for Medium-Range Weather Forecasts (ECMWF). This improvement derives mainly from an increase in computational resources and speed which, when combined with improvements in the models themselves and the increasing number and types of observations, has led to a continuing increase in NWP forecast skill over the same period.

Over the last decade or more, the above framework of utilizing observations in conjunction with data assimilation methodology and numerical forecast models has air quality and hydrology extensions to weather forecasts. For longer timescales, it has extended to ocean information for the purposes of forecasting El Niño Southern Oscillation and seasonal climate prediction. Most recently, this framework has been extended to consider decadal climate prediction and efforts to employ observations of atmospheric concentrations of carbon dioxide (CO₂), an ECV, to provide potential retrospective analysis and prediction information to climate treaty verification.⁶

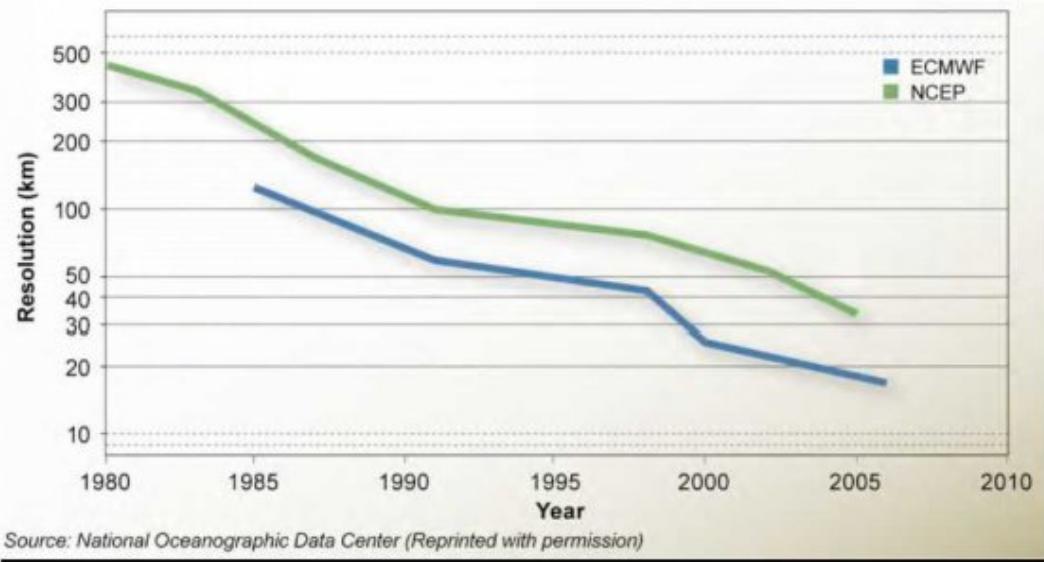


Figure 1-2. Trends in short-term weather (0-14 Days) numerical weather prediction resolution

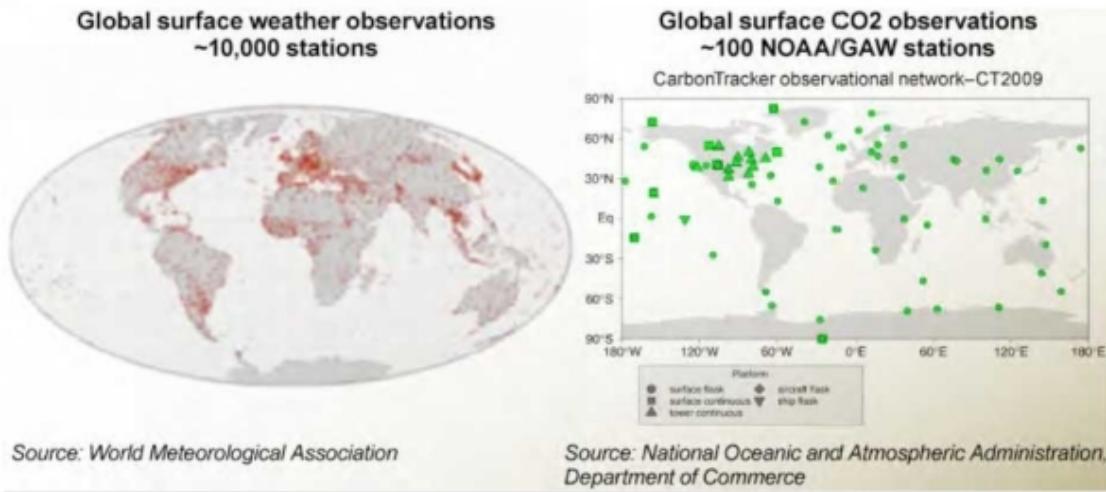


Figure 1-3. Relative density of existing surface weather stations in the United States and global CO₂ observations

Figure 1-3 offers a striking comparison between the density of global surface weather stations, an operational system used to support NWP, and surface CO₂ observations from the Global Atmosphere Watch, an exploratory science program, and the National Oceanic and Atmospheric Administration (NOAA). The orders of

magnitude difference in weather versus CO₂ observations and associated funding (Table 1-2) also reflect this stark disparity. The implication for CO₂ is that significant gaps will need to be closed to offer an improvement in capability analogous to that experienced with the evolution of NWP.

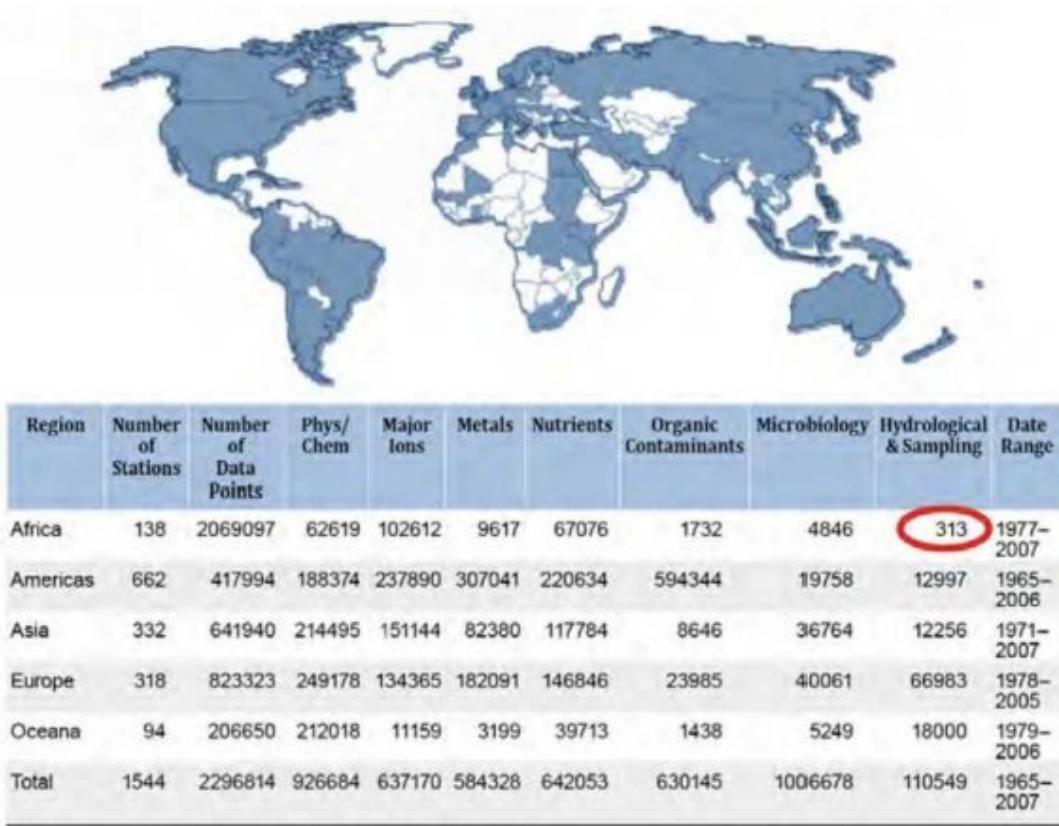
With regards to surface hydrology observations, Figure 1-4 offers a summary of existing United Nations Environmental Program (UNEP) Global Environment Monitoring System (GEMS) data collection resources by continent. Africa significantly lags other regions in terms of observational density with only 3 percent of hydrologic measurement sites spanning a region representing 20 percent of the Earth's inhabited land surface area.

Table 1-2. Comparison of total observation assets and annual expenditures (FY09) on the global weather system and global CO₂ observations including satellites in geostationary and low earth (polar) orbits.

	Weather	Surface CO ₂
Surface-based stations	>10,000 globally	100 globally
Geo satellites	>10 (all nations)	0
Leo satellites	>10 (all nations)	1*
Product spatial resolution (reanalysis and forecast)	10–40km	>2000km
U.S. annual funding (average, civilian)	\$3,000M (\$1,000M NWS, \$2,000M NESDIS)	\$120M (across 7 agencies, USGCRP)

Note: The asterisk indicates the current capability lacks the required precision and spatial resolution for decision support.

Source: World Meteorological Association



Source: UNEP GEMS Water Programme (Printed with permission)

Figure 1-4. Comparison of hydrologic observation sites for UNEP GEMS program

As of June 2010, the National Aeronautics and Space Administration's (NASA) plan for satellite observations relevant to water resource management includes the following funded programs:⁷

- Measurements. The Global Precipitation Mission, with a 2013 scheduled launch, will provide an important advance over the Tropical Rainfall Measuring Mission by providing enhanced geographical coverage, dual frequency radar for precipitation type, and three-hour temporal resolution coming from its constellation of satellites using passive microwave sensors.
- Soil moisture and freeze-thaw state. The 2014 launch of the Soil Moisture Active Passive (SMAP) mission will provide global measurements of soil moisture and freeze-thaw state.
- Inland water height. The launch of the Surface Water and Ocean Topography (SWOT) mission, planned for launch in 2020, will provide unprecedented insight into the quantity of water in rivers and lakes and higher resolution ocean surface topography.
- Ground water measurements. The Gravity Recovery and Climate Change Experiment (GRACE) Follow-on (FO) mission will provide continental (1.000s kms) information on changes in surface snow, ice, water, and stored ground water building upon the approach demonstrated with the GRACE mission.
- Glacier volume changes. The Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2) and Deformation, Ecosystem Structure and Dynamics of Ice (DESDynl) lidars can provide information about glacier volumes and their changes over time, especially, but not exclusively, at high latitudes.

■ Water quality in coastal regions. The launch of the Ocean Ecosystem Spectroradiometer instrument aboard the first platform of the Pre-Aerosol, Clouds, and Ocean Ecosystem mission, planned for launch in 2018, will provide new, high quality information on the biogeochemical properties of coastal waters and their implications for ecosystem and human health.

■ Northern latitude land, lakes, and permafrost. Change in Arctic features is a broad bellwether of climate change. Coupling of data from the Soil Moisture Active Passive mission, SWOT, DESDynI, and GRACE FO will enable an integrated view of the land portion of the water cycle in this key region.

Similarly, in October 2010, the United States Group on Earth Observations (USGEO)⁸ offered several recommendations to avoid near-term gaps aligned with seventeen topical areas.⁹ However, subsequent changes in funding impacted multiple elements of the above plans for sustained observations. Additionally, failures of the launch of scientific satellites continue to occur. The decision to launch one-of-a-kind spacecraft and instruments on lower-cost, lower-reliability launch vehicles may be compatible with priorities in a program driven by exploratory science. It does not provide for reliable operational data delivery. There is no indication this trend will be corrected in the near future to maintain a reliable deployment schedule for an operational capability. Operational observations from space today with relevance to climate information are primarily limited to the weather satellites of NOAA/NASA and their defense counterparts in polar and geostationary orbits.¹⁰

The above discussion on observation is consistent with the following from the 2010 National Research Council study Advancing the Science of Climate Change:

An integrated Earth system analysis capability, or the ability to create an accurate, internally consistent, synthesized description of the evolving Earth system, is a key research need identified both in this report and many previous reports. Perhaps the single greatest roadblock to achieving this capability is the lack of comprehensive, robust, and unbiased long-term global observations of the climate system and other related human and environmental systems.¹¹

Findings on Climate Observation

Today's climate observations and models exist as a loose federation of programs at many government agencies, academia, industry, and nongovernmental organizations (NGOs). While some of these assets are operational systems (e.g., those supporting weather and seasonal climate like the ENSO forecast services), the majority of observational assets and many of the modeling assets today are intended primarily for exploratory science rather than supporting operational, long-term climate assessments.

Many of the observational assets of the civilian scientific community are not robust to failures or data gaps.

Many observations are intended to help improve basic climate process understanding such as closing global-scale energy, carbon, and water budgets but do not necessarily offer the spatio-temporal resolution, completeness or accuracy to support needed improvements in, or validation of, regional climate models, particularly in developing countries.

The US government needs a scientifically robust, sustained, and actionable climate information system that addresses these and other issues. The needs for such a system and key barriers to its establishment are described in Appendix A of this report.

Climate Models

Climate assessments and projections rely on three categories of models:

■ Global climate models, sometimes referred to as Earth system models, that represent the biogeophysical processes of the Earth system including atmosphere, hydrosphere, cryosphere, and carbon cycle

- Impact assessment and vulnerability models that address the impact of climate on human resources including infrastructure, health, food, and water availability
- Integrated assessment models which seek to determine the connectivity of human action such as energy, land, and water use with the other two model domains

The three types of models have some degree of overlap. A more complete treatment of these domains for synthesis assessment is presented in Appendix A. This section focuses on the evolving capabilities of Global Climate Models (GCMs).

GCMs vary in complexity and capability but generally consist of coupled atmosphere-ocean general circulation models, with additional components that account for land surface and some cryospheric components (e.g., snow, sea ice). Such models are the backbone of objective, physically-based climate projections. There are three principal limitations when projecting the combined impacts of climate change in specific regions of the world:

- Uncertainty in the trajectory of future emissions of anthropogenic greenhouse gasses and their airborne fractions in the presence of a changing climate
- Limitations and uncertainties associated with GCMs
- Limitations in deriving predictive information at relatively fine local-to-regional scales (~ 1 to 100 km) from GCM simulations which are presently limited to representing climate changes on scales larger than about 1000 km

The first limitation involves the wide range of potential future greenhouse gas stabilization scenarios with the shortcomings in coupled carbon-climate models. In 2001, the Intergovernmental Panel on Climate Change (IPCC) developed a family of future emission scenarios, the Special Report on Emission Scenarios (SRES). The SRES scenarios, illustrated in Figure 1-5, formed the foundation of the range of climate projections associated with the third and fourth IPCC assessments. In the figure, colored lines indicate the six illustrative SRES marker scenarios. The 80th percentile range of subsequent "post-SRES" scenarios comprise the gray shaded areas. Dashed lines show the full range of post-SRES scenarios. Emissions cover CO₂, CH₄, N₂O, and F-gases.

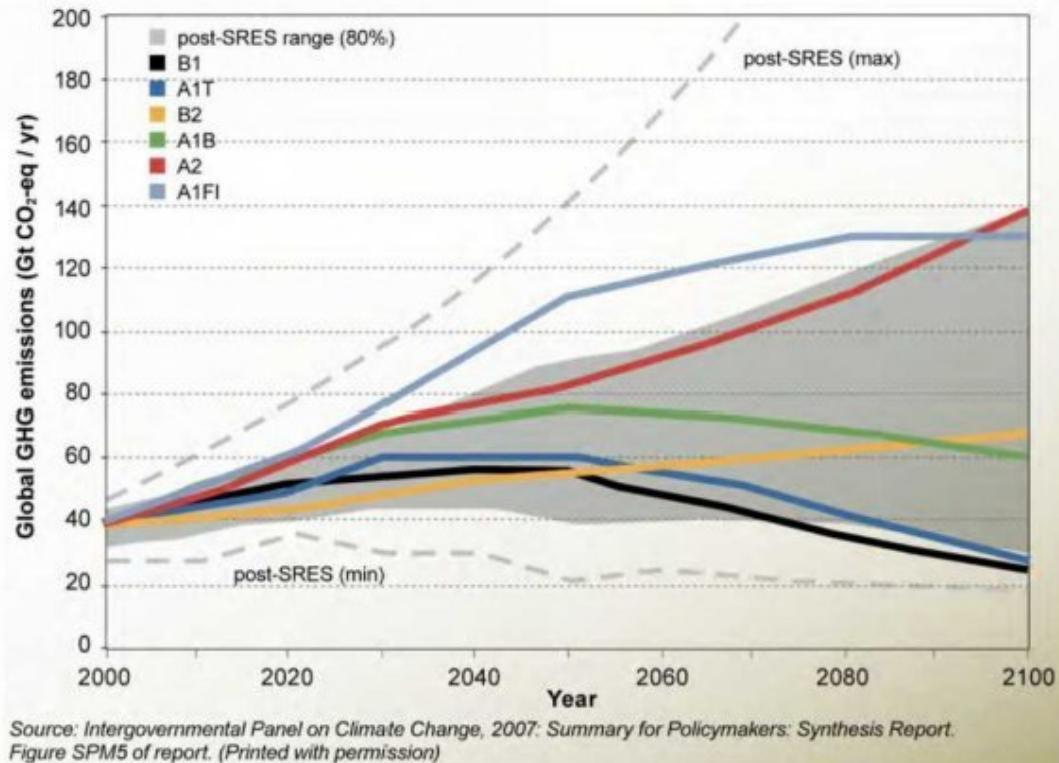


Figure 1-5. Global greenhouse gas emissions

The socioeconomic assumptions behind the SRES scenarios lead to a divergent set of potential outcomes regarding airborne fractions of greenhouse gasses over multiple decades. It should be emphasized that in past IPCC assessments, only a subset of such emission scenarios were fully evaluated by GCMs and subjected to integrated assessment of impacts and vulnerability. To some extent this was due to practical limitations in computational capacity that precluded running full GCMs for all emission scenarios. For example, in the IPCC Fourth Assessment Report (AR4), the most intense scenario A1FI (the FI representing fossil intensive) received partial treatment with Simple Climate Models that attempted to predict the warming that the more complex GCMs would have projected. Given this artificial limitation in the assessment, process readers of AR4 were presented with an impression that a global warming of 4°C by 2100 represented a worst-case scenario; whereas, a closer examination reveals that the likely range of the scenarios is 1.6-6.9°C.

There is an ongoing debate about the likelihood of scenario A1FI. On one hand, recent observations of atmospheric greenhouse concentrations indicate a trend consistent with the A1FI scenario, suggesting this scenario may represent a more likely trajectory. On the other hand, we are still only one decade into the 21st century and some experts continue to assert that A1FI paints a "non-credible" picture of future emissions: that fossil fuel use will peak early this century due to resource limitations. In any event, decision makers should be aware of the uncertainty inherent in predicting future emission trajectories and the broad range of possible outcomes, including those that could lead to two to three times greater warming by 2100 than the 2°C warming scenario that has been the focus of some recent policy discussions and an earlier onset of such warming.

The preceding discussion dealt only with uncertainty in the climate forcing from an emissions perspective in an otherwise static environment. However, the other confounding issue in projecting the climate (radiative) forcing is an incomplete understanding of the biogeophysical processes associated with the carbon cycle and the climate feedbacks on the carbon cycle (with implications on the net atmospheric levels of the two most significant anthropogenic greenhouse gases, CO₂ and CH₄). The airborne fractions of CO₂ and CH₄ undergo significant interannual variability due to natural processes such as the El Niño Southern Oscillation. The preponderance of

evidence suggests the mean airborne fractions of CO₂ and CH₄ are likely to change in the presence of an evolving climate due to impacts on the carbon sequestration potential of the terrestrial ecosystems and oceans.

While there is disagreement about whether current observations are already showing a trend in increasing airborne fraction (difficult to assess given uncertainties in terrestrial carbon cycle measurements), coupled models such as those contributing to the Coupled Carbon-Climate Model Intercomparison Project (C4MIP) have shown unanimous agreement that this mechanism is a positive feedback. The airborne fraction is expected to accelerate in a warming climate. Recent coupled carbon-climate models and expert assessment report a best estimate for the A1FI scenario of a 4°C mean warming by 2070—or in the early 2060s if the carbon cycle feedback is stronger than predicted.

The second limitation mentioned above involves the present-day shortcomings and challenges of developing accurate GCMs that form an essential component of our synthesis of the climate system. Equally, if not more important, is their role in providing objective, physically-based climate projections, and thus a backbone of our assessments. Up to, and including, the 2007 IPCC Fourth Assessment, these GCMs accounted for the physical interactions between the oceans, atmosphere, land surface (e.g., soil moisture, land cover type, and influences of vegetation), and elements of the cryosphere (e.g., snow cover, sea ice).

At present, modeling groups are developing their contributions for the next set of coupled model experiments, referred to as the 5th Coupled Model Intercomparison Project (CMIP5)¹² that forms the principal model simulation and projection component for the upcoming IPCC Fifth Assessment Report. For CMIP5, the state-of-the-art in the above-mentioned components continues to evolve and improve, with more realism in the representation of aerosols and the microphysics of clouds and their interactions together, with solar and infrared radiation in the sophistication of the land surface processes, namely vegetation, snow pack, runoff, and soil moisture, of clouds and aerosol, and in the thermodynamic and dynamic representation of sea ice. Moreover, there is capacity for a slight improvement in horizontal resolution, now about 100km for many models when running century-long simulations and projections.

This increased computing capacity, along with additional component understanding and need for better decision support, have necessitated two significant additions to past CMIP model archives and associated science and assessment activities. The first includes explicit carbon cycle coupling within a suite of historical simulations and century-lead projections. For these cases, rather than specify the carbon dioxide concentration, the emissions are specified and the, as yet identified, principal sources and sinks of CO₂, along with transport processes, are simulated to provide prognostic values of CO₂. These projections allow for more degrees of freedom and will test the understanding of how the land and ocean sources and sinks will respond to the various emission pathways that could be considered.

The second targets more tangible and near-term assessments, with more realism at regional scales, via thirty-year climate projections. These are characterized by using an ensemble of observed initial conditions from the recent past climate (e.g., 1975, 2005) and the associated GCM model predictions from these initial conditions, with the possibility of slightly higher resolution given the shorter integration time. Decadal prediction is still very much in an experimental stage, and the degree of predictability of the natural variability at decadal timescales is still uncertain. In any case, both the century-scale projections (whether carbon-coupled or not) and, in particular, the decadal scale predictions will serve as useful input to regional downscaling efforts to bring more information to decision support issues (e.g., local/regional hydrology, sea level, and extremes).

Given the significant number of global models (~20), each with differences in the manner they model the physical system, along with the multi-member ensemble of simulations and projections expected from each model, and the array of specification for CO₂ (e.g., levels of specified concentration or emission scenarios). These models provide a significant advance in phase space sampling to better quantify scenario, model, stochastic, and initial condition uncertainties. Such information can be utilized from the global models, as well as augmented with downscaled information from a suite of regional models, to provide global to local policy and decision makers a broad sampling of physically-based information. In addition to the above primary new elements to CMIP5, there is a host of science-motivated experiments designed to improve understanding of the physical climate system and provide improved information on climate change and variability attribution.

While the model simulation and projection component of the next IPCC assessment, namely CMIP5, is expected to be an advance over past assessments, there are a number of processes that warrant better understanding and modeling fidelity. Still missing are realistic interactions with soils, ocean chemistry, and deep ocean floor sources and sinks, and processes. Coupled interactions with glaciers and ice sheets have yet to be incorporated, with implications on the fidelity of future sea level rise projections on local and regional scales.

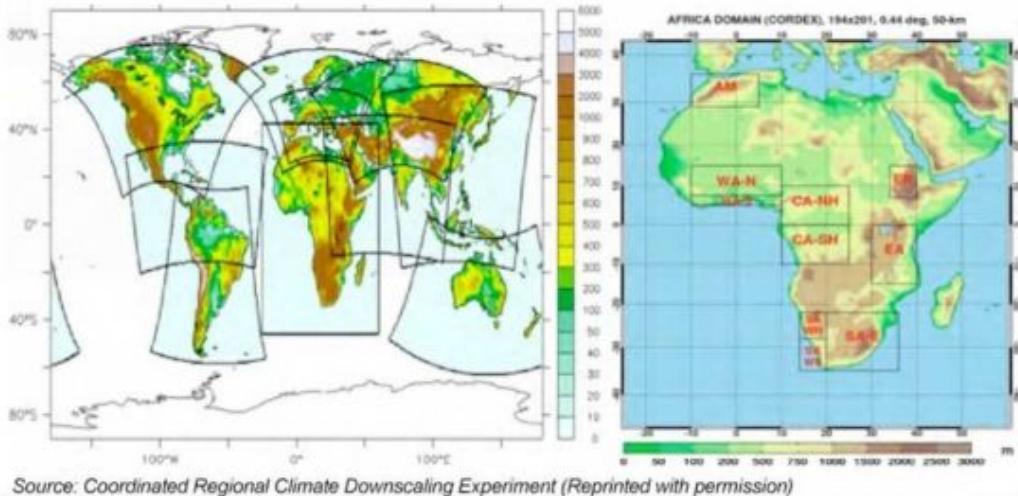
Illustrative of model shortfalls are future projections related to water availability in Africa. The IPCC Fourth Assessment Report¹³ provides the latest synopsis of model projections for Africa along with a discussion of model limitations. To summarize, warming in Africa during this century is very likely to be larger than the global annual mean warming throughout the continent, and in all seasons; rainfall is likely to decrease in much of Mediterranean Africa, the northern Sahara, and southern Africa, and increase in East Africa. However, it continues to be unclear how rainfall in the Sahel, the Guinean Coast, and the southern Sahara will evolve.

In addition to these micro- to meso- scale physical issues, on a macro- to global-scale the relative importance of changes in sea surface temperatures and land use change on rainfall is not well understood. Dust and black-carbon are accounted for in many cases but still carry large uncertainties.

The continued and increasing focus on vulnerability and impacts in the upcoming IPCC Fifth Assessment Report, coupled with the new element of decadal-lead predictions (e.g., thirty years from 2005), places greater emphasis on regional downscaling models. While the GCMs are improving their horizontal resolution, the nominal 100 km grids are still much too coarse to represent critical physical details in the landscape (e.g., finer topography, detailed river routing, and vegetation variations) or the interactions of the circulation and hydrology over the landscape. To help address this gap, the GCM output, at the needed temporal sampling ($\sim \leq$ six hours) and spatial grid specifications, is provided under some CMIP scenarios that allow for dynamical downscaling with higher resolution.

Regional Climate Models (RCM) activity, as applied to climate change, has proliferated in the last decade or more. In fact, as part of the modeling experimentation for the IPCC Fifth Assessment Report framework, a framework called the Coordinated Regional Climate Downscaling Experiment (CORDEX) has been initiated whereby several specific sub domains (Figure 1-6) have been identified for systematic RCM downscaling.¹⁴ The CORDEX effort builds on two earlier European efforts, Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects (PRUDENCE) and Common Ensembles Climate Forecast System (ENSEMBLES) and one North American effort, North American Regional Climate Change Assessment Program (NARCCAP) that primarily focused on these respective continents.

In all these cases, more than one RCM is used to form an ensemble of possibilities and account for the uncertainties and individual model biases. RCMs are faced with the same challenges of model shortcomings and evaluations of their fidelity as GCMs with typically the same issues: clouds and convection, aerosol-radiation-cloud interactions, snow and soil processes, etc. In fact, RCMs in some sense are more challenged because of their attempt to represent more processes, particularly those related to impacts.



Source: Coordinated Regional Climate Downscaling Experiment (Reprinted with permission)

Figure 1-6. Sub-domains for CORDEX regional climate model downscaling, including Africa

Similar to the GCM industry, the modelers are taxed simply by the model development efforts, including the numerous processes at a finer, more detailed level, and are not able to always take advantage of new and sophisticated observation resources to evaluate their model and either improve it or quantitatively characterize its uncertainties. Moreover, the process of effectively conducting this sort of experiment (e.g., several RCMs using several GCMs for boundary conditions) is very demanding in terms of computational capacity and workforce. The time, expertise, and resources currently available for these sorts of efforts are not commensurate with the critical role such models will play in future assessments.

Findings on Climate Models

Carbon-cycle models, including their interactions with the water cycle and interactive vegetation models, are in their infancy.

Further development is needed in a number of modeled processes, e.g., cloud processes, soil moisture, interactive snowpack and vegetation processes. The modeling also needs to address how this may influence aerosol sources; sea ice and ice-shelf interactions with the ocean; and, large-scale thermo-haline circulation in association with the details of ocean vertical mixing, convection, and horizontal eddies.

The influences and feedbacks that can arise from melting ice sheet and glacier driven sea level increases, albedo reductions, and ocean circulation modifications are not yet accounted for in the present-day coupled climate modeling framework with significant implications on the accuracy of future sea level projections on regional and local scales.

The inability to provide accurate, regional-scale, long-range precipitation projections is driven by continuing challenges in understanding and representing moist physical processes in the atmosphere and their interactions with aerosols (e.g., biomass burning or dust in the case of Africa) and radiation as well as the limitations of coarse spatial resolutions of climate-scale models.

Despite recent progress towards improving their utility for supporting vulnerability and impact assessments, current climate models are still largely research assets and hampered by limitations in computational and personnel resources.

Increased personnel, education, and funding resources for model development are required to provide the needed more accurate and robust climate projections.

RECOMMENDATIONS ON CLIMATE INFORMATION SYSTEM NEEDS

The President's Office of Science and Technology Policy should expand on the Roundtable for Climate Information Services to:

- Define requirements for information systems, catalog existing resources relevant to those requirements, identify gaps, and produce a conceptual roadmap for addressing those gaps.
- Identify obstacles to sustained availability of climate information with international scope.
- Define an operational framework for sustained translation of climate data records and other geophysical information into societal benefitmetrics.
- Identify approaches and mechanisms for providing sustained, timely, and actionable synthesis assessments focused on developing regions and locales beyond the current US focus, including options for growing in-country capacity.

The Administrator of the National Oceanic and Atmospheric Administration should:

- Work with NASA to conduct a renewed study of options for increasing the availability of low-cost, high-reliability launch vehicles for civil science satellites critical for climate observations.
- Establish a mechanism for frequent reassessment (annual vs. decadal) of observational needs responsive to changing scientific understanding and impacts due to failures or funding, including an evaluation of impacts of such developments to the operational needs of the Department of Defense.

The President's Office of Science and Technology Policy should work with the Department of Defense (DOD), Department of State (DOS), and United States Agency for International Development (USAID) to identify priorities for operational (distinct from research) climate data in priority regions.

Chapter 2. Current Climate Change Situation and Trends

Global Climate Change Trends

This chapter examines trends in global climate change to provide insight into the overall scale and speed of change. This chapter is intentionally rich in detailed observed data. The purpose is to report the availability of credible data on observable trends. This chapter also identifies some specific areas where there is incomplete data or a lack of credible data. All of this data needs to be viewed in the context of the limitations in observed data, predictions, and projections discussed in Chapter 1.

Climate change is not a smooth process. Natural variability that arises from both internal variability, such as the Pacific Decadal Oscillation, as well as external forcing from decadal and longer-term variations in solar activity and from episodic forcing by volcanic eruptions can result in irregular, periodic, and/or singular disruptions in the climate system that act as masking functions to the anthropogenic climate signal.

Dimensions of current climate trends

The Intergovernmental Panel on Climate Change provides a series of reports that document observed climate changes and project future changes. The most recent Fourth Assessment Report was published in 2007.¹⁵ However, continued collection of observational data and the faster than anticipated rate of recent changes have led to several more recent reviews that update key elements of the AR4.¹⁶

Surface temperatures increasing

Between 1906 and 2005, the global average surface air temperature increased by approximately 0.74°C . The warming trend increased toward the end of this period (from 1979 to 2005), to a rate of $0.17^{\circ}\text{C}/\text{decade}$.¹⁷ The trend fell in the period 2006-2009, with a global mean temperature rise of $0.24\text{--}0.28^{\circ}\text{C}$.¹⁸

NOAA's most recent analysis of global surface temperature change states: "Global temperature is rising as fast in the past decade as in the prior two decades, despite year-to-year fluctuations associated with the El Nino-La Nina cycle of tropical ocean temperature. Record high global 12-month running mean temperature for the period with instrumental data was reached in 2010" (Figure 2-1).¹⁹

The current estimate of continued temperature increase is $0.2^{\circ}\text{C}/\text{decade}$.²⁰ We may be entering a multi-decade period of low solar activity that could give rise to a cooling effect of around 0.2°C over the next two to three decades. At the same time, atmospheric aerosols that have been estimated to reduce warming by 1.1°C have been decreasing since the 1990s, slowly increasing the amount of sunlight reaching Earth's surface.²¹

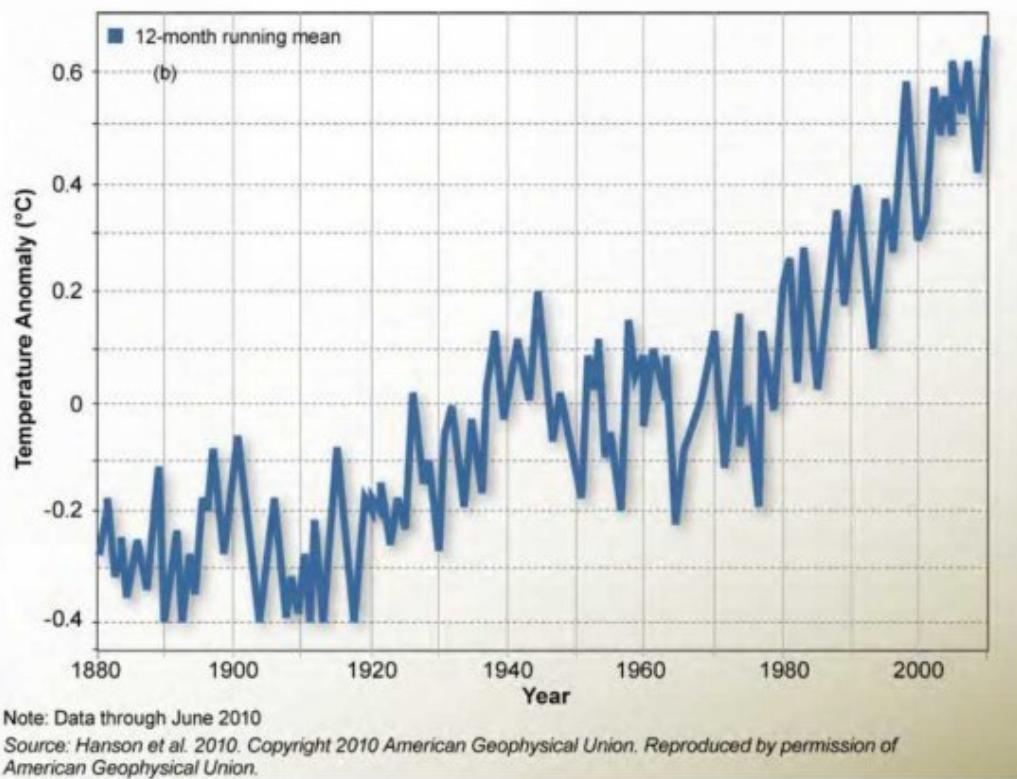


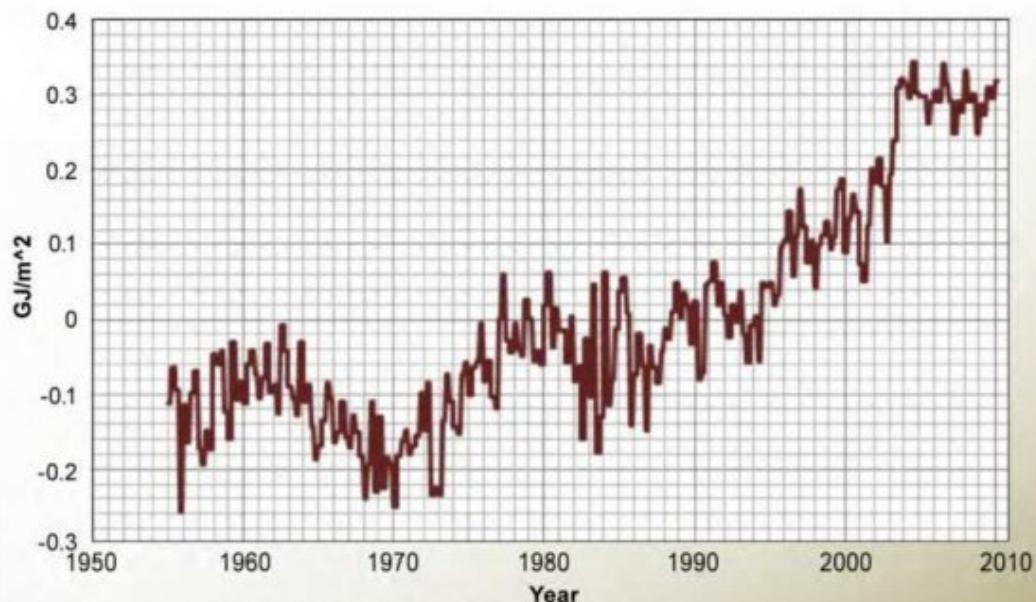
Figure 2-1. Twelve month running mean

Ocean temperature is increasing

The ocean temperature has a major impact on marine ecosystems, and the associated thermal expansion plays a role in global sea level rise. Increases in sea surface temperature (SST) have been linked to increases in storm activity in the Atlantic. Warming of the Indian Ocean appears to have been a significant factor in the increase of drought in East Africa.²² A southward shift of the warmest SSTs in the Atlantic has likely contributed to drought in West Africa.²³

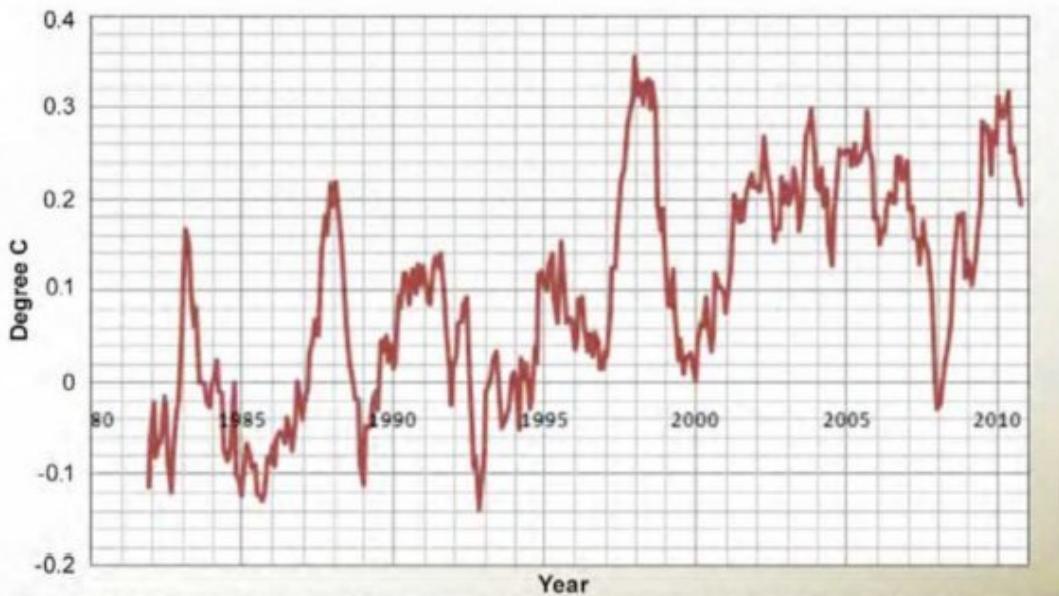
The heat content in the upper 700 meters of the ocean increased over the period 1969-2003 by more than 50 percent.²⁴ The heat content then reached a plateau in the years 2004-2008 (an earlier reported cooling has been assigned to two systematic biases in the ocean temperature data used) (Figure 2-2).

Figure 2-3 shows changes in global SSTs. In general, measurements indicate that warming is greater in the Northern Hemisphere. The North Sea and the Baltic Sea, in particular, have experienced an unprecedented warming trend since the mid-1980s in all seasons.²⁵ Temperatures in summers since 1985 have increased at nearly triple the global warming rate and two to five times faster than those in other seasons. In the Southern Hemisphere, each 1°C rise in global average temperature boosted Indian Ocean SSTs by about 1.5°C during the past few decades.²⁶



Source: National Oceanographic Data Center (Reprinted with permission)

Figure 2-2. Ocean heat content anomalies (0–700 meters), global (January 1955 to March 2010)



Source: NOMADS: A Climate and Weather Model Archive at the National Oceanic and Atmospheric Administration. (Printed with permission)

Figure 2-3. Global Optimum Interpolation (OI) SST anomalies (OI.v2) (November 1981 to September 2010)²⁷

Greenland and Antarctic ice sheets losing mass

Observational data indicate that melting land ice contributes significantly more to sea level rise than thermal expansion of the oceans. Over the last five years, for example, land ice was responsible for 80 percent of the observed sea level rise over the past five years.²⁸

Gravitational measurements from the Gravity Recovery and Climate Experiment satellites indicate that the Greenland ice sheet is losing mass at an accelerating rate.²⁹ During the most recent eleven summers melting has been greater than the average of the available time series (1973 to 2007). Melting in the summer of 2007 established a new record, which was 60 percent above the previous high in 1998.³⁰ Between early 2002 and early 2009, the Greenland ice sheet is estimated to have an accumulated ice loss of 230 ± 30 gigaton (Gt)/year³¹

Satellite observations show that the Antarctic ice sheet as a whole is also losing mass at an accelerating rate. The loss is most significant in the West Antarctic where warming has exceeded $0.1^{\circ}\text{C}/\text{decade}$ over the past fifty years.³² Ten major ice shelves collapsed in the last decade, and the Wilkins ice bridge failed in spring 2009. Losses along the Bellingshausen and Amundsen seas increased the ice sheet loss by 59 percent in ten years.³³ In the Peninsula, losses increased by 140 percent.³⁴ In contrast, there were small glacier losses in Wilkes Land and glacier gains at the mouths of the Filchner and Ross ice shelves.³⁵

Glaciers and snow cover decreasing

Mountain glaciers serve as important water reservoirs in many countries. Aside from contributing to global sea level rise, glacier melting can result in near-term flooding, including that from the outbreak of glacial lakes, followed by water scarcity. Glaciers and snow cover also reflect solar radiation back into the atmosphere, so decreases in the surface area feed back into increased surface warming.

The average annual melting rate of mountain glaciers has doubled since 2000 compared to the already accelerated melting rates observed in the two decades before. The year 2006 established a new record for annual mass loss of the reference glaciers under long-term observation.³⁶ The mass lost from glaciers and small ice caps in recent years is estimated to be of a similar magnitude as the total mass loss of the large ice sheets (Figure 2-4).³⁷

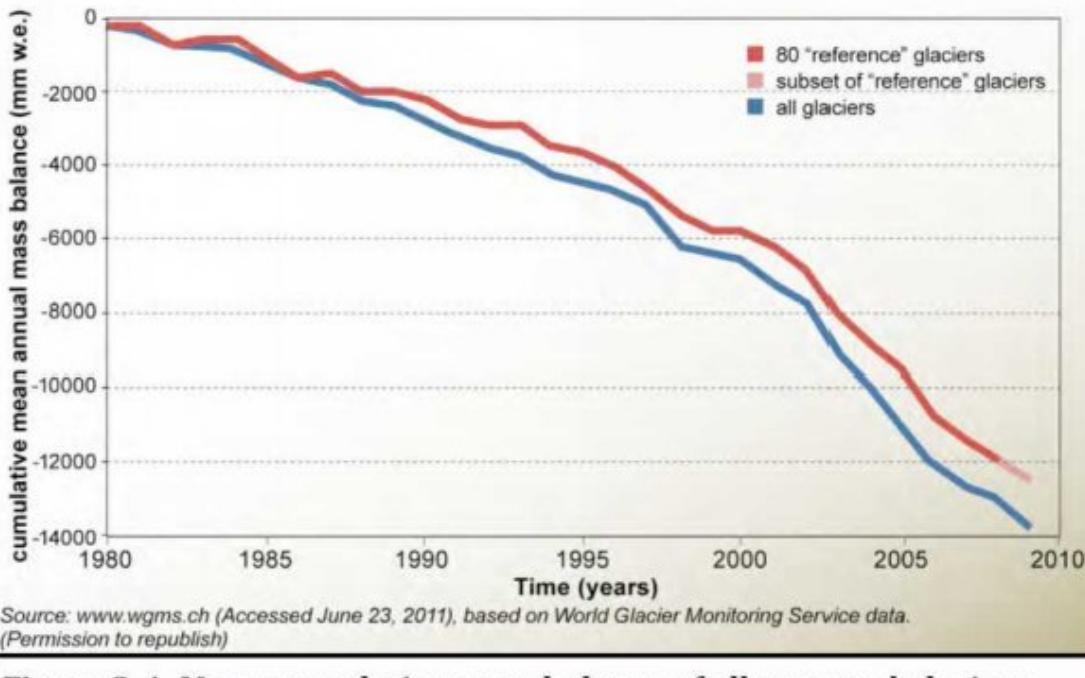


Figure 2-4. Mean cumulative mass balance of all reported glaciers (blue line) and the reference glaciers (red line)

Arctic sea ice extent decreasing, thinning increasing

The potential for access to new energy resources and shipping routes has made changes in Arctic sea ice and is one of the most studied aspects of climate change. The Arctic sea ice also regulates the exchange of energy between the ocean and atmosphere and between Earth and Space; thus, its loss influences temperature, atmospheric circulation, and weather pattern in several ways.

Recent studies predict that the Arctic will be free of summer sea ice sometime between 2030 and 2080, earlier than previously anticipated.³⁸ Since 1979, the Arctic sea ice extent has been declining at a rate of eleven percent per decade.³⁹ Ice coverage in summer 2007 reached a record minimum of 4.3 million km², a decline in extent by 42 percent relative to conditions in the 1980s.⁴⁰ This remains an all-time low. The reduction in the maximum winter extent is smaller, showing a decrease of 2.9 percent per decade.⁴¹ Figure 2-5 shows a time series of the sea ice extent for February and September.

The average thickness of the sea ice has also decreased, increasing the vulnerability to further changes. Thick perennial ice has essentially disappeared, and 58 percent of the multi-year ice now consists of relatively young two- and three-year-old ice, compared to 35 percent in the middle of the 1980s.⁴² Submarine sonar measurements covering the central ~38 percent of the Arctic Ocean show an overall average winter ice thickness of 1.9 m in 2008, compared to 3.6 m in 1980.

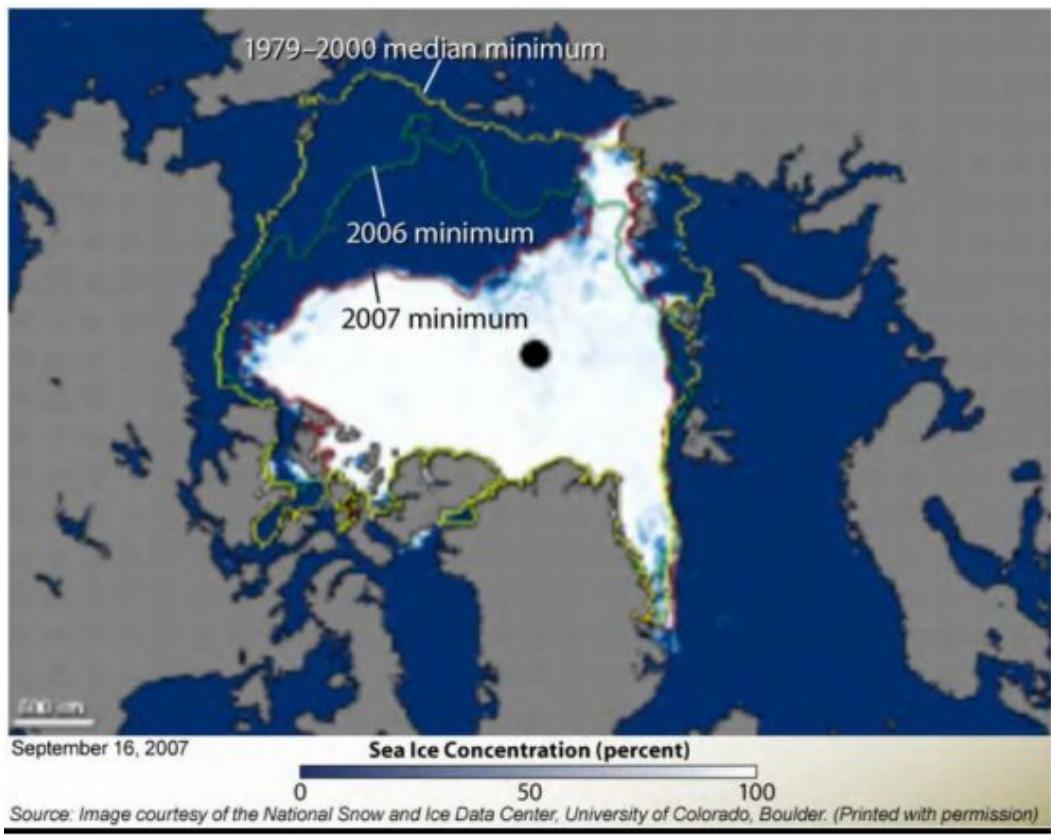


Figure 2-5. Decrease of Arctic ice

Figure 2-6 shows the most recent data on annual minimum sea ice extent. Ice extent for September 2010 was the third lowest in the satellite record for the month, behind 2007 (lowest) and 2008 (second lowest). The linear rate of decline of September ice extent over the period 1979–2010 is now 11.5 percent per decade relative to the 1979 to 2000 average. Changing atmospheric patterns, such as the North Atlantic Oscillation circulation, may lead to a partial short-term recovery of Arctic sea ice depending on the effect of increased warming.

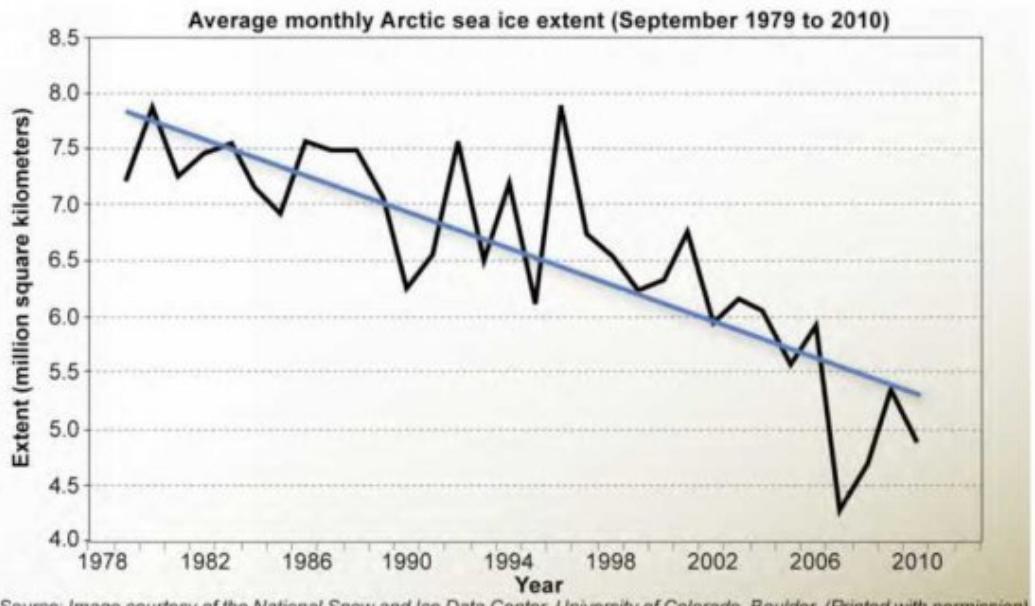


Figure 2-6. Average monthly Arctic sea ice extent, 1979 to 2010; area of seasonally frozen ground is decreasing

Thawing of frozen ground can have major impacts on infrastructure and transportation. Of more significance to the global climate, the process of exposing organic carbon to microbial decomposition results in emissions of carbon dioxide, methane, and nitrous oxide. This positive feedback cycle is significant because methane is thirty (roughly) times stronger than CO₂ in terms of its short term warming potential. Although not as strong in short term effect, N₂O is important because it is a particularly long-lived greenhouse gas.

Thawing is occurring at a faster rate than anticipated. For example, the maximum area covered by seasonally frozen ground has decreased by about 7 percent (up to 15 percent in spring) in the Northern Hemisphere since 1900.⁴³ The temperature at the top of the Arctic permafrost layer has increased by up to 3°C since the 1980s.⁴⁴ The expansion of Siberian thaw lakes in response to Arctic warming has led to an estimated 58 percent increase in methane emissions, largely from thawing permafrost. Current estimates of future emissions from these lakes exceed previous estimates by a factor of five or more.⁴⁵ Emissions have also been detected in unexpected regions, such as from the submerged wetlands of the East Siberian Arctic Shelf.

Figure 2-7 shows the most recent data on increasing temperatures in monitored permafrost sites in the Northern Hemisphere.⁴⁶ Projections suggest that a further decrease in extent of 30 to 50 percent is possible by mid-century.⁴⁷

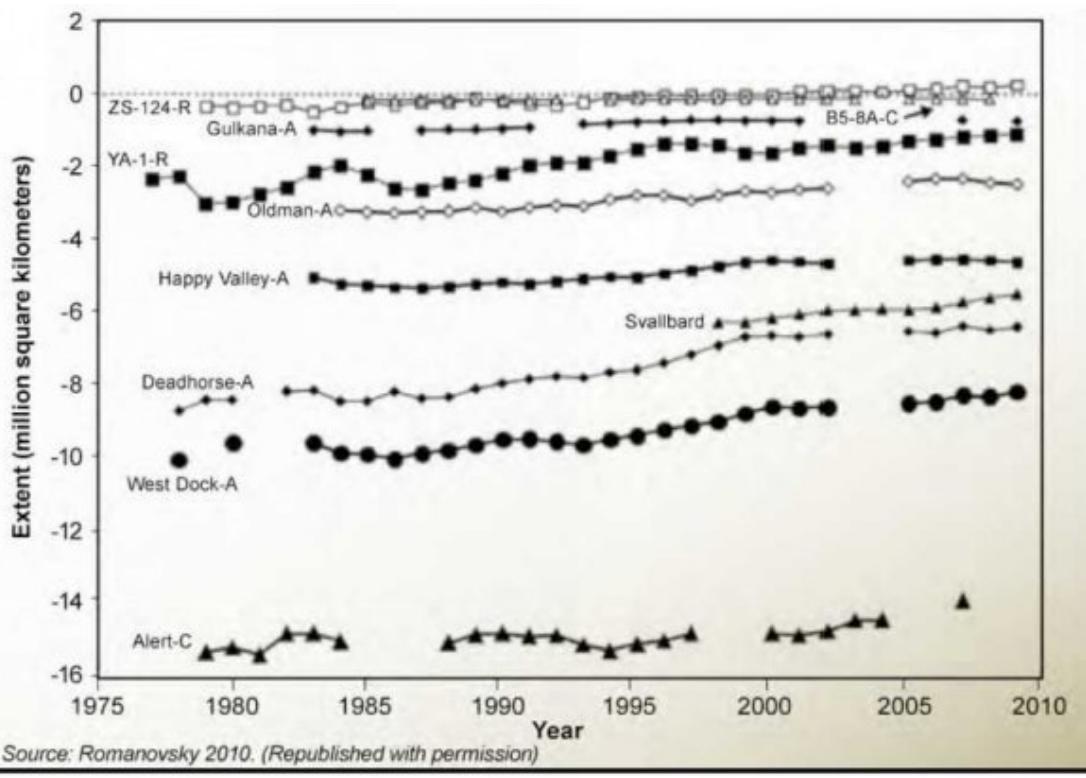


Figure 2-7. Mean annual ground temperatures between 10 and 20 m for boreholes in the circumpolar northern permafrost regions

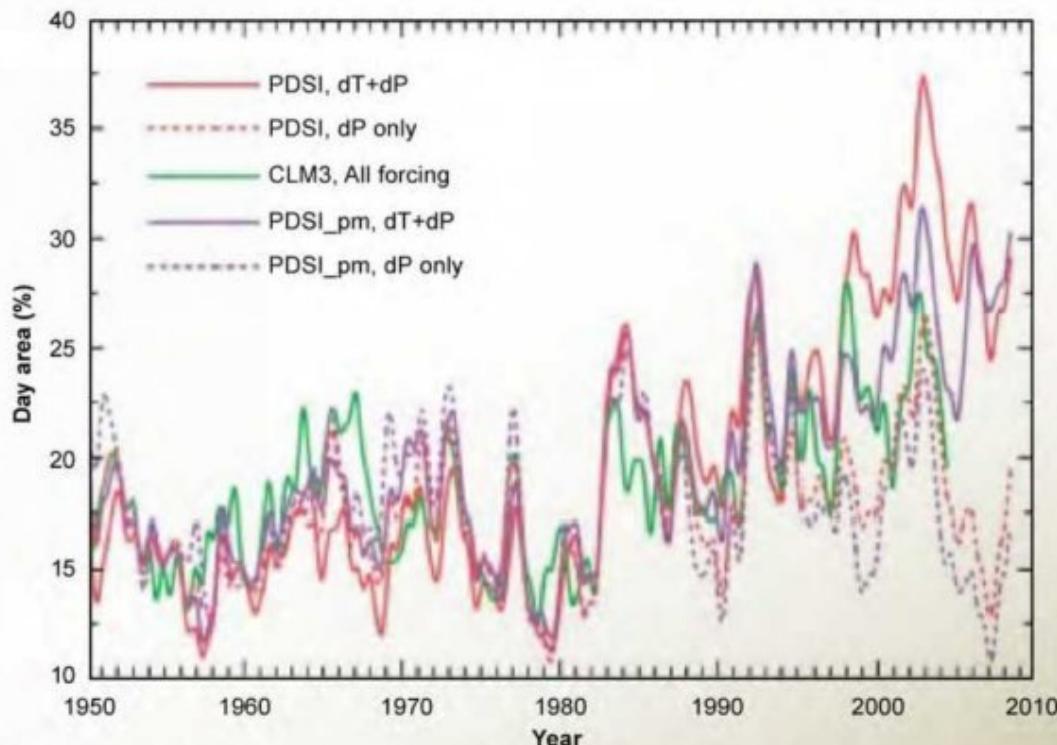
After a period of slowdown in the growth of atmospheric methane concentrations, measurements since 2007 show a global increase.⁴⁸ Estimates of the carbon stored in global permafrost have doubled in the last few years, putting the permafrost carbon stock at an equivalent of twice the atmospheric carbon pool.⁴⁹ Potentially, the amount of carbon released during the 21st century could lead to accumulated emissions of around 50-100 Gt Carbon (C) by 2100.⁵⁰ Alternative estimates, based on experimental Arctic data, suggest the potential for thawing permafrost to release an additional 38-100 GtC per degree of warming.⁵¹

Fewer data are available on recent and projected releases of greenhouse gases from methane hydrates that can be found in polar continental sedimentary rocks and oceanic sediment at water depths greater than 300 m. Methane hydrates occur when large amounts of methane are trapped within a crystal structure of water, forming a solid similar to ice. The size of these reservoirs is uncertain.

More frequent and longer droughts

Increased drying in the tropics and subtropics due to higher temperatures and decreased precipitation have increased global dry areas, as indicated in Figure 2-8.⁵²

The percentage of global land surface in drought has increased by 3.4 percent per decade in the period 1952-1998.⁵³ In terms of the Palmer Drought Severity Index, areas in severe and extreme drought have more than doubled since the 1970s, with a large jump in the early 1980s due to an El Niño Southern Oscillation-induced precipitation decrease and a subsequent expansion primarily due to surface warming.⁵⁴



Note: Based on the CLM3-simulated top-1 m soil moisture content (green), and Palmer Drought Severity Index calculated with both observed precipitation and temperature and Thornthwaite (red solid line) 15 and Penman-Monteith (magenta solid line) Precipitation-Evaporation (PE), and with precipitation only (dashed lines). Monthly data were used in the Palmer Drought Severity Index and PE10 calculations with variations on <12-month time scales were filtered out before plotting.

Source: Dai 2010. (Printed with permission)

Figure 2-8. Time series of global dry areas as a percentage of the global (60°S–75°N) land area

Figure 2-9 shows which regions have experienced the largest change in droughts over the last fifty years and the projections for the next fifty years. These projections indicate how severe the problem is expected to become, particularly across the tropics and subtropics. Based on decreases in soil moisture, the number of short-term (four to six month duration) droughts is expected to double from the mid-20th century to the end of the 21st century. Long-term, more than twelve month duration, droughts are projected to become three times more common.⁵⁵ Using a different model and lower emissions scenarios, the proportion of the land surface in extreme drought is predicted to increase from 1 percent for the present day to 30 percent by the end of the twenty-first century.⁵⁶

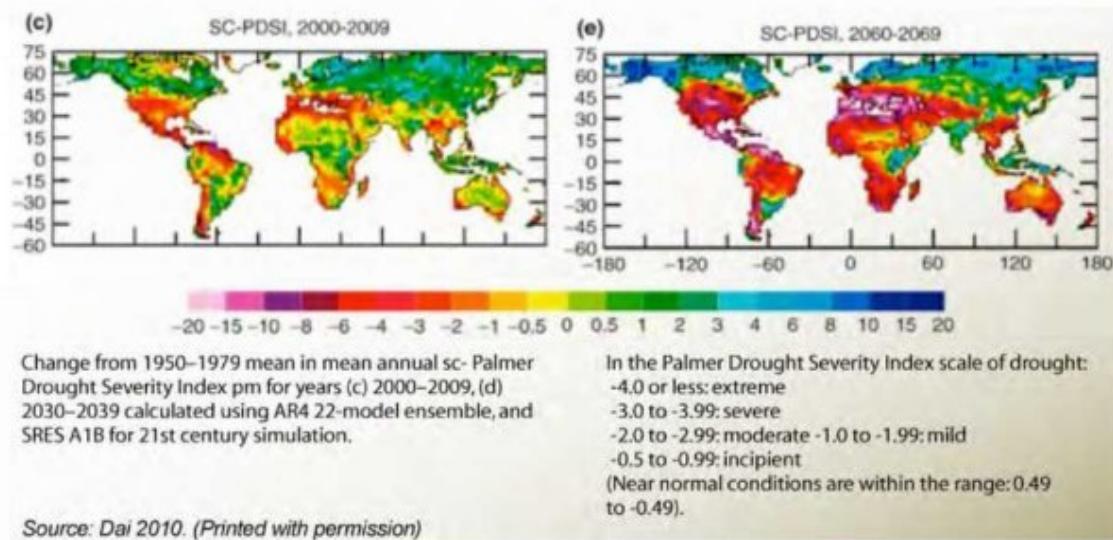
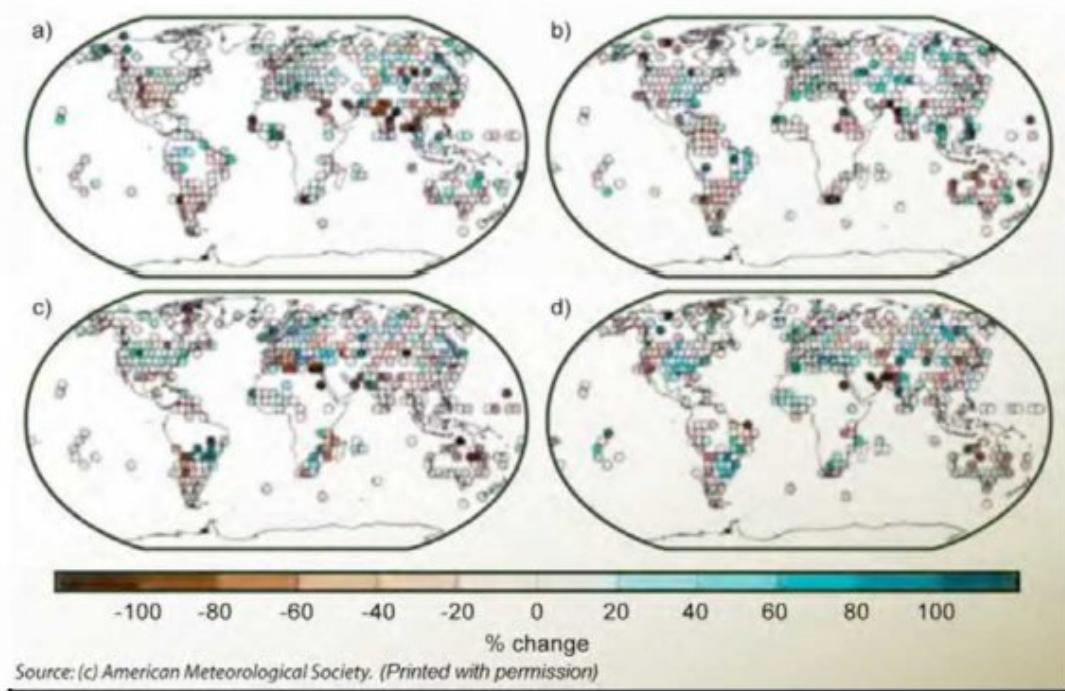


Figure 2-9. Observed and projected changes in drought, in terms of mean annual adjusted Palmer Drought Severity Index (22-GCM ensemble, SRES scenario A1B)⁵⁷

Increasing frequency of heavy precipitation events, flooding, and landslides

Globally, there has been no statistically significant overall increase or decrease in precipitation, although trends have varied widely by region and over time.⁵⁸ Figure 2-10 shows global precipitation anomalies.

Long-term trends over the 20th century show a general pattern of precipitation increases at higher northern latitudes and a drying in the tropics and subtropics over land. Significantly increased precipitation has been observed in eastern parts of North and South America, northern Europe, and northern and central Asia. Decreases have occurred in the Sahel, the Mediterranean, southern Africa, and parts of southern Asia. Spatial and temporal variability have increased over the century. Increases in extreme precipitation have been observed even where overall precipitation has decreased,⁵⁹ with the amount of rain falling during the heaviest precipitation events increasing by 3–10 percent per degree of warming.⁶⁰



Source: (c) American Meteorological Society. (Printed with permission)

Figure 2-10. Global precipitation anomalies⁶¹

The number of great inland flood catastrophes from 1996-2005 doubled, compared to 1950 and 1980, and has been associated with an increasing frequency of heavy precipitation events.⁶² The contributing effects of increasing human impact on the environment and increasing exposure of people and property to flood damage are uncertain.

Projections of changes in the number and intensity of future floods are scarce. One approach is to look at the exceedance of peak volumes in river flow. Figure 2-11 shows how one hundred-year peak volumes of monthly river flow are likely to be exceeded more frequently with a quadrupling of CO₂ in fifteen of sixteen large river basins. In some areas, the current hundred-year flood is projected to occur as frequently as every two to five years.⁶³

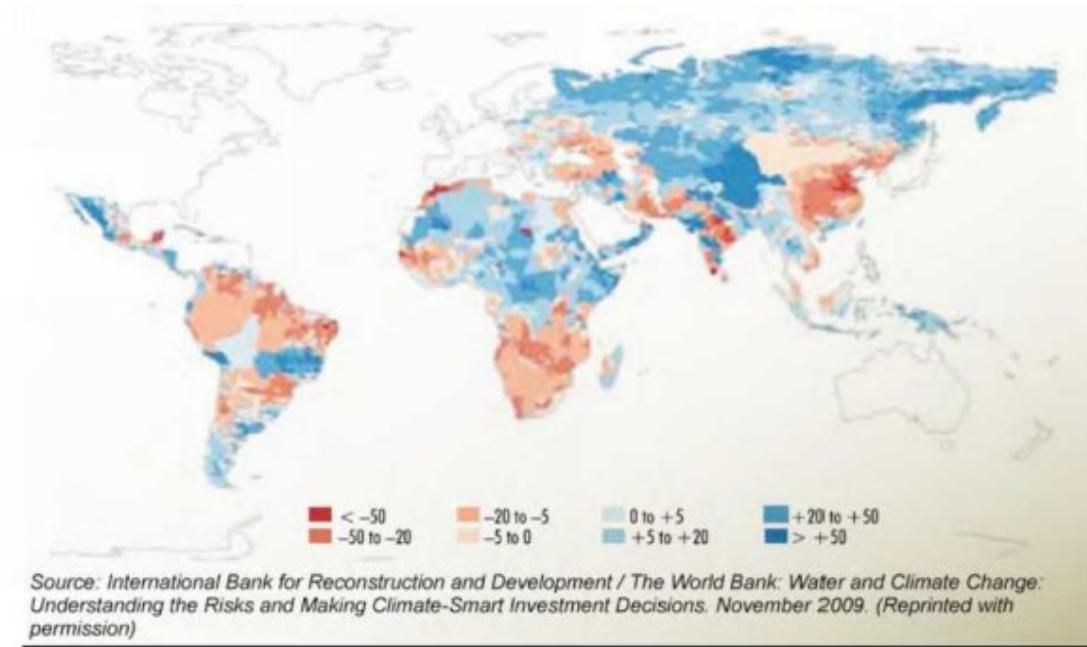


Figure 2-11. Projected percent change in high flows (floods) for 2030⁶⁴

Landslide (including mudslide) activity at national and regional scales has intensified. As with floods, it is difficult to separate the effects of changes in extreme precipitation from those human impacts on the environment. The high number of small to medium-scale landslides, which are widespread in many parts of the world, cause high costs to human society, in large part due to the economic, political, cultural, and geographical barriers to effective landslide risk reduction strategies that exist in many developing countries.⁶⁵

Extreme temperatures more common

Elevated temperatures have both direct and indirect impacts on many important biological systems. Those most commonly discussed are impacts on human health and agricultural growing seasons.

Since 1950, elevated temperatures have increased by between 1°C and 3°C, significantly more than the change in average temperature.⁶⁶ Models using moderate emissions scenarios, Special Report on Emissions Scenarios A1B, project that hundred-year return temperature values will exceed a dangerously high level of 50°C in densely populated areas of India, the Middle East, North Africa, the Sahel, Australia, and equatorial and subtropical South America by 2100.⁶⁷

Other recent research combines observation and modeling data to suggest a high probability (>90 percent) that growing season temperatures in the tropics and subtropics by the end of the twenty-first century will exceed the most extreme seasonal temperatures recorded from 1900 to 2006. In temperate regions, the hottest seasons on record will represent the future norm in many locations.

Tropical cyclone intensity increasing

The consequences of increased cyclone intensity are potentially severe, particularly when coupled with sea level rise, and could affect coastal communities around the world.

The destructive power of tropical cyclones (storms, hurricanes and typhoons) has increased since 1970, owing to increases in intensity and duration, as much as 70 percent in the Atlantic and Pacific. The changes in the power destructive index are highly correlated with SSTs in the critical region where tropical cyclones form.⁶⁸

Observational data indicate that a 1°C rise in SSTs can increase surface wind speed 5 m/sec, potentially doubling the number of Category 5 cyclones (Figure 2-12).

There is agreement that climate change is likely (>66 percent probability) to increase the occurrence of more intense cyclones, although uncertainty remains as to whether this is the result of natural variability in the system or warmer temperatures.

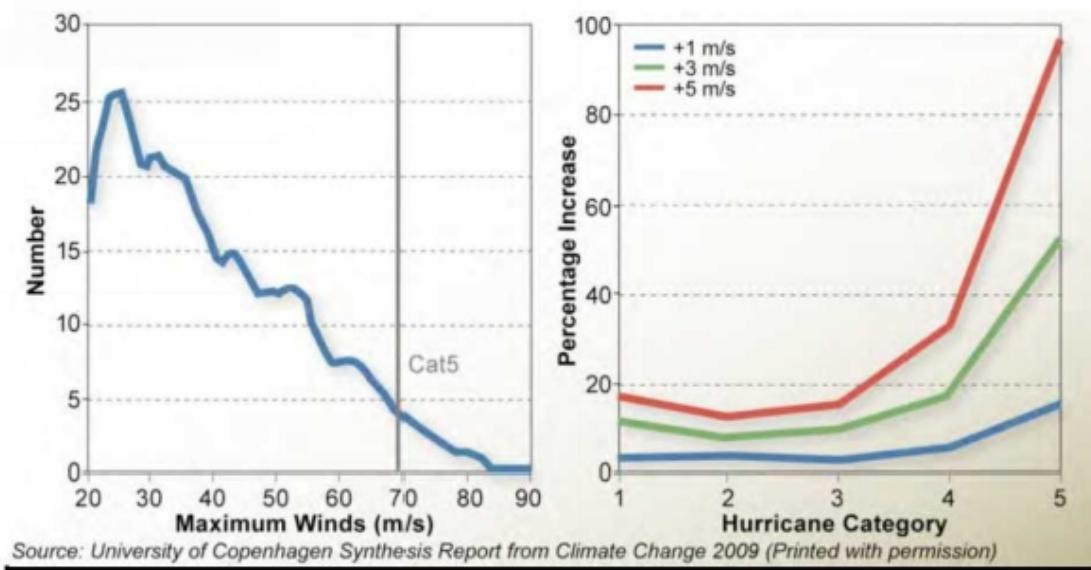


Figure 2-12. North Atlantic tropical cyclones⁶⁹

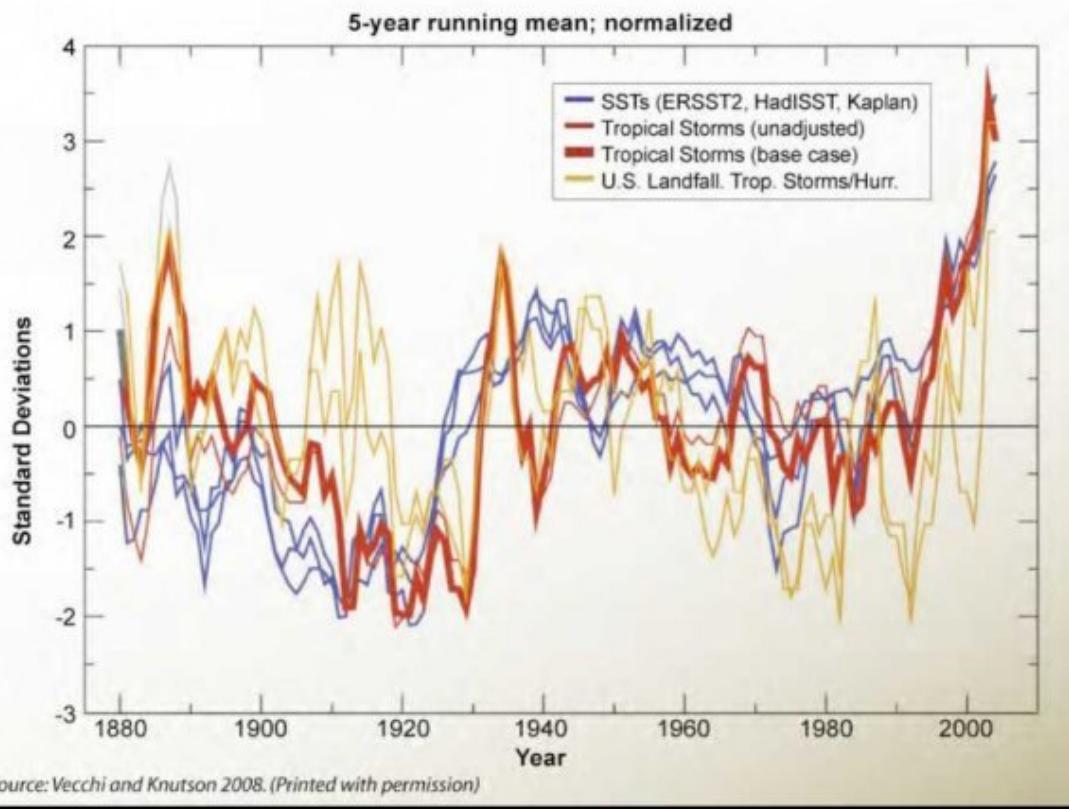


Figure 2-13. Tropical Atlantic SSTs, tropical storms, and US landfall series⁷⁰

The scientific community similarly agrees that the number of cyclones is unlikely to increase. However, a recent study that accounted for the number of North Atlantic cyclones likely to have been missed by the observing system in the pre-satellite era finds a significant increasing trend for 1900–2006 of ~4.2 storms per century in tropical Atlantic storms (Figure 2-13). The extent to which a minimum in 1910–1930 influenced this trend is uncertain, but this work merits further consideration.⁷¹

Mid-latitude wind patterns and storm tracks shifting poleward

Mid-latitude westerly winds have increased since 1950, but it remains uncertain whether this is due to warmer temperatures or decadal-scale fluctuations.⁷² There is wide agreement on a poleward shift in storm tracks.⁷³ Any such change leads to changes in regions affected by storm-related strong winds and heavy precipitation, as well as high waves and storm surges.⁷⁴

Sea level is rising

After the last glacial maximum about twenty-thousand years ago, global sea level rose by more than 120 m. The rate of rise slowed down to a steady rate of 0.25 mm/year before the start of the 20th century.⁷⁵ Global average sea level rose at an average rate of 1.8 ± 0.5 mm/year during the period 1961–2003, increasing to 3.2 mm/year from 1993 to early 2006.⁷⁶ Satellite measurements of sea level rise in more recent years show no major change, with an average rate of increase around 3 mm/year.⁷⁷

Increased understanding of feedback cycles and glacier dynamics has resulted in dramatic increases in projections of future sea level rise, compared to that given in AR4. Figure 2-14 compares the results of these studies to the AR4 projection.⁷⁸ It is increasingly probable that global sea level rise will exceed 1 m by 2100.⁷⁹

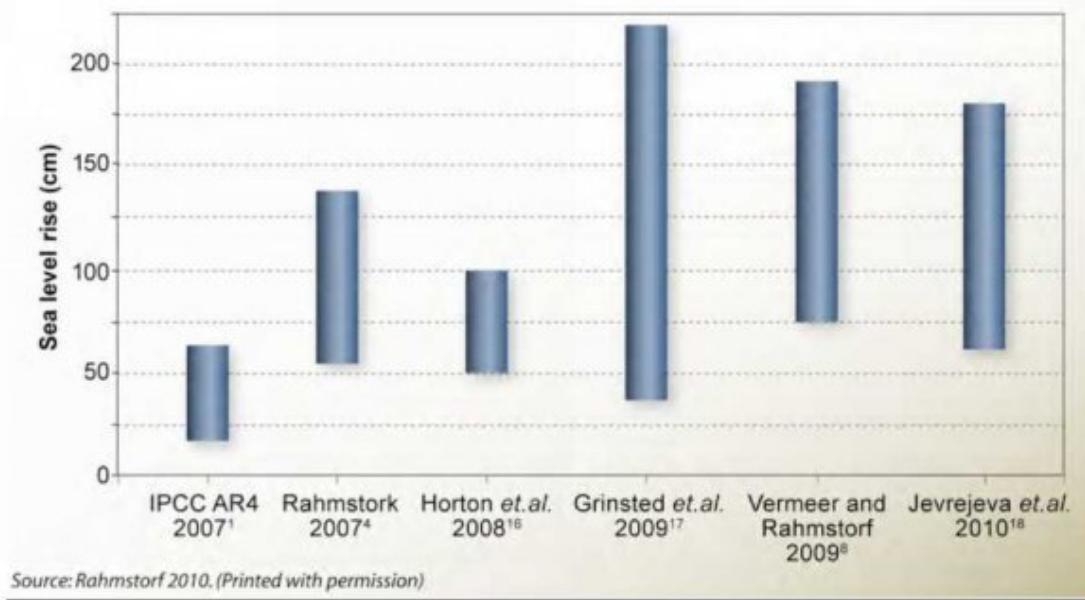


Figure 2-14. Estimates of twenty-first century sea level rise from semi-empirical models as compared to the IPCC AR4

Crosscutting points

- Inertia in the climate system means that we are committed to an additional rise in temperature (0.4°C to 0.6°C) comparable to that experienced in the 20th century even if greenhouse gas emissions ceased today.⁸⁰ The additional warming is larger when feedback cycles are considered.
- An increase of more than 2°C is commonly cited as having serious impacts on the human habitat. It is expected to exceed this limit in the next few decades. Current best estimates suggest that if all emission reduction efforts registered under the Copenhagen Accord, and subsequently captured in the Cancun Agreements, are fully-delivered, global average temperature is still likely to rise by 3-4°C by 2100.⁸¹
- Some greenhouse gases are long-lived. Changes in surface temperature, precipitation, and sea level are largely irreversible for more than one thousand years after emissions cease.⁸²
- Sea level rise will not stop in 2100. Changes in ocean heat content will continue to affect sea level rise for several centuries at least. Melting and dynamic ice loss in Antarctica and Greenland will also continue for centuries.⁸³ There are a number of critical thresholds, or tipping points, at which a relatively small additional forcing induces an abrupt change in the response of some large-scale components of the Earth system. Figure 2-15 provides the global temperatures estimated for tipping points of the most important subset of components.⁸⁴ Future policy-relevant tipping elements in the climate system and estimates of the global warming (above present) that could cause their control to reach a critical threshold.

The paleoclimate record shows several periods where abrupt changes occurred. At the end of the Younger Dryas (11,500 years ago), temperature in central Greenland jumped to about 15°C in a single decade.

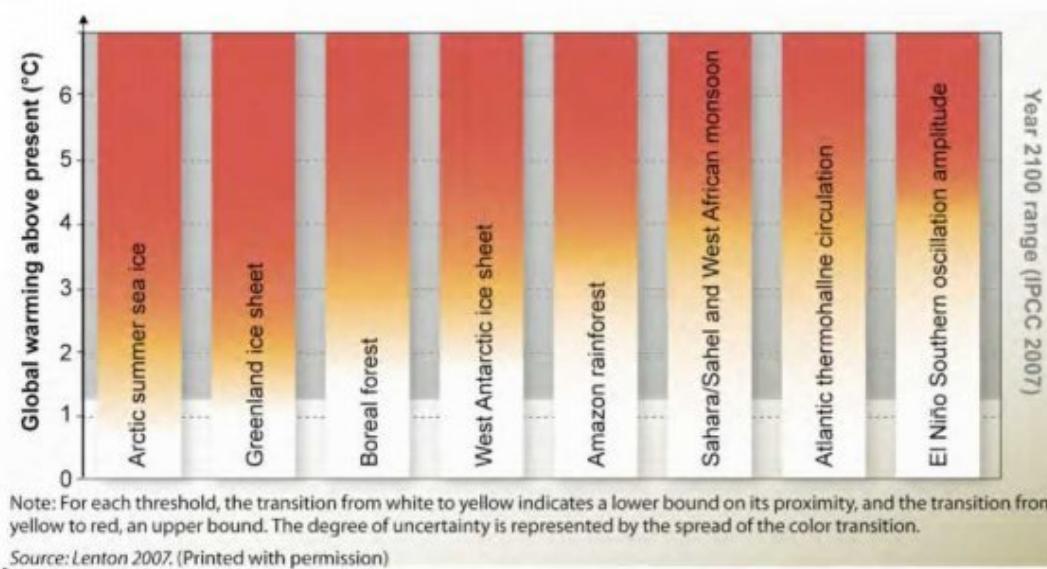


Figure 2-15. Potential policy-relevant tipping elements that could be triggered by global warming this century, with shading indicating their uncertain thresholds.⁸⁵

Findings on Climate Trends

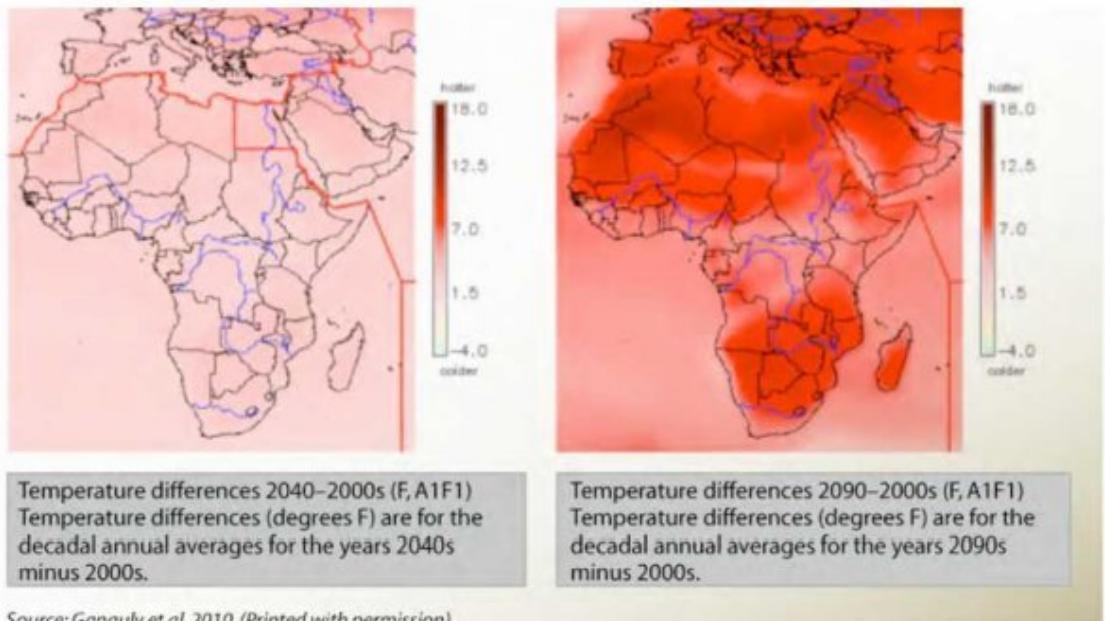
Observational data indicate that changes in the climate system are continuing at a faster rate than reported in the IPCC AR4 (2007). The rate of change in land and sea surface temperatures over the 21st century is expected to at least double that of the 20th century.

The consequences of continued changes necessitate a risk management approach to climate-related decision-making. Decisions should be based on assuming a global temperature increase of 3-4°C (best case 2°C; worst case 5-7°C) by 2100. This necessitates including the potential for high impact abrupt changes.

Recommendations arising from the climate trends are found in Chapters 4 and 5.

Current Trends and Projections for Africa

Climate changes vary significantly at local levels. The rate of warming in the Arctic, for example, is outpacing that of the remainder of the planet. The remainder of this section provides a snapshot of some of the observed and projected changes for temperature (Figure 2-16) and precipitation in Africa.



Source: Ganguly et al. 2010. (Printed with permission)

Figure 2-16. Projected temperature increase in Africa 2040, 2090⁸⁶

Precipitation in the Sahel zone in West Africa shows a general negative trend since 1970, and years of varied positive and negative indexes were more common in the years preceding 1950. The 200 mm/year and 600 mm/year isohyets (contours of equal precipitation) are shifting south with the climate conditions of the Sahel and Sahara also migrating south. The extent of this shift varies across the region but averages about 200 km in West Africa (Figure 2-17). Modeling studies project a significant shortening of the rainy season over much of southern Africa after 2050, an increase in the severity of dry extremes (ten-year driest events) over western Africa that parallels a significant mean decrease in summer precipitation, and an appositive shift of the whole precipitation distribution.⁸⁷

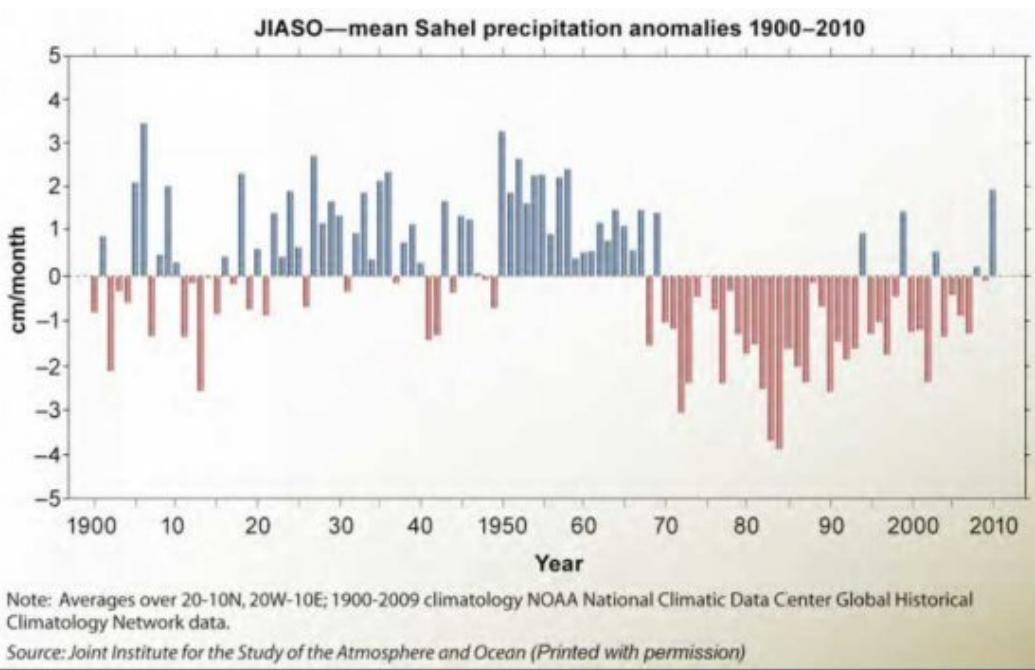


Figure 2-17. Mean precipitation anomalies for Sahel zone West Africa, 1900–2009

The frequency of anomalously strong rainfall that causes floods has increased in East Africa. Reported floods have increased from an average of less than one event/year in the 1980s, to seven events per year between 2000 and 2006. This is the strongest increase among the full set of hydrometeorological disasters (an increase from an average of less than three events per year in the 1980s, to over seven events per year in the 1990s, and almost ten events per year from 2000 to 2006).⁸⁸

Projections of changes in river flows by 2030 and 2050 suggest increased flooding in East Africa and Central Africa, as shown in Figure 2-18.⁸⁹ Another study projects an increase in the intensity of ten-year wettest events that also translates into increasing flood risks for East Africa between 2051 and 2100.⁹⁰

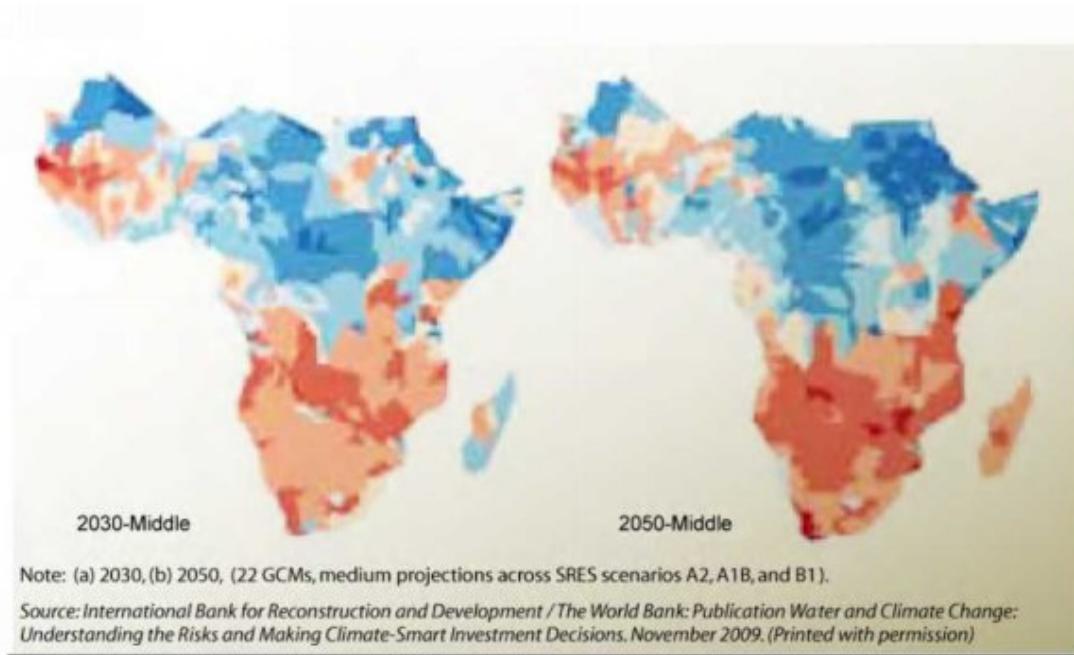


Figure 2-18. Projected percent change in high flows (floods) at catchment level compared to a 1961–1990 baseline

The southward shift of the warmest SSTs in the Atlantic and warming in the Indian Ocean are responsible for a long-term drying trend over Africa and the recent Sahel droughts. Increases in aridity are broadly consistent with trend patterns of independent records of precipitation and stream flow.

The annual variability of rainfall has increased. The chances of drought occurring in parts of the Greater Horn of Africa have doubled from one in six years to one in three years.⁹¹ North African countries now experience five or six years of drought per ten years instead of the one drought every ten years common at the beginning of the century.⁹² Dry years have become more frequent in the Volta river basin since the early 1980s and have occurred at shorter intervals. The areal extents to this dryness have also been increasing. The basin recorded at least four moderate dry years covering over 50 percent of the area between 1983 and 2001.⁹³ The Niger river basin is experiencing a 30% reduction in annual volume.⁹⁴ Climate models project increased aridity in the 21st century over most of Africa.⁹⁵

Findings on Climate Trends in Africa

Information on climate change trends in the United States Africa Command (AFRICOM) area of responsibility (AOR) is essential to planning for operations.

Better understanding of current and future climate-related impacts can focus military to military training, exercises, and outreach activities on changing needs.

In general, information on the regional and local impacts of climate change that is useful for near and mid-term decision-making is inadequate. The range of information deficiencies includes:

- Lack of availability of data on changes in the periodicity of critical events (e.g., return period of floods)
- Lack of assessment of the impact of climate changes on urban environments (Current studies limited to the impact of sea level rise and storm surge on coastal areas)

- Failure to integrate the full set of environmental, socio-cultural, economic, and governmental factors into impact assessments
- Lack of methods and data to support identifying and assessing the cost-benefits of particular adaptation options
- The scenarios and models in use to project continued climate changes lag current scientific understanding.
- Understanding on any one geographical area, type of change, or impact requires synthesis across an increasingly vast array of materials developed by diverse stakeholders.
- Ongoing DOD activities to address responses to climate changes can also aid partner nations in reducing climate-related risks. US Army Corps of Engineers (USACE) guidance on sea level rise, for example, is applicable to African coastal countries.
- Lack of visibility into international efforts impedes effective action. Could, for example, RANET (supporting low-tech information dissemination to rural and remote populations) support the African Development Bank's effort on climate and weather forecasting?⁹⁶

Chapter 3

Potential Consequences of Climate Change

Climate change effects on water availability, food production, health, and local and regional economies can be particularly severe where living conditions, food supplies, health, and governance are fragile. Thus, climate change can be thought of as both an exacerbating factor intensifying existing resource and security problems and as a catalyst creating new environmental and resource challenges (Figure 3-1).⁹⁷

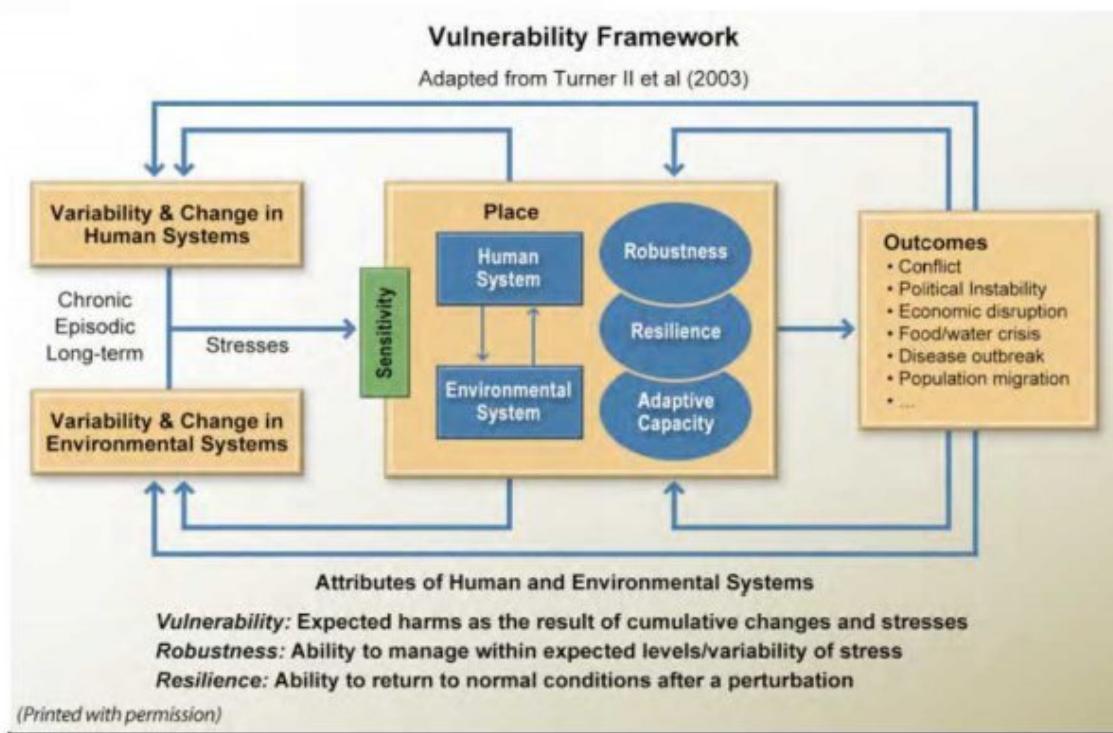


Figure 3-1. Vulnerability Framework

The discussion of consequences in this chapter will focus on Africa, where the capacity to adapt to the effects of climate change is low. Ineffective or inadequate governance will impede near-term responses and adaptation over much of the continent, where potentially helpful institutions are weak. Poverty and disease are widespread, security forces are often unprofessional, and political violence is common.

Climate change can impact:

- Health. Warmer climate could increase the carriers of vector-borne diseases including malaria and yellow fever. Increased deaths from heatwaves, floods, droughts, and malnutrition
- Food supplies. Climate change in Africa is likely to adversely affect agricultural productivity. (While the most northern climes on the planet may experience an increase in agricultural productivity, Africa, along with much of South America and South Asia, are projected to see steep declines. The economies of many African nations are still based on subsistence agriculture; well over 50 percent of all Africans are engaged in subsistence agriculture. More frequent and intensive droughts and floods can lead to food shortages and famines.)
- Refugees. Dwindling food and water supplies can trigger migrations leading to conflict at regional, international, and local levels for struggling nations.
- Coastal regions. Increased damage from storms and floods and developed regions at risk from rising sea levels

Africa is especially vulnerable to drought and agriculture challenges. Ten of the twelve countries most at risk for each of these two challenges are in Africa (Table 3-1).⁹⁸

The remainder of this chapter focuses on water supply issues.

Table 3-1. Five Climate Threats, Top 12 Most Vulnerable Countries

Drought	Flood	Storm	Coastal Im	Agriculture
Malawi	Bangladesh	Philippines	Micro states	Sudan
Ethiopia	China	Bangladesh	Vietnam	Senegal
Zimbabwe	India	Madagascar	Egypt	Zimbabwe
India	Cambodia	Vietnam	Tunisia	Mali
Mozambique	Mozambique	Moldova	Indonesia	Zambia
Niger	Laos	Mongolia	Mauritania	Morocco
Mauritania	Pakistan	Haiti	China	Niger
Eritrea	Sri Lanka	Samoa	Mexico	India
Sudan	Thailand	Tonga	Myanmar	Malawi
Chad	Vietnam	China	Bangladesh	Algeria
Kenya	Benin	Honduras	Senegal	Ethiopia
Iran	Rwanda	Fiji	Libya	Pakistan

Source: World Bank 2009.

Impacts of Climate Change on Water

The availability of water underlies all other elements of human security. Changes in precipitation or seasonal delivery patterns can threaten established water supplies supporting agriculture, fisheries, transportation, human consumption, and the natural environment.⁹⁹

Water is a key determinant of land productivity, as well as aquaculture and inland fishery productivity. USAID predicts that global food supplies will need to increase by an estimated 50 percent to meet demand increases by 2030. The Food and Agriculture Organization of the United Nations predicts that water for agriculture needs to increase 60 percent to meet the demand. Clean water supports good health. In Africa, increases in population are outpacing improvements in accessible drinking water and sanitation.¹⁰⁰ New water-related health risks are emerging. The World Health Organization reports that water shortages have driven up the use of wastewater for agricultural production in poor urban and rural communities. More than 10 percent of people worldwide consume foods irrigated by wastewater that can contain chemicals or disease-causing organisms.¹⁰¹

Growing populations and rising demands from agricultural, municipal, industrial, and environmental uses increase pressure on water resources. Increased variability and changing patterns of precipitation, melting glaciers, rising sea levels, and increased evapotranspiration are some of the most direct ways in which a warming climate will exacerbate shortages. Societies design themselves around stable climate and resource expectations. Expectations that are unmet or altered significantly on a repeated basis are likely to lead to instability in already weak states.¹⁰² Resolution of rightful use or ownership of water is already a significant issue for local governments around the world.

From 1960 to 2005, the average per capita renewable water resources in northern Africa decreased by more than a factor of three: from almost 3,500 m³/year to less than 1,000 m³/year in 2005, with further reduction expected. The African Development Bank estimates that twenty-one countries, nearly half the continent, will experience water stress by 2025, and nine countries will be facing extreme scarcity (Figure 3-2).¹⁰³ Declining

water levels in many rivers and lakes will likely decrease water quality, exacerbate waterborne diseases, and reduce available hydropower.

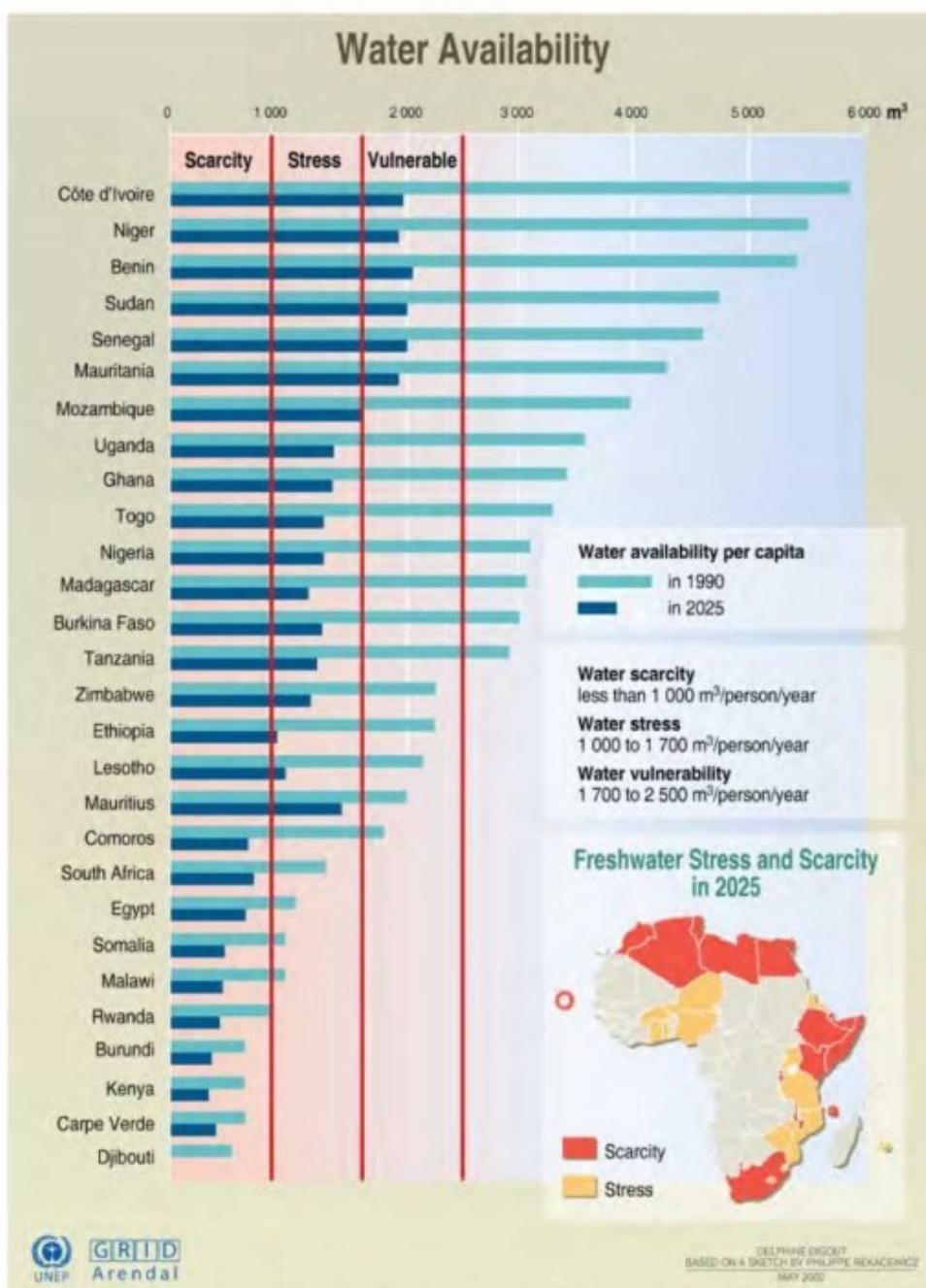


Figure 3-2. Water availability in Africa

Unlike most of the world, the primary cause of water scarcity across Africa is a lack of development of available water resources and not physical water scarcity (Figure 3-3). Africa has one-third of the world's major international water basins but can access less than 6 percent of its renewable water resources. The lack of hydrologic data makes it impossible to determine the location and sustainable yield of water in most regions.

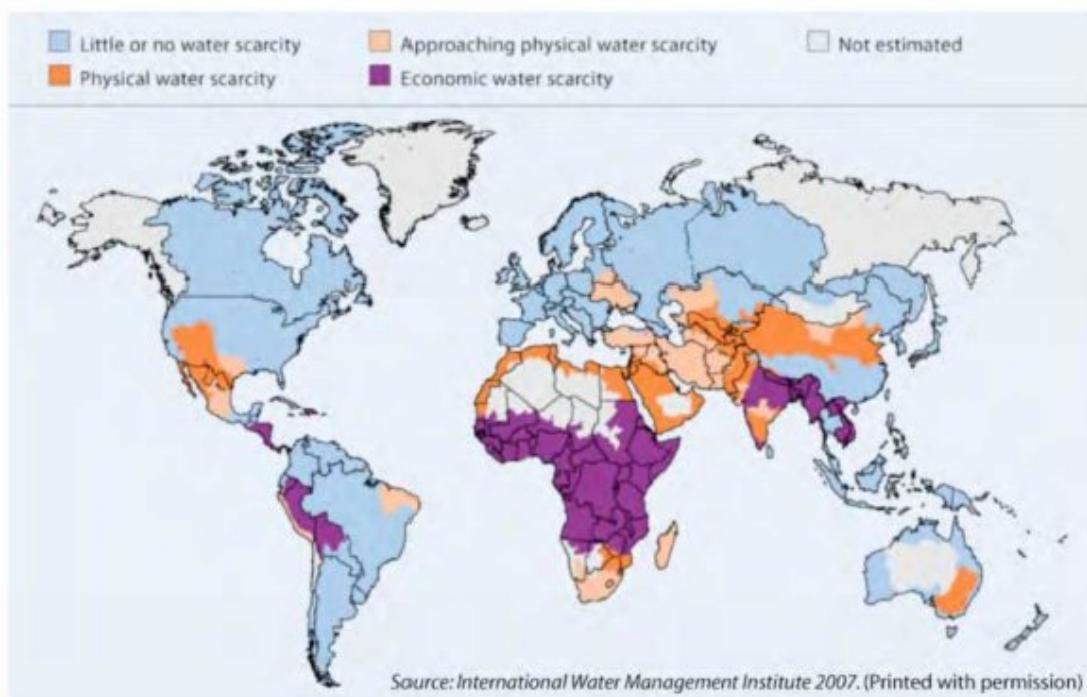
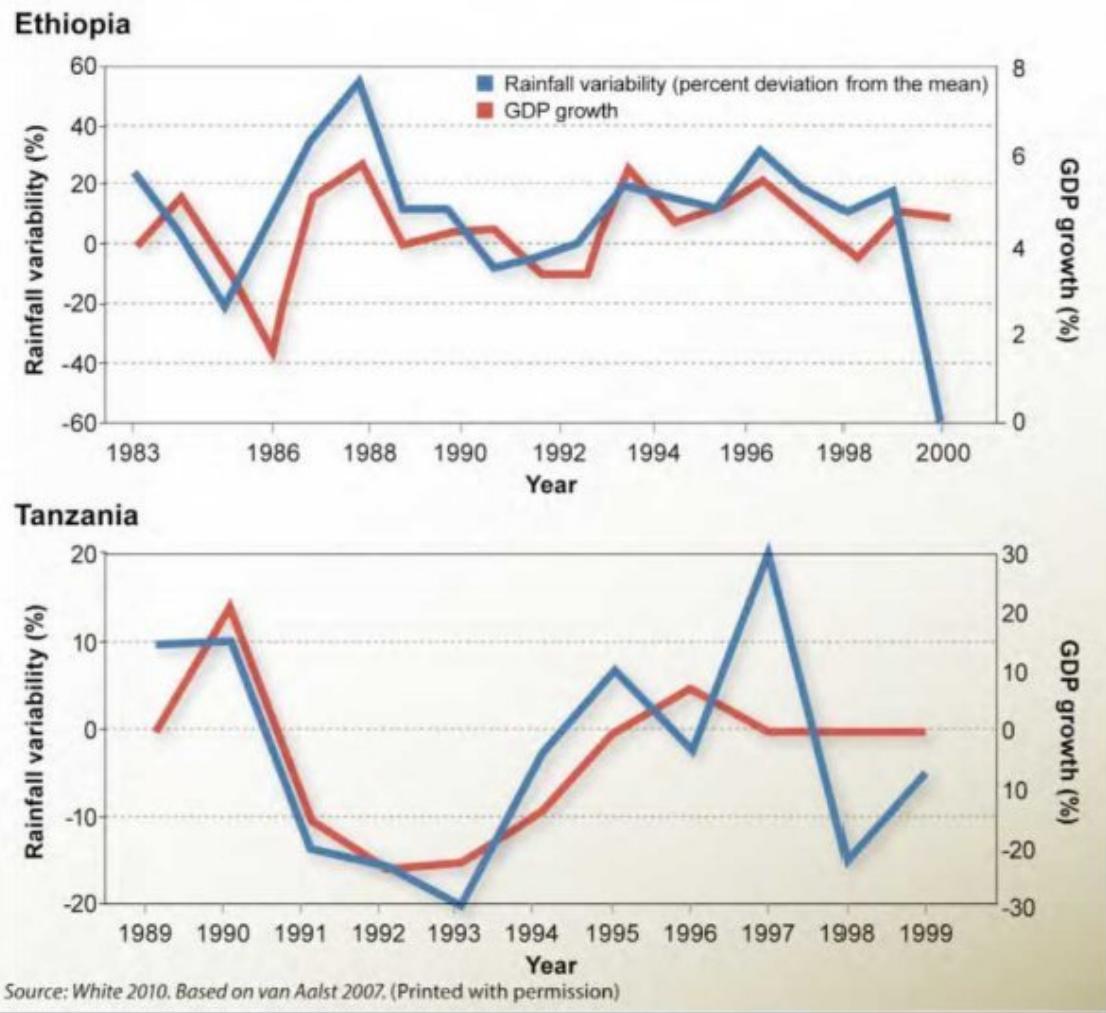


Figure 3-3. Areas of physical and economic water scarcity

Increasing variability in precipitation and higher evapotranspiration rates have forced farmers in many developing countries to rely more heavily on groundwater. As a result, aquifer levels are declining at rates between 1 m/year to 3 m/year, and depleted aquifers may not refill for centuries.

In sub-Saharan Africa more than 95 percent of the farmed land is rain-fed. Current farmers' yields in rain-fed areas are two- to fivefold lower than achievable potential yields, and that current rainwater use efficiency is only 35-45 percent.¹⁰⁴ The lack of storage capacity is one factor that contributes to this heavy reliance on rain-fed agriculture and increases the vulnerability to changes in adequate precipitation. In many African nations, agriculture dominates the economy, which in turn is dependent on variations in precipitation. Figure 3-4 captures the results on gross domestic product (GDP) for Ethiopia and Tanzania.¹⁰⁵



Source: White 2010. Based on van Aalst 2007. (Printed with permission)

Figure 3-4. Gross Domestic Product growth tracks rainfall variability (inadequate storage & distribution)

While water consumption and withdrawal in Africa have been increasing over time, the continent's water resources have been decreasing, mainly as a result of persistent droughts and changing land use patterns. The volume of water estimated to have been lost; for example, from the African landmass during a three-year period ending in approximately 2006, was about 334 km³, which is as much water as Africans consumed over the same period.¹⁰⁶

Climate change will intensify existing water issues (shortages, floods, droughts) and effective water management will become ever more critical in developing countries. The many different uses of finite water resources are interdependent. High irrigation demands and polluted drainage flows from agriculture mean less freshwater for drinking or industrial use; contaminated municipal and industrial wastewater pollutes rivers and threatens ecosystems; if water has to be left in a river to protect fisheries and ecosystems, less can be diverted to grow crops. These multiple uses of water complicate water management but offer opportunities for cooperation.

Water security

Water security is fundamental to all forms of human security and development. Many African nations do not know how much ground water and surface water supplies they have. Over extraction and sustainability are

already issues. These problems will worsen as climate change uncertainties come into play, resulting in increased transboundary disagreement and increased local conflict over this scarce resource.

DOS and USAID water security efforts are decentralized at the embassy level and do not engage US government technical experts such as hydrologists and engineers in the planning and execution of water projects. The lack of a coordinated US government water security vision and a long term plan, results in a broad and undefined environmental security program at the embassy and combatant command levels, which in turn means that limited resources are not utilized as effectively as possible to achieve US government objectives.

The embassies and combatant commands have a poor understanding of water security issues. Therefore, water security efforts are underfunded by DOS, USAID, and DOD. The Paul Simon Water for the Poor Act107 is a DOS unfunded earmark, and DOD humanitarian assistance funds are very limited and restrictive. Projects and capacity-building is supported through a myriad of funds such as humanitarian assistance, Humanitarian and Civic Assistance, DOD Environmental International Cooperation Program (DEIC), and 1207/1210 funds.¹⁰⁸ The lack of a dedicated appropriation for water and environmental security projects makes it impossible to develop realistic long-term plans at the embassy and combatant command levels. This leads to difficulty in managing expectations, which ultimately jeopardizes US credibility with partner nations.

Efficient and effective action necessitates a whole of government approach led by DOS/USAID that ensures a single US government approach to water security in Africa and other developing regions.

RECOMMENDATIONS ON WATER SECURITY

Adopt the DOD/Combatant Command Water Security Program Strategy to institute water security as a core element of DOD strategy that includes:

- Developing a DOS-led interagency team in the combatant command area or responsibility that establishes goals, provides guidance to embassies, and prioritizes efforts to improve water security in regions
- Focusing on areas that meet US government collective interests (e.g., development challenges, potential for conflict, importance of bilateral relations, or existence of forward operating bases)
- Assisting embassies in developing programs that support partner nation efforts to:
 - Locate, quantify, and characterize water resources
 - Identify potential impacts to water resources from climate change
 - Develop long-range plans for sustainable water use and associated land use management for food, agriculture, and livestock
 - Encourage policy and economic practices that promote sustainable water usage
 - Promote the need for clear, and transparent, shared data on water resources
 - Use lessons learned from the United States and other countries' regional water resource management experience (USACE, Environmental Protection Agency, US Geological Survey (USGS), Tennessee Valley Authority, numerous regional commissions, and NGOs) to address co-riparian (shared water resources) equity
- Developing a DOS/USAID lead interagency team at the embassy level to establish a long-term water and environmental security engagement plan for the nation
- Using lessons learned from the United States and other countries' regional water resource management experience (USACE, Environmental Protection Agency, USGS, Tennessee Valley Authority, Bureau of

Reclamation, numerous regional commissions, and NGOs) to address co-riparian (shared water resources) equity

Transboundary Issues

Many water troubles are regional problems. Forty percent of the world's population lives on shared basins, which cover more than 50 percent of Earth's landmass. Transboundary water issues are particularly critical in Africa (Figure 3-5)¹⁰⁹ where its major river basins cross many national boundaries (ten for the Niger and Nile rivers; nine for the Congo River), more than those on any other continent. Since one of the primary roles of dams is to manage resource variability and the extremes that can lead to flooding, climate-related changes in precipitation can be expected to increase construction. Drying lands will have a similar effect through increasing demands for irrigation water. However, water projects themselves can be a flashpoint for conflict. Dams, for example, are often beset by problems including forced migration and extensive downstream environmental damage.

The multiple shared interests around water provide a strong economic argument for cooperation and there are trends of cooperative behavior. However, the likelihood of conflict in river basins rises as the rate of change within the basin exceeds the institutional capacity to absorb that change (as demonstrated by the history of conflicting and cooperative water interactions over the last fifty years). The effects of rapid environmental change or rapid population growth are compounded by major unilateral development projects, a lack of institutional capacity, or generally hostile relations.¹¹⁰ Changes in precipitation, evapotranspiration, and environment degradation, coupled with increased migration in search of water resources and stable livelihoods, could tip the balance in fragile regions.

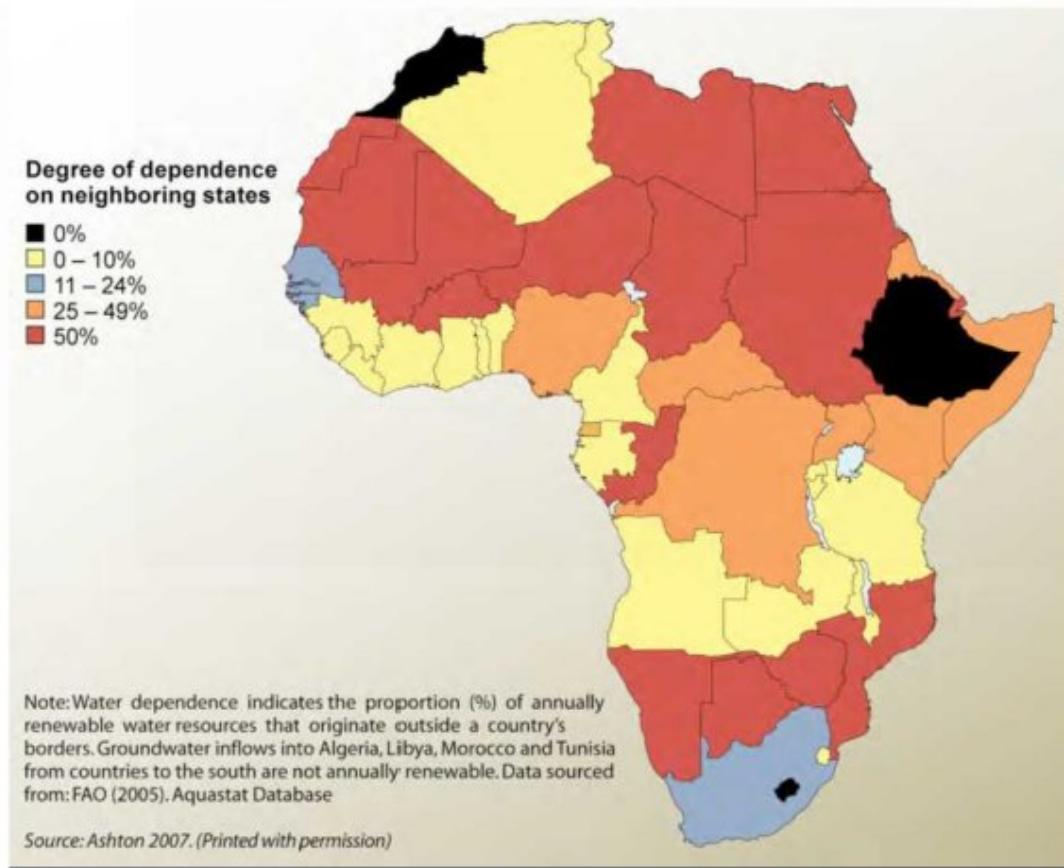


Figure 3-5. Dependence on inflows/water transfers

Equitable sharing of resources among riparian countries will be increasingly vital in the face of resource unreliability and shortages. Yet the high levels of conflict between African countries such as Ethiopia and Eritrea, or internally, such as in Somalia, prevent governments from establishing meaningful institutional support mechanisms for management of transboundary resources.¹¹¹ Existing treaties, especially among contentious partners, may falter with the change in the climatic conditions on which resource management strategies are based. Upstream countries may seek to use climate change as a screen for renegotiating water-sharing agreements to more favorable terms; and, in times of heightened tension over other issues, water infrastructure can become an increasingly attractive weapon of diplomatic pressure, or target in a military confrontation.¹¹² The shrinkage of Lake Chad illustrates the potential international import of alterations in the geographical distribution of transboundary resources; once shared with Niger and Nigeria, the lake perimeter is now bound by only Chad and Cameroon.

The primary obstacles to effective negotiation are the uncertainties surrounding present and future water uses and water availability. These forestall building trust among partners. Key security unknowns include the likelihood of countries experiencing extreme water scarcity resorting to unilateral actions that generate, for example, retaliatory trade actions, escalating tensions at the international level.¹¹³ Recent years have seen many instances of countries building large-scale dams to meet the needs of their growing populations and economies to the detriment of their neighbors. Potential conflict is now brewing between the neighboring countries of Ethiopia and Kenya as several large-scale hydropower dams are constructed or planned along major stream courses downstream from their headwaters.¹¹⁴

A separate issue arises when a country's borders are defined by changing transboundary waters instead of geographical coordinates. Uganda and the Democratic Republic of the Congo, for example, have acted quickly to head off a dispute as changes in the course of the River Semliki over the last fifty years, have transferred as much as 50 km² of Congolese territory to Uganda.¹¹⁵ Border issues like the Migingo Island saga that has pitted Uganda against its eastern neighbor, Kenya, could become more complicated if a further fall in Lake Victoria water levels increases the size of the island above water. Uganda is also looking at border changes occurring along the West Nile and its border with Rwanda in the Katuna wetlands.

These climate-related stresses open up opportunities for conflict-prevention and peace-building. The shared problems are a basis for bringing adversaries to the negotiating table and providing a common language for building cultures of cooperation. History shows that even countries with a history of conflict will come together to negotiate water issues.

Water problems are recognized as "wicked problems" which are further complicated by the need to integrate two very different types of knowledge, work across several socio-political units of analysis simultaneously, and better organize water as a common resource.¹¹⁶ More fundamentally, most African nations lack data on the extent of their current sustainable surface water, much less data on renewable groundwater resources. Adding increasing climate variability and future climate uncertainties into this mix only compounds the difficulties. Until now, water managers have developed models and tools for a stable climate with known seasonal and decadal cycles. Changes in the variability of precipitation, extreme events, and increases in storm surge in coastal regions raise additional issues for the development of typically long-lived water infrastructure. Tradeoffs between competing uses will become progressively more difficult as demands on those resources increase.

The former President of South Africa and Nobel Peace Prize recipient, Nelson Mandela, stated that: "Security is an all-encompassing condition in which individual citizens live in freedom, peace and safety; participate fully in the process of governance; enjoy the protection of fundamental rights; have access to resources and the basic necessities of life; and inhabit an environment which is not detrimental to their health and well-being."¹¹⁷

Consequences for National Security

Climate change is an observable fact. Regardless of cause, recent global temperature rise is outside the range experienced since the end of the last ice age approximately ten thousand years ago. This change has the potential to change many of the delicate balances that affect US national security.

Changes already underway are having, and will have, major consequences for the political, economic and geographic world as we know it. Geographic modifications, driven by climate change, can decide the fate of island territories, even countries, whose highest points are only meters above current sea surge levels. Shifts in river courses and lake levels can result in changing international boundaries.

Climate change's impact on US national security will be determined by its political, economic and geographic manifestations, yet most current climate research seeks to understand and model the climate itself. Modeling climate change physics is like assembling a puzzle. One seeks to find all the pieces. Eventually some ability to forecast rainfall, winds, temperature, sea level, and storm intensity will emerge. The future rate of shift and ultimate magnitude of climate variations now underway are, as yet, impossible to accurately predict, but the direction of these shifts is certain. Earth is warming. It is clear that the shift is a fundamental one that inevitably will alter factors critical to US global interests.

Dealing with the political, economic, and geographic fallout from these physical forces, on the other hand, is a mystery. No amount of data collection will illuminate, with any certainty, actions which result from human emotions, cultures, and personalities.¹¹⁸ Much work remains in understanding processes for dealing with likely climate-induced conflict types.

In some instances, climate change will serve as a threat multiplier, exacerbating tensions between tribes, ethnic groups, and nations. In other cases, climate change will seem more like Mother Nature's weapon of mass destruction. This natural weapon of mass destruction may also be slow-acting. When rainfall shortage in the Atlas Mountains causes decrease in ground water, salt ocean water can intrude, exacerbating sea level rise related to salinization under North Africa's coastal port cities (e.g., Tunis, Algiers, Rabat, Tripoli, and Casablanca). Fresh water will be displaced, imperiling both potable and agricultural sources.¹¹⁹ Low-lying ports are vulnerable to damage or disruption resulting from violent storm surges. In time, these currently prosperous centers could become as forsaken as today's Timbuktu; pressure for population displacement to Europe and elsewhere in Africa will grow.

Each of these changes, and many, many more, can strongly affect US national security. Impacts likely will not be directly military. If, and when, military responses are necessary to protect US national interests, responses will be too late to rectify underlying conflicting forces. Climate change will more likely first affect human security, resulting in population and political instability that threatens nonmilitary US interests (access to natural resources, criminal activity and terrorism, economic damage, or political agreements), then escalate to kinetic military conflict.

The climate shifts that produce instability may not occur in the proximity of the disturbance. For instance, the unrest leading to the Egyptian government's downfall in winter 2011, exacerbated by escalating food prices brought on by failure of the Russian wheat crop, could threaten the Egypt-Israeli peace agreement, a matter of US national security. Understanding the political and economic pressures of climate change is a global problem, not just a regional one. Analysis of climate change effects must embrace multiple layers of understanding.

Some additional consequences of continued changes in Africa

Continuing increase in local mean temperature and extremes, including the frequency and intensity of floods and drought, will compound existing problems that include:

- Reduced fresh water availability
- Reduced agricultural production
- Loss of biodiversity
- Increased food insecurity

- Increased health problems
- Increased migration

The impacts of these consequences can only be understood in their proper context-environmental, socio-cultural, economic, governmental, etc.-that determines vulnerability, resilience, and adaptive capacity.

Developing regions face differing but equally critical climate change-related issues. The one common critical issue is water.

Agriculture

Climate change may have a graver effect on Africa than any other continent. According to IPCC AR4 projections of a minimum increase in temperature of 2.5°C by 2030, around 600,000 km² of cultivable land may be ruined.

Several modeling studies have assessed changes in crop yields under projected future changes, with results such as those shown in Figure 3-6.120 This type of study either excludes the fertilization effect of additional atmospheric carbon or includes assumptions based on laboratory studies. An alternative approach is to project changes in the length of the growing season (Figure 3-7).121

Fish are a major source of daily protein for a large percentage of the population. Figure 3-8 shows how changes in ocean temperature and chemistry are projected to change fisheries' catch potential in the oceans around Africa.¹²² Changing temperatures and water levels in many of Africa's lakes also affect the productivity of aquaculture and inland fisheries.

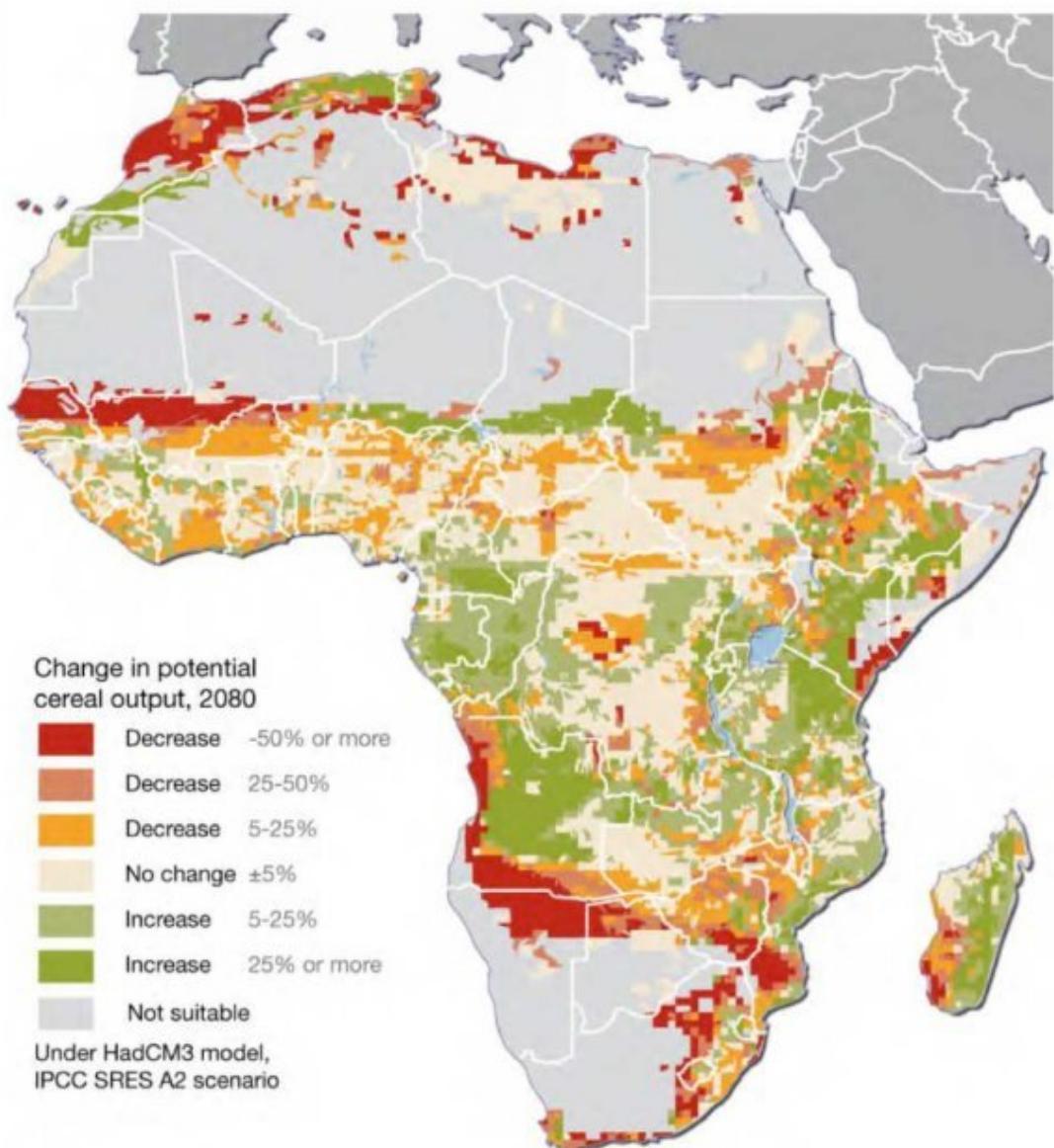
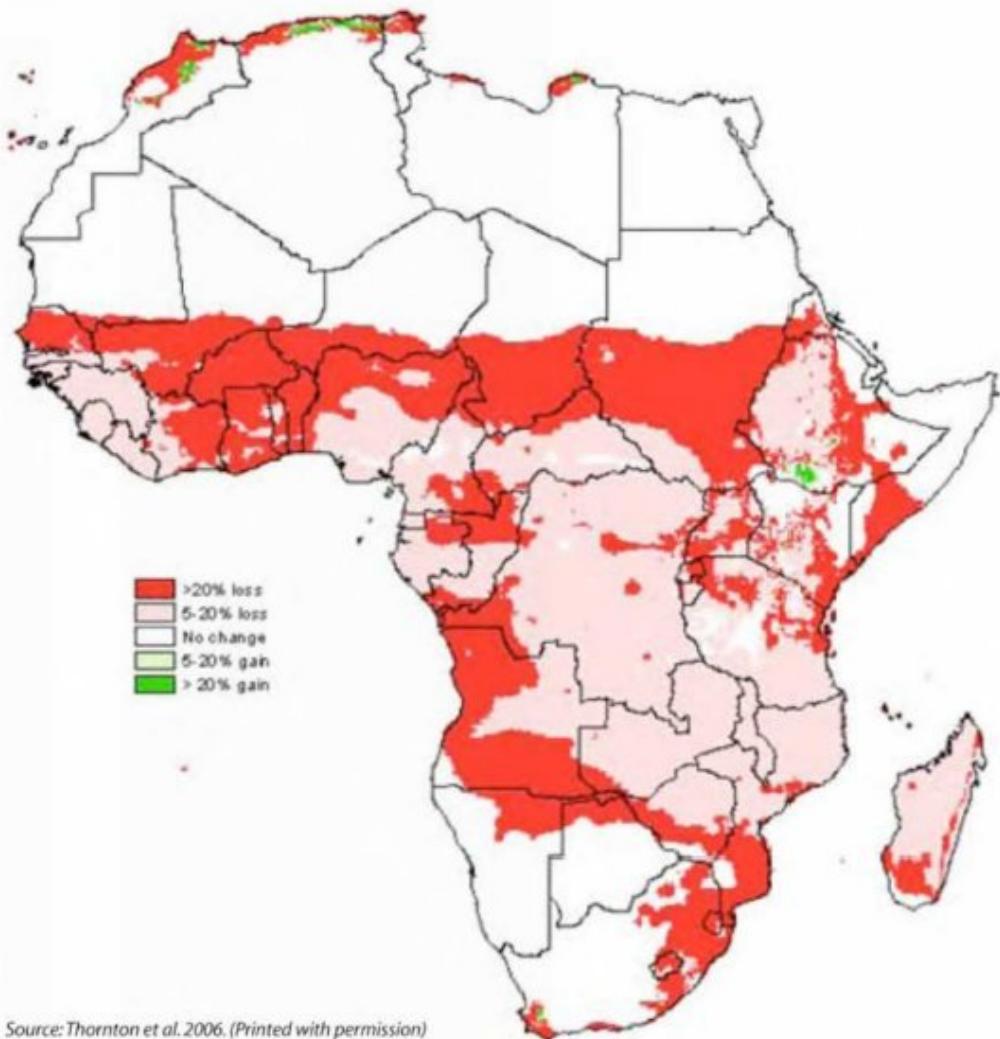
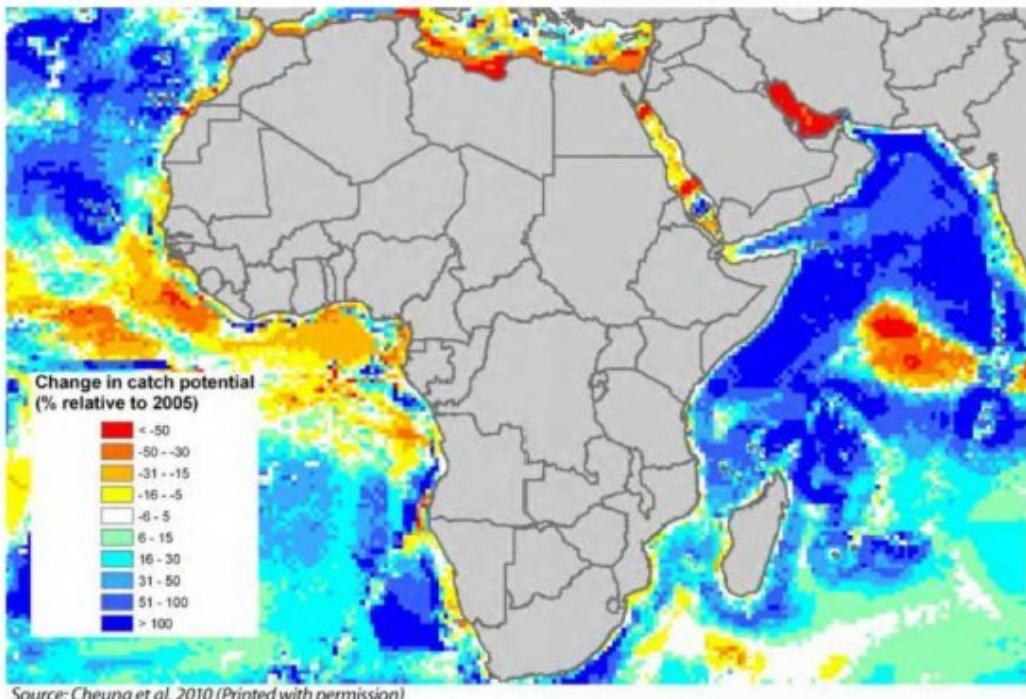


Figure 3-6. Projected climate change impacts for cereal output for 2080



Source: Thornton et al. 2006. (Printed with permission)

Figure 3-7. Percent changes in length of growing period changes to 2050 (HadCM3D, SRES A1FI)



Source: Cheung et al. 2010 (Printed with permission)

Figure 3-8. Change in fisheries catch potential (10-year average) from 2005 to 2055

Sea level rise

Relative sea level rise is not uniform due to effects that include variation in ocean dynamics, regional variations in thermal expansion, and gravity-elastic influences from land-based ice sheets and glaciers.

A rise in sea level exacerbates storm surge to increase flooding and potential storm-related damage (Figure 3-9). This effect is inversely proportional to the intensity of the storm. An increase in sea level of two feet doubles the storm tide associated with a tropical storm with a normal storm surge of two feet. The storm tide of a severe cyclone with a storm surge of fifteen feet only increases by thirteen percent for the same sea level rise.¹²⁴ Even so, a relatively small increase can result in breaching storm defenses. Table 3-2 lists assessed impacts for a projected sea level rise of one meter and a ten percent increase in extreme water (i.e., a one-in-one hundred year storm).¹²⁵

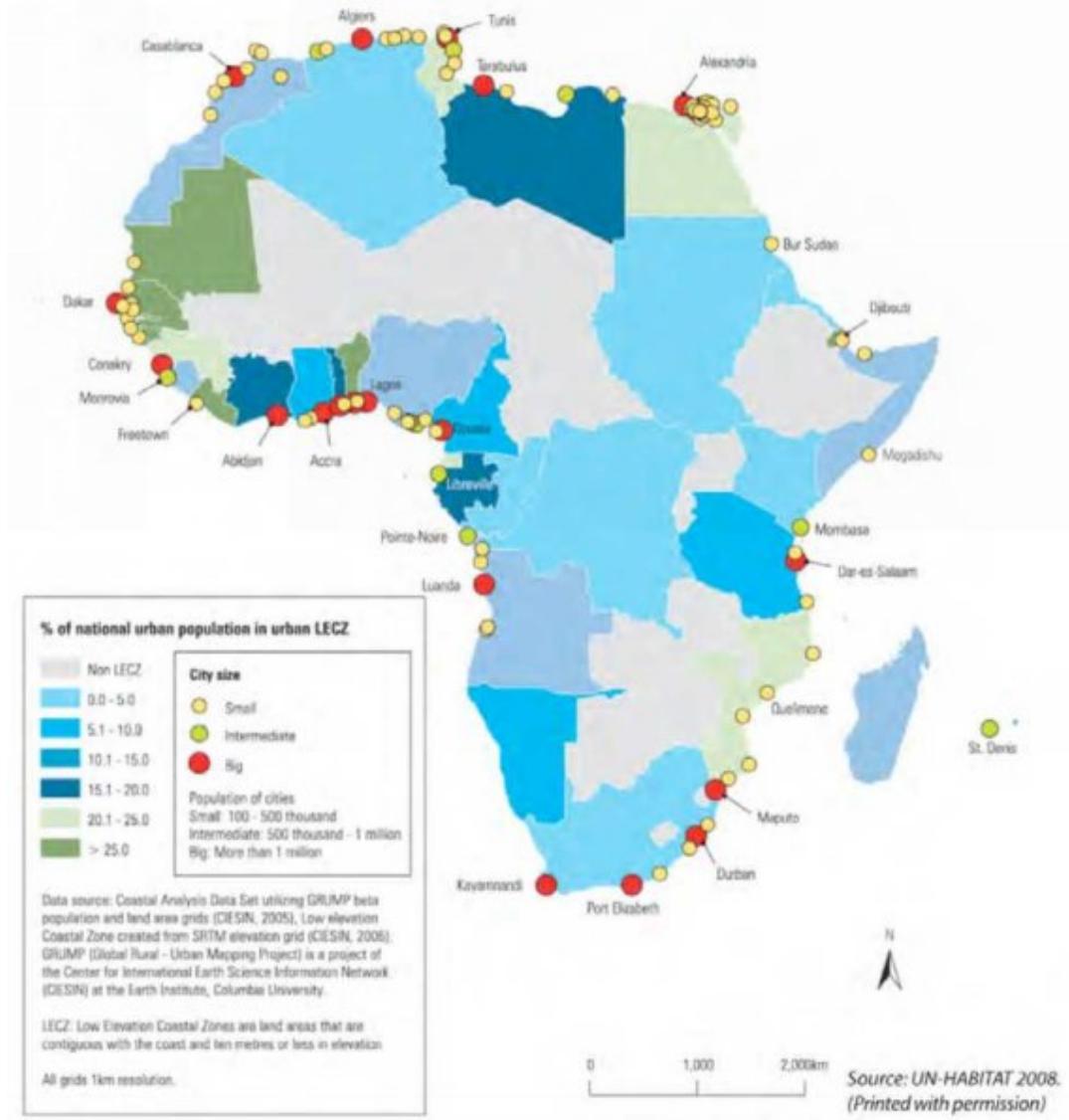


Figure 3-9. Cities at risk due to sea level rise¹²⁶

Sea level rise can have several additional consequences. These include coastal erosion, loss of barrier wetlands, saltwater intrusion, pollution from spread of landfill, industrial contamination, and agricultural wastes; and damage to sanitation systems.

Table 3-2. Sea level rise (1 m) and storm surge increase (10%) impacts

Country	Land area (km ²)	% coastal (approx.)	Population impacted	% coastal (approx.)	GDP impact (US\$ million)	% coastal domain	Agricultural impact (km ²)	% coastal (approx.)	Urban extent (km ²)	% coastal (approx.)	Wetlands (km ²)	% coastal (approx.)
Mozambique	3,268	41%	380,296	52%	140.73	55%	291	24%	78	55%	1,218	47%
Madagascar	2,312	45%	102,439	43%	27.89	44%	0		36	44%	617	51%
Nigeria	2,264	31%	870,276	25%	407.61	22%	0	100%	94	29%	1,365	39%
Mauritania	1,754	21%	149,576	33%	74.21	35%	0	2%	59	43%	710	33%
Senegal	677	17%	190,690	21%	111.66	21%	29	2%	27	16%	395	22%
Guinea-Bissau	670	36%	61,134	33%	10.01	33%	0		12	34%	278	40%
Cote D'Ivoire	668	30%	315,609	48%	176.27	43%	0		99	53%	162	38%
Gabon	630	26%	34,500	28%	120.95	24%	0		30	30%	253	27%
South Africa	607	43%	48,143	33%	174.30	31%	70	34%	93	48%	132	46%
Somalia	555	28%	33,756	31%	8.90	26%	15	16%	1	25%	94	25%
Sierra Leone	549	29%	39,080	35%	5.69	38%	0		1	37%	451	34%
Namibia	470	60%	957	42%	2.31	37%	0		13	50%	18	82%
Angola	457	29%	72,448	46%	88.54	45%	23	14%	19	46%	129	15%
Eritrea	452	32%	8,238	31%	0.97	29%	0		4	43%	31	32%
Tanzania	426	47%	75,493	50%	34.45	49%	64	22%	15	53%	177	42%
Guinea	420	59%	58,967	44%	37.99	40%	0		8	33%	193	62%
Ghana	400	39%	137,206	49%	45.04	51%	0	67%	35	48%	268	48%
Sudan	370	50%	18,762	49%	10.77	48%	0	0%	7	50%	107	59%
Kenya	274	42%	27,453	40%	10.12	32%	40	22%	9	39%	177	53%
Liberia	269	27%	88,535	45%	16.77	41%	0		15	43%	44	46%
Benin	260	20%	221,029	39%	107.35	47%	0	0%	44	44%	164	21%
Cameroon	172	40%	57,124	35%	44.53	32%	0		14	40%	111	43%
Togo	95	34%	147,274	54%	48.20	54%	1	50%	28	60%	52	27%
Djibouti	82	38%	28,559	60%	22.87	49%	0		5	60%	7	19%
Congo	65	15%	10,361	22%	13.14	22%	0		3	21%	20	11%
DRC	51	17%	1,812	8%	0.17	12%	0		9	32%	21	23%
Gambia	39	4%	47,233	40%	18.54	47%	0	0%	8	24%	21	4%
Equatorial Guinea	22	17%	892	38%	6.32	42%	0	50%	1	53%	4	8%
Sao Tome & Principe	2	44%	1,053	24%	0.30	20%	0	33%	1	30%	0	

Source: Based on Dasgupta et al. 2009, Table 3; International Bank for Reconstruction and Development/The World Bank: Sea Level Rise and Storm Surges: A Comparative Analysis of Impacts in Developing Countries, Public Research Working Paper 4901, 2009.

Health-malaria and dengue transmission

The time it takes for the malaria parasite to mature in the mosquito is sensitive to temperature. The parasite takes fifty-six days to mature at 18°C, which is longer than the average mosquito life span but only nineteen days at 22°C and eight days at 30°C. Figure 3-10 shows the potential change in malaria vectors for 2°C temperature increase and associated precipitation changes.¹²⁷

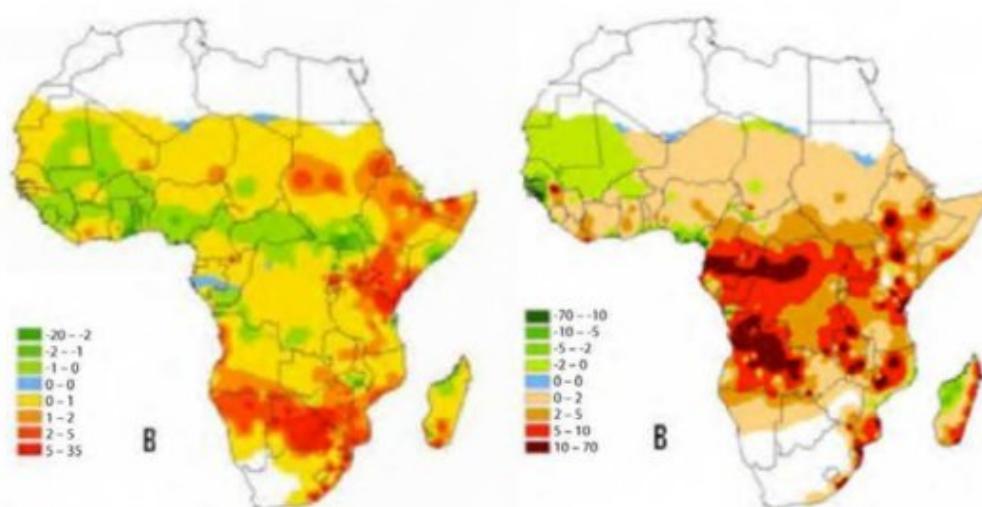
The transmission of dengue fever is sensitive to humidity. Figure 3-11 shows how climate change is expected to change the area of land with a climate suitable for dengue fever transmission and, assuming no other contributing factors change, the proportion of the human population that would be at risk.¹²⁸

Vulnerability

Funded under the DOD's Minerva Initiative, the Climate Change and African Political Stability program maps vulnerability to climate change as shown in Figure 3-12.¹²⁹

Adaptation

The UNEP-funded AdaptCost Africa project has estimated the potential adaptation costs in Africa. While there is high uncertainty, the integrated assessment models indicate that the central economic costs of climate change for Africa could be equivalent to 1.5-3.0 percent of GDP each year by 2030, as shown in Figure 3-13.¹³⁰



Note: (Left) *A. arabiensis*, (right) *A. gambiae*.

Source: Tonnang et al. 2010. (Printed with permission)

Figure 3-10. Change in distribution of the two most prevalent malaria vectors (Anopheles mosquitoes) for a rise of 2°C Africa wide temperature, 10% increase of summer rainfall, and 10% decrease in winter rainfall

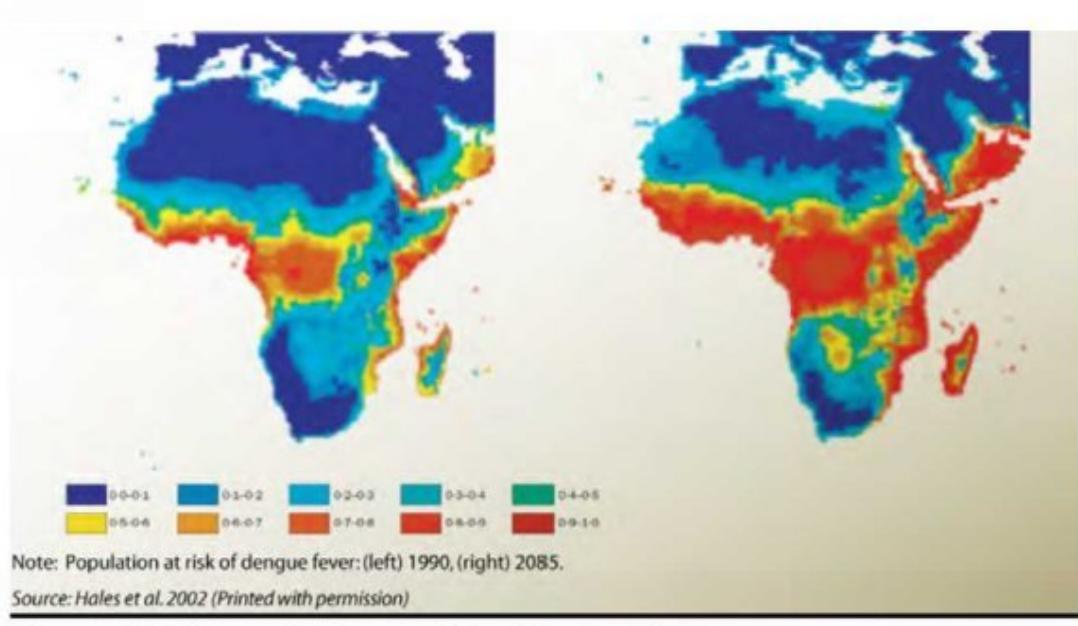
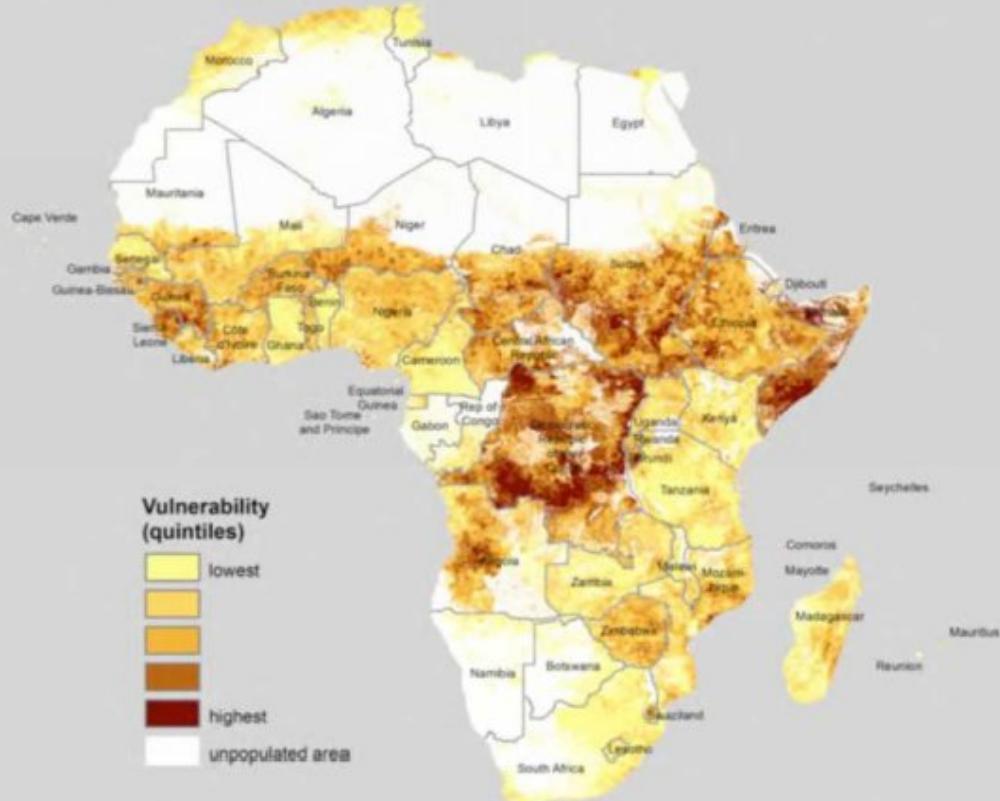


Figure 3-11. Population at risk of dengue fever

Composite Vulnerability in Africa

Climate Related Hazard Exposure + Population Density + Household & Community Resilience + Governance & Violence



Data Sources: World Bank Governance Indicators; Polity IV Project: Political Regime Characteristics and Transitions; KOF Index of Globalization; Armed Conflict Location and Event Data (ACLED); World Health Organization; World Development Indicators; Food and Agriculture Organization of the United Nations Food Security Statistics; UNICEF Multiple Indicator Cluster Survey (MICS); Demographic and Health Surveys; UNEP/GRID-Europe; Global Precipitation Climatology Center; DEM from USGS; LandScan; CIESIN
Map Author: Kalba White (2011)

Source: Busby et al. 2010 (Printed with permission)

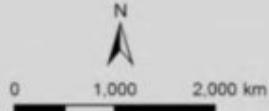


Figure 3-12. Composite vulnerability in Africa

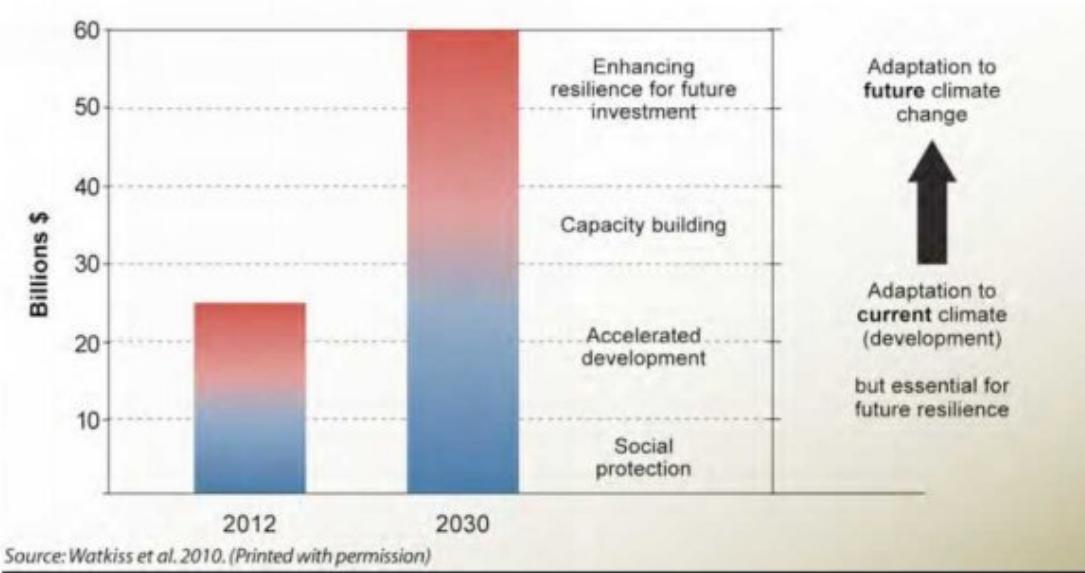


Figure 3-13. Potential costs of adaptation to current and future climate in Africa

Findings on Consequences

Climate change may have the greatest impact on security through its indirect effects on conflict and vulnerability. Many developing countries are unable to provide basic services and improvements much less cope with repeated sudden-onset shocks and accumulating slow-onset stresses.

Climatic factors affect conflict through influence on food prices, migration patterns, government revenues, competition for water, grazing land, and other resources. The capacity of the international NGO community to fill critical gaps on a much larger scale is at best uncertain.

CCAPS indicates that social conflict-protests, strikes, riots, inter-communal violence, and other unrest have a strong correlation to rainfall. Precipitation in Africa may become more variable bringing more extreme wet and dry years; and, social conflict is more common in extremely wet and dry years than in years of normal rainfall.

Social conflict has been more prevalent than armed conflict in Africa in recent decades, resulting in more than twenty thousand deaths since 2000, many of which came during violent, politically destabilizing episodes.

Climate change is an exacerbating factor. It can be a contributing factor to conflict, but the underlying political, economic, social, and cultural contexts probably will have a more direct effect. Grievances develop, mobilizations occur, and violence erupts more easily where there are weak, corrupt, fragile, or failed governments.

Climate change could intensify environmental or resource problems that communities are already facing by intensifying grievances, overwhelming coping capacities, and possibly spurring migration and displacement. Climate change could also create new environmental problems that lead to instability.

DOD and the combatant commands recognize these conditions. AFRICOM and United States Southern Command (SOUTHCOM) initiatives incorporate environmental security, the role of climate change, and disaster preparedness into their security cooperation programs.

Addressing Climate Change Effects on African Populations

As noted in Chapter 2 of this report, climate change effects in Africa destabilize fragile states by overloading the political systems and eroding governmental legitimacy. Many of these states determine continued US success in achieving national security objectives, such as securing strategic mineral and fuel resource access; maintaining freedom of navigation covering choke points and sea lines of communication; combating terrorism; maintaining geopolitical influence; promoting democracy; and, establishing strong market economies. Thus, climate change by definition affects US national security interests. Moreover, DOD has the potential to promote US national security interests with confidence-building measures and by promoting multilateral cooperation and communication.

There is compelling evidence of the importance and the potential of DOD's measures. Before the droughts began in Sudan in the 1980s, herders from the north and farmers from the south coexisted and shared the arable land. When drought became a permanent condition, farmers began to fence in their lands to protect increasingly fragile crops. The resulting tensions multiplied existing differences in religion, culture, and ethnicity and underpinned the conflict in Darfur. Similar conflicts occurred across the margins of the Sahel, to include northern Nigeria, and drought has promoted tensions between Zimbabwe and South Africa over forced migration. The questions, then, are these: How are those effects manifest? How should the problem be addressed? What should be the national security community's role in managing it? To manage the problem, one should begin with a clear end state, develop strategic concepts for achieving it, and specify the resources necessary to succeed.

End state

A stable Africa, where civilian governments, supported by defense cooperation among capable militaries, maintain resilience to the effects of climate change, and in which intra and interstate conflict over resources is not a threat to security and stability; and, where preparedness for reducing the risk and responding to increased and natural disasters, is a priority.

Findings on Addressing Climate Change Effects on African Populations

Environmental security and resource issues have been associated with all phases of the conflict cycle; climate change is already implicated in some African conflicts.

Climate change increases the porosity of border areas and ungoverned spaces, especially in areas of pastoral landscape.

Water security is a driver of conflict, an avenue for peace building, and a critical element of economic growth in Africa.

Many African governments lack the capacity to adapt to the effects of climate change. Regional militaries have many of the technical, health, engineering, and manpower capabilities necessary for civil authority's efforts to create climate change resilience.

The successful cooperation between the SOUTHCOM-DOS Environmental Hubs on climate change adaptation and environmental security could easily be replicated between AFRICOM and the three DOS African Hubs. This cooperation would make efforts to build climate change adaptation capacity and resilience attainable.

Private sector corporations, such as the Coca-Cola Company, and nongovernmental organizations, such as The Nature Conservancy and World Wildlife Fund, have established and respected programs in Africa addressing the climate-related issues such as clean water and food security that could inform AFRICOM efforts to build regional capacity.

Because of its widespread occurrence across the continent, climate change adaptation is a viable issue for multilateral cooperation and a confidence building measure for intrastate and interstate conflict.

USAID's regional and bilateral missions could harness AFRICOM engagement and capacity building programs to support US sustainable development and climate change initiatives.

Recommendations arising from the consequences of climate change are found in Chapters 4 and 5.

Chapter 4

Roles of the National Security Community

This chapter examines the roles of the national security community in addressing climate change issues. Climate change is increasingly recognized as having a multiplier effect for existing tensions and regional instabilities. It places additional stress on the state political system, complicating the ability of governments to meet the demands placed on the system by a suffering population and by reducing system resilience. This can lead to a loss of legitimacy, internal conflict, state failure, population migration, and the growth of extremist ideology. Climate change threatens US national security interests at the regional levels.

This study does not address means to halt or reverse global climate change. Lack of knowledge of complex climate mechanisms makes any such suggestion speculative at best. However, the United States has understanding, resources, and skills that can blunt some effects of climate change.¹³¹¹³² The United States, however, has neither the knowledge nor the resources needed to produce widespread amelioration. US resources must be focused on the most serious US national risks. The United States must also reach out internationally to spread the burden of adaptation to climate change.

Strategic Concepts for Addressing the Challenges

Strategic concepts include:

- Whole of government cooperation with meaningful support from DOD
- Cooperation with allies, NGOs, and those of common purpose
- Military to military engagement and capacity building

The current US approach to national security interests related to climate change is based on three elements of national power: defense, diplomacy, and economy. While other US agencies can make valuable contributions to this effort, the Department of Defense, the Department of State, and the US Agency for International Development, referred to here as "the 3 Ds," will determine the success or failure of US efforts to reduce the risks associated with climate change in areas of the world of greatest relevance to US national security interests. Success in building cooperation on climate change adaptation will depend heavily on the efforts of these three organizations, supported and guided by:

- An intelligence community analysis of where US national security interests are most likely to be affected by regional changes in climate
- A realistic assessment of the individual capabilities of these organizations to affect climate change adaptation capacity building in the corresponding regions be conducted
- A synchronized plan that capitalizes on the strengths of each organization be created and implemented

Meeting the physical impacts of climate change like changes in water, temperature, sea level, and storm violence are mostly the provinces of civil engineering, hydrology, energy, agriculture and land use, and infrastructure planning. The bulk of resources to address local problems must come from affected regions. However, many of these areas are impoverished and lack even basic technical knowledge. To help address this shortfall, the United States has the capability to build and educate local and regional cadres of engineers,

hydrologists, planners, agricultural and fishery specialists, and medical personnel to support local resilience to climate shifts. A major training effort, similar to past US foreign military training assistance programs, could be mounted to educate field personnel in hydrological, civil engineering, construction, agricultural, biological, medical, and criminal justice critical skills in those countries where climate change can be addressed through technical means. The United States should also lead an effort to call on other nations to assist with similar training and education capabilities.

The United States and its developed world allies should be prepared to support, both technically and financially, civil projects that increase resilience and provide ways to adapt to forecasted climate change effects. As in the case of foreign military sales, such support could serve to boost world markets for construction and agricultural equipment, seeds, and medical supplies.

The conventional view of national security is based on conflict and economic interests. Threats to a state are often seen in terms of territory, migration, access to resources (energy, water, food, and materials) or markets. Climate change threats are much less focused. Human security lies at the heart of the climate change threat to US national security. Conventional national security threats arise from human security origins.¹³³ Dealing with climate change requires a human security-based strategy to prevent emergence of national security challenges.

As a nation, the United States has a reputation for being better at addressing acute crises than at sustaining efforts to remedy chronic problems before they become dire. History suggests the United States is able to do both effectively. The Agricultural Extension Program, in its first one hundred years, led a farm revolution that developed new technology, escalated productivity, battled the Dust Bowl, and dramatically reduced the number of people required to feed the nation. The Public Health Service fostered changes in sanitation and food and water processing that virtually eradicated common childhood epidemic diseases. The US Army Corps of Engineers, since the early 1800s, and the Bureau of Reclamation, since the 1890s, have altered the US riverine transportation system, enabled growth in the water-starved West, and reduced the impact of seasonal flooding. Mounting each of these efforts required enduring commitment to make changes in the country's interest. Countering climate change's adverse effects on national security will require a similar long-term effort.

Protecting against climate change threats to US national security will require broad-based action well before a conflict. In order of increasing effectiveness, the spectrum of national climate action responses include kinetic military operations, aid after the effects of climate change are manifest, adaptation (encouraging permanent changes in the affected area to cope with climate change effects), and to develop indigenous resilience in anticipation of climate change impact. To the extent that the nature, impact, and location of destructive influences of climate change can be reasonably predicted, the most effective, least costly actions to protect US national security lie at the development of indigenous resilience end of the response spectrum; the least effective, most costly lies at the kinetic military end. Setting the right priorities, and effectively engaging the right government entities, will require broader and deeper attention. Still, there is increased sensitivity to the potential impacts of climate change and the need to address them.

Former Secretary of Defense Robert Gates addressed the importance of recognizing the Department of State and USAID as elements of national security. Secretary of State Hillary Clinton spoke of the importance of migrating development functions back to the Department of State and USAID. The 2010 US National Security Strategy assigns the responsibility for addressing the climate change threat to national security to both DOS and USAID. No senior-level Pentagon official has been assigned responsibility for the DOD interest in climate change adaptation. While there is a general recognition of the importance of the impacts of climate change to national and international security, there is a need for clear top-down guidance to proactively address climate change adaptation before it leads to conflict or instability. There is a need for clear assignment of an individual and organization as the coordinating agency in the US government responsible for climate change adaptation at the regional level.

National leadership, interagency coordination, and the strategic documents that govern policy development in Washington need to be further strengthened. Still, at the regional level, the framework for cooperation on climate change capacity building exists. The regional missions of USAID and the Department of State Regional Environmental Hubs are currently focusing on sustainable development and environmental diplomacy in ways that address such climate change related issues as water resource management and adaptive agricultural practices. These programs have successfully sought to develop host nation and regional climate change resilience and should

be given consistent combatant command support. Providing the support of the combatant command engagement activities would multiply the effectiveness of these programs and could markedly change the conditions for populations impacted by climate change. Several nations are currently facing new and growing environmental challenges, many of which require regional cooperation to solve. Bringing nations together in a region to work on a common environmental problem—a common threat—can advance US interests in ways that go far beyond the scope of the environmental issue itself. The government's commitment to a regional strategy complements our bilateral and multilateral diplomatic environmental efforts.

During the Clinton Administration, the Department of State created the Regional Environmental Hub program as the flagship for its environmental diplomacy efforts. It was created with the belief that, "Bringing nations together in a region to work on a common environmental problem—a common threat—can advance US interests in ways that go far beyond the scope of the environmental issue itself."¹³⁴ These offices have thrived and, during subsequent administrations, have consistently brought multilateral cooperation to environmental issues that threaten to destabilize regions. In 2009-2010, the Department of State Regional Environmental Hub for Central America and the Caribbean partnered with the US Southern Command to conduct two climate change and security events to determine climate change adaptation threats to the region and to develop responses. The second conference was the region-wide, Central America and the Caribbean Climate Change and Security Conference: from Strategy to Action. There are three Regional Environmental Hubs in Africa and two in South and Central America.

In the 1990s the Department of Defense established the preventive defense concept to avoid costly conflict and successfully sought interagency cooperation in its efforts to "mitigate the impacts of adverse environmental actions leading to international instability."¹³⁵ Since then, the regional combatant commanders have used environmental security as an engagement vehicle and have worked closely with the Hubs to build cooperative relationships among regional states and military support for civil authority and democracy. DOD cooperation with partner countries has been regularly supported by agencies such as the US Agency for International Development, US Geological Society, the Environmental Protection Agency, and the Department of the Interior. These build partner capacity and capabilities to address environmental security issues and promote stability. It is important to understand that this international interagency cooperation is ongoing and already addressing the security dimensions of many climate change issues.

Findings on Strategic Concepts for Addressing the Challenges

The least expensive way to deal with threats to US national security will be through anticipatory and preventative actions using primarily indigenous resources.

The United States needs better insight into the political, economical, and geographical impacts of climate change.

US national security threats will require government-wide, coordinated outreach in training and education, planning, engineering, agriculture, health, justice, and military areas.

No single person or organization in the US government has been assigned coordinating agency responsibility for climate change adaptation or coordinating interagency efforts to address issues at the regional level.

There is a need for a strategic level, interagency process to identify climate change adaptation hotspots, determine what resources each agency can provide, and synchronize cooperation to create climate change resilience.

Climate change effects, particularly those related to water and food security, can erode the legitimacy of fragile states and create the conditions terrorists and extremists seek to exploit. Therefore, they are significant factors in combating terrorism.

The United States can best use its informational and technical capabilities to build and support local resources to anticipate and adapt to climate change impact.

The United States has demonstrated capabilities to deal with issues similar in scope and similar to the potential impacts of climate change, e.g., the Agricultural Extension Program that led a farm revolution and transformed the food supply, the Public Health Service that fostered changes in sanitation and food and water processing that virtually eradicated common childhood epidemic diseases, and the US Army Corps of Engineers and the Bureau of Reclamation, since the 1890s, that altered the US riverine transportation system and enabled growth in the water-starved West.

The United States has demonstrated a capacity for training in the foreign military training programs that could be expanded to provide education and training most relevant to adapting to climate change, e.g., hydrological, civil engineering, construction, agricultural, biological, and medical training.

Disaster preparedness and climate change

As Hurricane Katrina and the earthquake that led to the fall of the Somoza government in Nicaragua made clear, natural disasters that expose a government's lack of preparedness have quantifiable effects on governmental legitimacy. Climate change will have a disruptive effect on state systems, putting at risk the resource base and sustainability of the government. Reducing the risk and responding to resulting natural disasters are emerging challenges for local, regional, and state governments. Lack of preparedness for environmental challenges, such as those in Tunisia, Egypt, and flood-ravaged Pakistan can multiply tensions from existing grievances and lead to instability. Resilience, sustainability, and preparedness are essential to avoiding political instability and important to any national security community effort to mitigate the regional effects of climate change.

It is useful to conceptualize the role of the national security community in addressing this destabilizing issue as creating climate change resilient communities. NOAA was tasked by Congress in 1994 to assess tsunami awareness and preparedness for parts of the United States. As a result of their analysis and research, NOAA developed a concept for mitigating the damage of tsunamis. Called Tsunami Resilient Communities, it was created "to provide direction and coordination for tsunami mitigation activities in the absence of a disaster."¹³⁶ Recognizing that no effort would be successful without the support of local communities, NOAA designed a plan to leverage planning, education, and awareness to minimize losses and reduce fatalities and property damage. The seven variables of resilient communities are designed to enhance national, state, and local capabilities by determining the threat, preparedness, timely and effective warnings, preparation public outreach and communication, research, and international coordination. This concept could easily be adapted to climate change adaptation and would provide a clear end state for national security community efforts.

The concept of resiliency is in use by the United States Pacific Command's Center of Excellence for Disaster Management and Humanitarian Assistance (COE) as a framework to guide its efforts in dealing with the near-term effects of climate change. COE, now in its second decade, believes that the concept of societal resilience provides the best form of disaster preparedness to avoid unnecessary disaster response missions. It works with the interagency community, combatant commands, the international community, and NGOs on disaster preparedness and response efforts and drew upon that experience to draft its climate change resiliency concept. As presented by LtGen (Ret) John F. Goodman, COE Director, during his address to the recent Pacific Command Environmental Security Conference, the pillars of the climate change disaster resiliency concept are:

- Societal capacity. In order to confront the challenges posed by disasters, the community must have a developed public health system, diverse infrastructure, humanitarian assistance capabilities, and robust disaster preparation.
- Knowledge assets. An equitable education system, hardened communication and information exchange mechanisms, and inviting environment for research and innovation are critical to developing the intellectual capital to ensure resilience.

- Resource independence. A robust economy and established sustainable development and resource management practices enable a community to withstand and recover from the financial and environmental disaster threats.
- Community cohesion. A community that shares common values and objectives while respecting diversity and striving for social parity can better work collectively to resist the effects of disasters and rebuild in their aftermath.
- Good governance. A resilient community requires accountable leadership, just legal and regulatory codes, appropriate security and social protection mechanisms, and the ability to assess its risks.

COE's climate change adaptation program, founded on resiliency and its supporting framework, reinforces many of the objectives of USAID's sustainable development concept and the intent of the National Security Strategy. The success of a regional security organization such as COE in developing such a concept in cooperation with other interagency and international organizations, and applying this concept in its educational and operational activities, demonstrates the feasibility of a broader government approach to climate change adaptation. This type of coordination normally occurs after the onset of the crisis, as was the case in Iraq and Afghanistan. The provincial reconstruction teams and the agribusiness development teams have successfully worked to reduce the conditions of drought, water, and dry land agriculture that extremists seek to exploit in Afghanistan. These conditions mirror conditions already causing tensions in other regions from climate change effects. At the operational and tactical levels, much the same as with embassy country teams, interagency cooperation is possible and essential to success.

At the strategic level, success is also possible. Priorities in the national security community are recognized with the creation of an Interagency Policy Committee that develops policy options, assigns responsibility, and coordinates actions. Climate change adaptation is an important national security issue that affects regional stability and US national security interests, warranting this level of priority. With top level guidance and priority, agency strategic documents, such as the National Military Strategy or the Department of State and USAID Strategic Plan could speak to the importance of interagency cooperation and create regular cooperation and synergy among valuable programs that are already in place. Without this top level coordination and priority, strategic documents of the national security community may fail to stress the importance of climate change adaptation in a meaningful way, and the operational and tactical levels of these organizations will only undertake climate change adaptation if lower-level leadership deems it important. Moreover, the opportunity to promote multilateral cooperation in addressing a growing threat to regional stability and to undertake confidence-building measures that could lead to peace building could be lost.

Findings on Disaster Preparedness and Climate Change

Governments unable to meet challenges placed on their political systems by the effects of climate change are at greater risk of failure; this is particularly important in those areas where fragile states are pivotal to US national security interests.

Proactively reducing risk and responding to the increased natural disaster potential from climate change can best be achieved by promoting the concept of climate change resilience as a common theme to guide regional interagency activities.

Whole of Government

The government has numerous organizations which can contribute to both the understanding of climate change and actions to address near-term response and adaptation.

US government organizations

The Department of State has established a Special Envoy for Climate Change, and ambassadors lead our efforts abroad through the country team. USAID has the Famine Early Warning System which provides indicators

to complement the Intelligence Community's monitoring capabilities. The Senator Paul Simon Water for the Poor Act directs improving access to water supplies and sanitation, hygiene, and water management.

The Central Intelligence Agency has a Center for Climate Change and has established the Measurements of Earth Data for Environmental Analysis program to inform the scientific community of classified data.

The Department of Agriculture has a Foreign Agricultural Service which helps educate farmers worldwide how to improve productivity.

The Department of Energy manages an extensive laboratory system employing scientists of the highest caliber and an office of Energy Efficiency and Renewable Energy which contributes lessons.

The Environmental Protection Agency has a Climate Program Office and establishes policies and standards to mitigate climate change impacts.

The National Oceanic and Atmospheric Agency collects and publishes critical data on sea level and atmospheric changes.

The Jet Propulsion Laboratory can provide data on: 1. Carbon-agriculture-forestry and land management; 2. Precipitation and fresh water; 3. Sea level rise and coastal surveillance; and, 4. Geographic hazards-earthquakes, volcanoes, and tsunamis.

US Geological Survey uses a whole systems approach to understand global change. It documents and models past and present climates and environmental change through geological, biological, and hydrological processes, and has regularly supported the combatant commands.

The National Academy of Sciences and the National Research Council publish critical studies by eminent scientists on the causes and effects of climate change.¹³⁷

The President's Office of Science and Technology Policy through the President's Committee on Science and Technology provides advice and guidance on the science of climate change.

Other US organizations

In addition to governmental organizations, there are numerous organizations which can provide assistance and advice. They include The Nature Conservancy and the American Red Cross, as well as dozens of local and university groups which provide research and adaptation projects. NGOs provide a wealth of expertise and assistance from both within the United States and internationally.

International organizations and allies

Outside the United States, there are numerous efforts underway to address climate change and its impacts. The United Nations provides both military and humanitarian response to mitigate the results of aggression and disasters. The United Nations Environmental Program monitors and advises on the impacts to our environment. The World Bank and the African Development Bank monitor and provide financial assistance to adapt to the impacts of climate change. Britain recently co-sponsored a SOUTHCOP regional Climate Change and Security Roundtable in Colombia aimed at building military capacity to address the effects of climate change.

Findings on Whole of Government

There are US government organizations and international organizations available to:

- Provide indicators of pending disasters

- Support efforts to proactively build adaptation and resilience capacity
- Assist in the response to the effects of climate change
- Provide scientific and engineering support to understand and help mitigate change

There is no central organization to assist agencies in understanding what resources are available or to coordinate their efforts.

RECOMMENDATIONS ON ROLES OF THE NATIONAL SECURITY COMMUNITY

The Director of National Intelligence should:

- Establish, within an appropriate agency of the Intelligence Community, an intelligence group to concentrate on the effects of climate change on political and economic developments and their implications for US national security
 - An important focus of this effort should be to project human security changes that could develop into national security issues.
 - This group should make extensive use of open sources, seek to cooperate with other domestic and international intelligence efforts, and report most of its products broadly within government and nongovernment communities.
 - The intelligence group should commission the Central Intelligence Agency's (CIA) Center for Climate Change and Security to produce an assessment of regional climate change hotspots that threaten human security and governmental legitimacy and exacerbate existing tensions. They should use this assessment as a confidence-building measure to promote communication between antagonistic peoples or states. This document should be the basis for interagency cooperation at the strategic and regional levels.

The President's National Security Advisor, in conjunction with the Council on Environmental Quality, should establish an interagency working group to develop:

- Coordinated climate change policies and actions across US government entities
- A whole of government approach on regional climate change adaptation with a focus on promoting climate change resilience and maintaining regional stability
- The President's National Security Advisor should continue to emphasize strategic interagency documents, such as the DOD Strategic Guidance which details the link between climate change effects and the underlying conditions that terrorists seek to exploit and should direct relevant organizations to consider this relationship in developing their regional plans.

The Deputy Secretary of State and the Deputy Secretary of Defense should:

- Follow the example of the successful foreign military training assistance program to fashion education and training programs in the fields most relevant to adapting to climate change, e.g., hydrology, civil engineering, construction, agriculture, biology, and public health.
- Make conflict avoidance a priority of foreign assistance (including security assistance and foreign military sales), development, and defense concept development, and planning.

- Develop a strategic communication message that links water and food security and increased storm intensity to regional stability and US national security.

Chapter 5

Role of the Department of Defense

Guidance Shaping Department of Defense Efforts and Activities

The National Security Strategy describes dangers arising from climate change: "...new conflicts over refugees and resources; new suffering from drought and famine; catastrophic natural disasters; and, the degradation of land across the globe."¹³⁸ It further emphasizes that efforts to mitigate and minimize the impact of these changes need to be pursued both at home and abroad through international cooperation. There will be significant impacts on DOD.

President Obama, in accepting the 2009 Nobel Peace in Oslo stated that, "...it is not merely scientists and activists who call for swift and forceful action—it is military leaders in my country and others who understand that our common security hangs in the balance."¹³⁹ This point was included in the 2010 Quadrennial Defense Review, the first DOD strategic guidance document to give thorough treatment to the issues of climate change and energy. Thus, for the first time, the two documents that set the framework of defense policy guidance explicitly called for the need of DOD to address domestically and internationally a full range of issues associated with climate change. This guidance has since been incorporated into other DOD documents.

DOD clearly has significant roles in dealing with climate change. For its internal needs, DOD will need to assess how climate change can impact readiness by affecting or altering:

- Existing and planned military facilities and equipment both at home and abroad
- Training, exercises, and deployment of these forces
- The health and safety of military personnel
- The frequency, location, and types of military operations, the need for new or expanded training, and new equipment needs

Externally, DOD must prepare to support the climate change initiatives of the US government as a whole. DOD can, and will, be expected to provide critical support to interagency climate change efforts to direct near-term activities and adaptation towards conflict prevention. DOD will also need to play a lead role in military to military cooperation with other nations to enhance their capacity and resilience to deal with the impacts of climate change. Combatant commands will need to integrate climate change near-term response and adaptation into their theater security cooperation programs and campaign plans. Tangible steps may include identifying regional climate change threats to stability, building the capacity of regional militaries to support civilian authority in addressing these threats, assisting in monitoring and data collection, and engaging with foreign militaries on disaster preparedness.

DOD will need organization to address the full range of international climate change-related issues and their impact on the evolution of DOD's missions. Currently multiple DOD offices are addressing climate change and energy issues with a wide range of perspectives and with limited unifying guidance. This fragmented approach is inadequate to the need. The need is for clarity in responsibility and accountability. The need is for a lead office in the Office of the Secretary of Defense (OSD)—an office designated as the centralized DOD point of contact to serve as the coordinating authority within DOD and to act as the designated DOD representative or interface in relevant interagency activities. Similarly, each of the Services and the Joint Staff need to designate specific leads within their organizations. The current general guidance needs to be translated into specific requirements to provide executable orders to the Services and the combatant commands to address these issues more systematically and comprehensively.

The National Security Strategy, the Quadrennial Defense Review, and other documents have stressed that climate change impacts national security. It is important for all elements of the DOD to understand that climate change can, and will, impact its ability to carry out DOD missions now and in the future. The issues impact the combatant commands, the military departments, and at least some elements of the Joint Staff: J2 for providing required intelligence information, J4 for logistics and installations, J5 for assessing regional stability and country-specific impacts, and J8 for providing the required resources. There are ongoing Services' initiatives relevant to climate change and disaster risk reduction and the impact on their security interests and operations.

The US Navy has taken a forward-leaning approach, initially focusing on increased Arctic operations resulting from climate change. Navy attention has since expanded to include assessments of the potential offered by increased partnerships with other armed forces, the impacts of sea level rise on installations, and the potential for increased humanitarian assistance/disaster relief missions. The Oceanographer of the Navy heads the Task Force on Climate Change and issued a Climate Change Roadmap signed by the Vice Chief of Naval Operations in May 2010. This roadmap outlines the Navy's approach to observing, predicting, and adapting to climate change in the 2010-2014 time frame. It includes incorporating climate change impacts on national security into war college courses and strategy guidance documents; beginning to define the requirements of a next generation operational and climatic environmental prediction capability; including climate change considerations in training and planning; and pursuing international cooperation to enhance the Navy's capacity to assess, predict, and adapt to climate change.

The Marine Corps' expeditionary energy and water program focuses on expeditionary solutions for sustainable energy, which could have applicability to small or developing nations addressing climate change-related impacts, particularly with respect to those with limited infrastructure.

The US Army's climate change-related initiatives have resided principally with the USACE. On the domestic side, the USACE has been tasked to examine the effects of sea level rise on its installations in the continental United States. Internationally, the USACE has been working with other nations on water-related issues, such as water availability, conflict resolution scenarios, and water resource operations infrastructure development in foreign operations.

Air Force capabilities include its significant suite of meteorological data collection, atmospheric assessments, observational capabilities, and satellites. In addition, the Air Force provides air transportation and civil engineering units vital to disaster response missions.

The National Guard offers other important assets that can be drawn upon by the combatant commands to support activities in their AORs. Notably, the State Partnership Program has established relationships between various state National Guards and 62 countries throughout the world. Drawing on the expertise that its personnel bring from their civilian occupations, the National Guard supports US national security goals and assists in the achievement of respective theater security cooperation and individual country campaign plan objectives. It is able, for example, to help build capacity in partner nations in areas such as disaster preparedness, resource management, and other topics related to climate change effects.

A number of existing programs and activities support the Services' and combatant commands' needs for climate change-related initiatives. As noted above, the Navy Task Force on Climate Change and USACE have important vehicles for undertaking such work. In addition, both the Office of the Secretary of Defense for Policy (OUSD(P)) and the geographic combatant commands can draw upon the Defense Environmental International Cooperation Program, managed by the Environmental Readiness and Safety office in Office of the Deputy Under Secretary of Defense for Installations and Environment. DEIC is designed to support engagement activities with other nations' defense institutions.

As an example of work at the combatant command level, the AFRICOM Environmental Security Program, working with US government and international partners, is already in the process of implementing a series of climate change-related activities, such as coastal erosion and water security assessments, incorporating the participation of civilian and military stakeholders alike. The Africa Partnership Station represents another valuable

program to help build maritime security capacity in a host of African nations. The themes addressed under the program can easily be tailored to include those related to climate change and disaster risk reduction.

Findings on Guidance

DOD has unique capabilities and resources to help deal with climate change and disaster risks to include specialized expertise (e.g., engineering, hydrology, logistics, air and sea lift, and innovative research).

DOD's well-established, long-term planning capability and the engagement programs of the combatant commands can contribute to providing broader and higher quality climate change information to the domestic and international community.

DOD capacity needs to be presented with sensitivity to other agencies with more limited resources but with authorities and mandate to lead the effort

DOD currently engages in a range of approaches to engaging with the interagency on climate change. Individual offices bring individual perspectives and equities to their respective interagency discussions but have not systematically recognized climate change adaptation as a significant regional requirement for stability.

The Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L)) represents DOD in interactions with the Council on Environmental Quality.

The Deputy Assistant Secretary of Defense for Partnership, Strategy and Stability Operations interacts with National Security Staff on matters pertaining to development.

The Joint Staff J5 Directorate, Strategic Plans and Policy, and the Deputy Assistant Secretary of Defense for Strategy work with National Security Staff on matters of strategic planning.

The appreciation across the elements of DOD that climate change and disaster risk reduction have important implications for its roles and missions varies across Services and across the combatant commands.

There are parallels between climate change today and environmental security in the 1980-2000 time period. OSD developed an understanding of, and competency in, environmental security which was coordinated with the relevant regional offices within OUSD(P) and was available to the combatant commands and OUSD(P) in their bilateral and multilateral engagement activities.

Climate change is currently having a major impact on the demands of military operations in the Arctic. DOD will need additional capabilities to meet the demands of the expanded Arctic mission. For example, climate change is creating an unfunded mandate for additional ice breaking capability, but ice breakers are under the authority of the National Science Foundation, not under military authority.

RECOMMENDATIONS ON GUIDANCE

The Deputy Secretary of Defense should:

■ Establish a DOD-wide coordinating policy board for climate change impacts on national security. This board's functions should include:

— A coordinating role on climate change information from the strategic and operational perspective. This would include assessing implications for the force structure, deployment options, etc.

— Compiling and assessing climate change effects information across the geographic combatant commands to identify implications for regional stability and the development of global and regional foreign military assistance programs.

— DOD's interagency representative for climate change adaptation matters.

— Serving as the focal point for information, web-enabled, that can be accessed by other Office of the Secretary of Defense (OSD) offices as well as the Joint Staff, Services, and combatant commands.

■ Expand the authorities of the Operational Energy Plans and Programs Office to include operational climate change issues.

■ Direct the establishment of a program of climate change adaptation pilot projects in concert with related programs at USAID and other agencies to identify, solicit, and fund pilot projects focused on specific adaptation sectors and locales (e.g., management of regions or villages in Africa and Central Asia). Examples of pilot projects and suggested activities might include, but are not limited, to:

— Embrace and augment the World Climate Research Program CORDEX for one of the sub-regions in Africa. Apply CORDEX in concert with an assessment activity similar to the European PRUDENCE project.

— Extend the observational, modeling, and synthesis assessment capabilities applied today in the United States in the Upper Colorado River Basin to a priority water resource district in Africa, perhaps linked with the Nile Basin initiative.

— Apply coastal hot spot pilot projects focused on offering local-scale risk assessment and planning for integrated sea level and storm impacts on the coupled water-energy-waste resources and physical infrastructures for megacities such as Lagos, Karachi, and Daha.

— Engage the USGCRP, international research programs, DOD commands and their in-country security partners, and international aid agencies such as USAID in identifying opportunities to share climate change-related information and bringing more visibility into stakeholders' activities.

— Focus on near-term, achievable, and measurable goals to develop and demonstrate end-to-end threads of core information systems while incrementally building in-country capacity and competence.

OSD, Office of the Under Secretary of Defense for Policy and the Director, Joint Staff should direct development of a DOD strategic roadmap for climate change-related efforts that builds on the framework laid out in the US Navy Climate Change Roadmap to:

■ Ensure that the guidance to the combatant commanders, once signed, is considered to be adequate by the Services and combatant commands for translating the broad-level guidance offered in the Quadrennial Defense Review into actionable requirements.

■ Direct that combatant command missions include non-combat support to address serious climate change-induced US national security vulnerabilities.

The Deputy Under Secretary of Defense for Installations and Environment should assemble an inventory of critical facilities and infrastructure to include an assessment of vulnerability to climate change effects and the means to adapt.

The Director, Joint Staff should:

■ Create a holistic approach to climate change, integrating efforts of its relevant directorates: J2 (Intelligence), J4 (Logistics), J5 (Strategic Plans and Policy), and J8 (Force Structure, Resources, and Assessment Directorate).

■ Require that climate change and disaster risk reduction be integrated into training and exercises.

The Secretaries, Chiefs of the Services, and heads of defense agencies should:

- Better integrate climate change and disaster risk reduction considerations into exercises, training, and educational materials.
- Establish metrics focused on risk reduction to minimize the impact of climate change on military and support operations, forces, programs, and facilities.
- Develop guidance to ensure climate change resilience in DOD project designs and construction by incorporating climate change risk into design standards for facilities and installations, with emphasis on the elements related to energy intensive and water intensive uses.

The Secretaries and Chiefs of the Services should:

- Assess the Services' engineering organizations and the cost-benefits of using them in assisting climate change adaptation.
- Utilize military to military engagement opportunities with coalition partners to enhance resilience to climate change impacts and disaster risk reduction capacities. In so doing, they should expand consideration of roles for the National Guard and reserves. (For example, knowledge of traditionally non-military skills needed to respond to climate change threats is often found in the reserves.)
- Examine tasking authorities for domestic and international response to natural disaster or other disaster risk response situations. For example, the National Guard could bring important assets to an international disaster, as it already does in responding to domestic disasters.

United States Northern Command, with support from the Navy and Coast Guard, should identify the assets that will be needed to operate in the Arctic to include communication assets, personnel training, ice breakers, and other equipment.

Combatant Command Roles, Responsibilities, and Capacity

Each combatant command has unique missions and priorities. However, there is a universal need for each combatant command to consider the potential climate change and disaster risk reduction impacts on their readiness to meet mission needs in their AOR. One example of combatant command information requirements, AFRICOM needs detailed assessments within its AOR of climate and natural resource vulnerabilities, such as weather, food, and water. This information is crucial for defining AFRICOM's operational interests and requirements and also for identifying priorities in its interactions with African nations. In effect, such assessments are analogous to doing a national impact assessment at the regional level. These assessments would:

- Identify areas, countries, and regions where the impact of climate change on stability and US security interests is greatest.
- Identify the nature and potential scope of the most likely impacts.
- Identify what capacity building measures should be undertaken to address these impacts.

This information is essential for AFRICOM to develop its priorities for resource allocation. The criteria for funding would be a combination of the country's strategic importance to US security interests, the country's own capacity for addressing the impacts, the potential severity of the impacts, and possible spill-over effects.

- Each combatant command should include in its objectives:

— Developing and enhancing host nation military capacity to build resilience to climate change effects

- Raising the level of awareness of these issues with other partner nations and their militaries
- Taking into consideration capacity infrastructure interests of the United States

Again taking AFRICOM as an example, it has used vehicles such as the Africa Partnership Station, African Endeavor, the DEIC program, the National Guard State Partnership Program, and the Humanitarian and Civic Assistance program to:

- Enhance capacity on land, at sea, and in the air; promote interoperability
- Provide medical and veterinary assistance; prepare for crisis response
- Plan and prepare for disaster relief

This is not an exhaustive list of the programs AFRICOM has utilized or of its engagement activities; rather, it is offered as an illustration of existing resources that can support AFRICOM efforts to prevent the destabilizing effects of climate change.

United States Special Operations Command has important engagement activities that can similarly incorporate climate change and disaster risk reduction considerations. This is particularly important given the implications of climate change effects for fragile state legitimacy and combating terrorism. United States Transportation Command will need to prepare to respond to disaster relief missions and also to supply forces in the Arctic as that mission evolves.

The ultimate objectives for each combatant command are to build the capacity to operate successfully in a climate-changed milieu and the capacity of host nation militaries to address climate change effects that threaten regional stability.

Findings on Combatant Command Roles, Responsibilities, and Capacities

Climate change and natural resource issues should be viewed as cross-cutting issues rather than predominantly the concern of the J4 (Logistics). Climate change will have impacts across the command to include; planning, logistics, training, and relationship-building with nations in the AOR.

An interagency approach is essential to addressing climate-change related topics as many of the themes are outside the mandate of DOD-specific responsibilities.

SOUTHCOM and AFRICOM offer useful models for addressing climate change-related issues. United States Pacific Command has opted to use its Partnership Office (J9) to lead on these issues. Whatever the approach, these issues cut across the J-staff structure.

The combatant commands need focal points in OSD and the Joint Staff.

Regional US military commands have managerial and technical expertise and access to resources, like transportation, necessary to support and, when appropriate, lead US and international efforts to ameliorate climate change threats to US national security.

There are resources outside those normally tapped by the combatant commands to help address climate change and disaster risk reduction themes, e.g., DOD's Minerva Initiative, engineering services, the National Guard, and OSD-run programs. For example, much of the US military civil affairs expertise resides in National Guard and reserve units.

RECOMMENDATIONS ON COMBATANT COMMAND ROLES, RESPONSIBILITIES, AND CAPACITIES

The geographic combatant commands should:

- Identify early warning indicators for those areas critical to DOD's mission set.
- Incorporate the guidance from the Quadrennial Defense Review and classified guidance to the combatant commanders on energy, security, and climate change into theater campaign plans.
- Create a demand signal by articulating the need to understand the implications of climate change and resource scarcities in their region to support their campaign plans.
- Include in their theater campaign plans energy, food, water, and disaster risk reduction strategies and plans for reducing vulnerabilities within their respective AORs.
- Harness more systematically resources beyond the traditional combatant command structure, to include the National Guard and its State Partnership Program, service engineering units such as USACE and Naval Facilities Command, and OSD-led programs such as DEIC and the Strategic Environmental Research and Development Program.
- Conduct systematic regional or even more localized impact assessments to identify trends and where their resources should be focused. To this end, each should request that the CIA's Climate Change and Security Center provide a report on climate change effects and hot spots in their respective areas of responsibility.

Programs such as the Strauss Center's program on Climate Change and African Political Stability, funded through DOD's Minerva Initiative, could also be utilized in such undertakings.

- Include as a Tier 1 objective enhancing the capacity of host nation militaries and civil response readiness groups to plan for, and respond to, natural disasters (e.g., floods, coastal storm surges, and droughts).
- Integrate into their humanitarian assistance/disaster relief and other exercise plans additional climate change-related aspects. These exercises should include interagency activity.
- Promote the concept of coordinated management of shared natural resources like water.

Appendix A

Climate Information System Needs

As introduced in Chapter 1, the current collection of observational and model assets while important for conducting exploratory climate science do not constitute a robust, sustained, or comprehensive resource for generating actionable climate forecasts. Developing adequate climate projections will require contributions from, and cooperation within, the US government of NOAA, NASA, US Geological Survey, and the Central Intelligence Agency; the Departments of Agriculture, Defense, Energy, and State; and others with climate, geographic, economic, social, and political skills. Since much of this expertise lies outside the government, universities, the private sector, and NGOs will also need to be involved. Understanding a climate-changed future will require the richest possible effort, encompassing the world's best expertise. As with any mystery¹⁴⁰ the most effective way to tackle understanding it may be to treat it, for the most part, as an open question, transparent to all engaged in its study. Compartmentalizing climate change impact research can only hinder progress.

Climate Change Risk Management

Effective planning and execution of climate change responses are primarily exercises in risk management. This is a process (Figure A-1) involving the collection and evaluation of information, quantification of uncertainties, evaluation of risks (likelihood and impact), and response options, decision-making, and iterative re-evaluation.¹⁴¹ Climate change risk management shares many of the information resources and decisionmaking

processes involved in other decision-making processes already employed by governments, businesses, and other organizations.¹⁴² It shares their limitations and also introduces additional challenges with implications on the supporting information resources:

- Increased climate and ecosystem variability and extremes
- Climate/ecosystem threshold crossing events or tipping points
- Coupling across multiple scales (teleconnections)
- Interaction between human response efforts

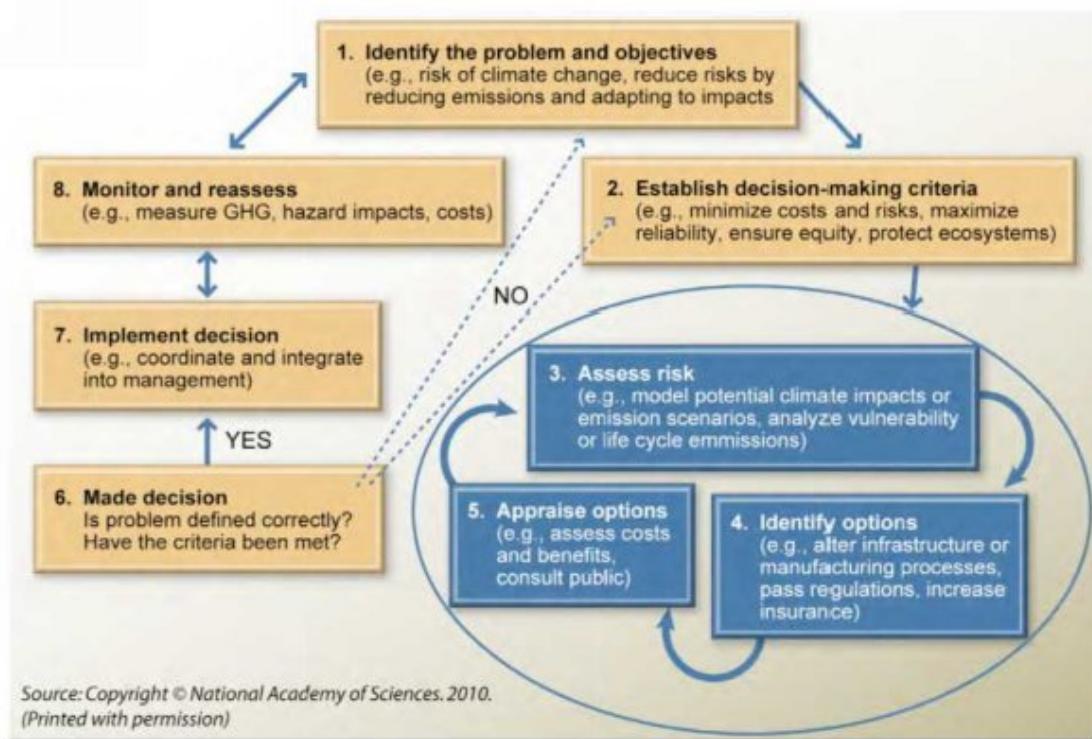


Figure A-1. The concept of an iterative, adaptive risk management process for climate change

In the absence of climate change, traditional risk management often relies on relatively steady-state assumptions with regards to environmental variability and extremes. Risk management for droughts, floods, hurricanes, and geohazards in most cases relies on information based on current observations and relatively recent historical trends from decades to centuries. The difficulty of managing risk for relatively mundane hazards was vividly demonstrated in the March 2011 events in Japan following a magnitude 9.0 earthquake, tsunami, and subsequent cascading failures of several nuclear reactors.¹⁴³ The potential of climate change to modify the steady background state and/or to significantly increase the frequency and intensity of climatic extremes such as heat waves, drought, heavy precipitation, storm surges, and tropical cyclones will likely stress the ability of existing information resources to accurately represent the distribution of those events. Climate change also introduces the possibility of abrupt, potentially irreversible threshold-crossing events or tipping points, in which the Earth's climate system undergoes a nonlinear response, essentially shifting into a qualitatively different and poorly characterized new stability regime,¹⁴⁴ a topic explored further in Appendix B. Special Topics.

Climate change involves direct coupling across a range of spatial and temporal scales that both overlaps and exceeds the boundaries of traditional risk management processes. Conventional risk assessment for tropical cyclones (hurricanes) and other severe weather currently leverages observations and models with global scope to produce local/regional scale forecasts and nowcasts. However, weather forecasts and supporting observations focus on timescales ranging from hours to days whereas climate forecaster projection time horizons span seasons to decades. Recent disasters such as the Eyjafjallajokull (2010) volcanic eruption, the Sumatra (2004) tsunamis, and Japan (2011) earthquakes offer stark reminders of the far-reaching impacts of localized and relatively short-lived events on global air transportation and coastal populations. However, such events are driven by geologic rather than climatic processes. Thus, risk management for them, to some extent, will remain invariant to future climate change.¹⁴⁵

The El Nino Southern Oscillation is a better example of a climate teleconnection, a strong, low-frequency (e.g., ~months) correlation with planetary scales. There are numerous examples in the literature indicating the presence and importance of such large-scale coupling mediated via ocean-atmosphere circulation and leading to remote-region impacts. These include tropical Pacific-North American patterns associated with ENSO, lower-frequency variations between the Pacific Ocean/ENSO, the Asian monsoon and/or Sahel rainfall, and the influence of the Indian Ocean on European/Atlantic climate.¹⁴⁶ Other teleconnections span the boundaries of geophysics and economics, such as CO₂ emissions embodied in international trade,¹⁴⁷ the lateral transport problem faced by carbon accounting systems with direct implications for the atmosphere and climate forcing.

Finally, the response space for climate change risk management is large, spanning mitigation (efforts to minimize climate change by stabilizing greenhouse gas emissions), adaptation (proactive and reactive efforts to minimize the societal impacts of climate change), geoengineering (a wildcard option described further in Appendix B), and acceptance (no action). Furthermore, the interactions between these response options are complex and uncertain, both in terms of decision-making (economic and policy considerations) and the effects on the Earth system.¹⁴⁸ For example, in the pan-tropics, public and private landowners are already forced to choose between preserving a stand of forest to receive a carbon offset credit under the United Nations program to Reduce Emissions from Deforestation and Forest Degradation versus planting biofuels versus planting grain for food, with implications on the carbon-cycle (contributing to climate change), ecosystems, watersheds, and agriculture.

In practice, given the wide range of decision makers and complexity of the supporting information, there will be no one-size-fits-all climate change risk management system. A notional framework for climate change risk management in Figure A-2 is introduced to offer some context from a US government perspective for the following evaluation of information systems and related processes. The framework is grounded in various information systems which offer input to assessment processes.

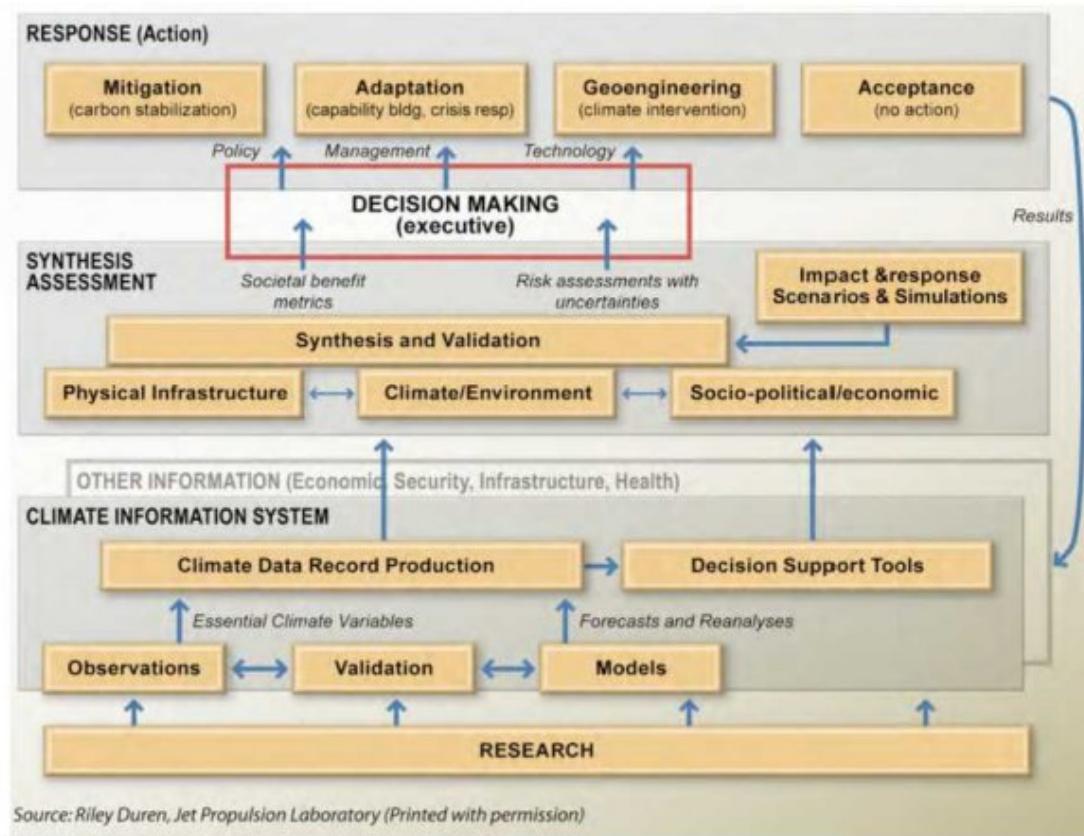


Figure A-2: Notional framework for implementing climate change risk management

The climate information system would use a combination of sustained observations and models to monitor, forecast, and reanalyze data associated with essential climate variables. A rigorous validation function will be essential to quantifying uncertainties and managing errors. Climate data records, including trends, will be produced, archived, and disseminated. Decision support tools present climate data in formats amenable to interpretation by non-climate scientists and risk assessors. The foundation for, but to some degree separate from, the operational climate information system is a research element that remains flexible to discovery and ensures that the latest understanding of climate processes is infused into operational information. The research program will contribute to, and benefit from, the outputs of the climate information system.

Synthesis assessment is a collaborative multidisciplinary process by which subject matter experts in the natural sciences, social sciences, economics, and policy translate the outputs from climate and other information systems into societal benefit metrics and actionable information for decision makers. Synthesis assessment includes the generation and simulation of scenarios to help evaluate risks spanning the option-space of response actions which are mitigation, adaptation, geoengineering or non-action which is acceptance. In some other frameworks, synthesis assessment is treated as a component of a climate information system but is presented separately here to emphasize the need to infuse non-climate information into the assessment process.

The decision-making executive function integrates the knowledge provided by the information systems and assessment process and takes action in the form of policy, management, deployment of technology, and other resources. Ideally, this executive function would serve as the overarching director and integrator of the climate change risk management framework. In a well-constructed risk management framework, the information systems and assessment function would receive requirements from the decision-making executive, starting with well-posed questions about the range of possible responses flowing down to what information is needed to support risk assessment.

Some potential contributing factors and consequences are described in the following sections.

Findings on Risk Management

Effective climate information systems will need to identify changes in the distribution of extreme events driven by changing climate, including updated likelihoods, impacts, and uncertainties and provide for frequent reassessment.

Risk management frameworks that have traditionally relied on relatively static or weak global connections will be challenged in the future to quantify climate driven changes in the modes of variability and strength of geophysical and socioeconomic teleconnections spanning the Earth.

Information systems and assessment processes need to enumerate and quantify the potential interactions across and between response options towards understanding the risks and benefits of taking a given action.

While there are related efforts underway by various organizations such as NOAA and the US Global Change Research Program (USGCRP), no systematic effort to define requirements, architecture, and implementation plan for a climate risk management framework and supporting information systems and assessment process has been completed by the US government or other entities.

In the absence of a focused effort to understand key needs, an infusion of new funding to develop a truly operational climate information system, and a mandate to address regions outside the United States, the tentative NOAA Climate Service and related programs may prove insufficient to meet risk management needs.

Climate Information Systems

Attributes of an operational climate information system include, but are not limited, to:

- Reliable, sustained climate data production over decades, including observations, state-of-the-art Earth system models, and advanced data assimilation processes
- Minimal gaps in data collection and minimal service interruptions
- Provide a clearinghouse of data records associated with essential climate variables
- Provide data records with global coverage and policy-relevant spatial-temporal resolution at all governance scales, from nations to individual landowners
- Latency of climate data record production consistent with decision maker time lines
- Decision support tools to enable synthesis assessment and translation of climate data records into societal benefit metrics
- Relentless attention to uncertainty quantification, calibration, and validation of data
- Transparency and reproducibility of observational data, models, and decision support tools and analysis
- Expert scientific interpretation and support for assessors and end users
- Sustained support for ongoing climate research
- Flexibility to respond to lessons learned from research, including coordination with non-operational, research-driven observations

Approaches for implementing a national Climate Information System or climate service in the United States has been a topic of discussion within the scientific community for some years.¹⁴⁹ The USGCRP, World Meteorological Organization (WMO), and Group on Earth Observations are principal leaders in identifying the needs and implementation options for climate services and related observational systems.¹⁵⁰ NOAA has aggressively worked to establish a National Climate Service for the United States.¹⁵¹¹⁵² To date, the NOAA Climate Service effort has largely focused on reorganizing the agency to align existing NOAA observational systems, data centers, line offices, laboratories, six Regional Climate Centers, and nine Regional Integrated Science and Assessment Centers under a single entity.¹⁵³ The US Department of Interior has independently established eight Climate Science Centers¹⁵⁴ that have some overlap with NOAA's regional centers. The NOAA Climate Service concept builds on the resources of the operational National Weather Service and also seeks to incorporate information from the broader community (e.g., USGCRP agencies such as NASA, Department of Interior/USGS, Department of Energy, National Science Foundation, and the United States Department of Agriculture.

Since the limitations in current climate observations and models were described in Chapter 1, the remainder of this section focuses on the other key elements of a climate information system and related processes.

Validation and uncertainty quantification

Assessment efforts such as the IPCC process, as introduced in Chapter 1 of this report, provide a critical scientific resource for climate change understanding and assessment as well as for potentially informing economic and political decision-making. A central element of these Assessment Reports is the climate model projections embedded in the Working Group I report(s) and indirectly in the impacts/adaptation and mitigation Working Group II and III reports. These quantitative projections are based on dynamical, multi-component, coupled global climate models (GCMs), now often referred to as Earth system models as they become more comprehensive (e.g., including the carbon cycle). Global observations have long been essential for providing resources for model development and validation (e.g., Tropical Rainfall Measuring Mission (TRMM) precipitation, Earth Radiation Budget Experiment/Clouds and the Earth's Radiant Energy Systems radiation budget, International Satellite Cloud Climatology Project cloud cover, and SSM/I water vapor). In the context of IPCC, such observations are becoming essential as a means for quantifying the uncertainties associated with these climate change projections. In fact, the rather new and informal research and development activities associated with model metrics for GCMs is moving toward more formal development and application of metrics and skill scores which can be, and are being, explored for use for quantitative weighting of an ensemble of model projections.

Figures A-3 and A-4 show results from two recent examinations of GCM fidelity based on Coupled Model Intercomparison Project (CMIP) GCM climate simulation archives. These studies are two of the first¹⁵⁵ that attempted to systematically and quantitatively score GCM fidelity across the CMIP archive(s) and across a number of quantities/processes. These attempts, and their further refinements, are crucial for quantitative weighting of future climate projections (e.g., projections from poorer performing models for the observed climate would be given less weight). Figure A-3 shows an example of a portrait diagram from Gleckler et al.¹⁵⁶

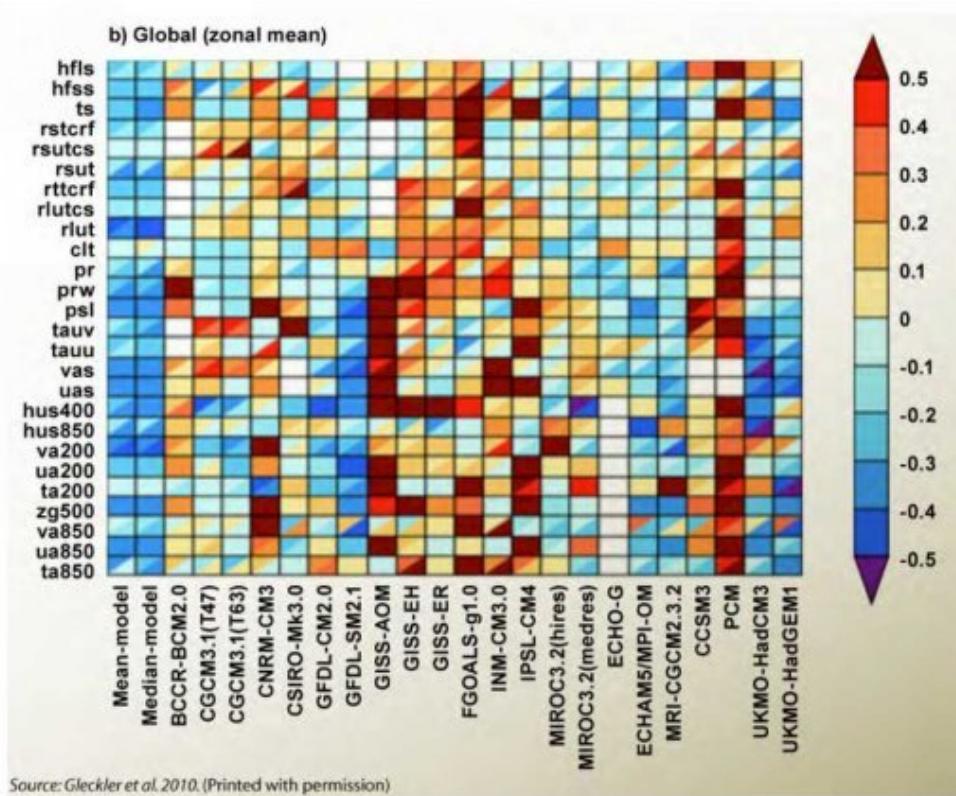


Figure A-3. Portrait diagram display of relative error metrics for 20th century CMIP3 annual cycle, climatology (1980–1999) for zonal mean (with bias removed)¹⁵⁷

The portrait diagram illustrates GCM fidelity measures for representing the recent climate based on observations and the CMIP3 model archive for the 20th century GCM simulations, and on the utilization of a given metric, in this case, a relative root mean square difference in the annual cycle of the zonal mean of a number of quantities. Note blue colors indicate the model performs better than the typical model in the entire group, and the two left columns indicate that an ensemble-mean of the models performs better than any given single model.

For both of these cases, the observations are based on a number of reanalysis products and a few satellite quantities. The latter includes the satellite data based on Global Precipitation Climatology Project (GPCP)/Climate Prediction Center Merged Analysis of Precipitation for rainfall, International Satellite Cloud Climatology Project for total cloud cover, NASA Water Vapor Project for precipitable water, and Earth Radiation Budget Experiment/Clouds and the Earth's Radiant Energy Systems for shortwave and long wave radiation products. Note however, the wealth of global satellite data products that are going unutilized in such evaluations, including most of the Earth Observation System and A-Train platforms and instruments (e.g., Terra, Aqua, Aura), as well complementary Earth Science platforms such as GRACE, TOPEX/JASON-1/Ocean Surface Topography Mission, and the suite of ocean vector wind products.

Figure A-4 shows results from Reichler and Kim¹⁵⁸ who utilized observation-based metrics to examine and characterize the degree that models as a whole have improved in skill over time. They applied a rather simple metric based on the annual mean climatology and over a number of variables to the suite of model simulations that made up the (~1991) CMIP1, (~1998) CMIP2, and (-2005) CMIP3 model archives. In this case, there is a clear illustration that application of a consistent set of metrics to a multigenerational set of models indicates increased model fidelity over the last two decades. As with the Gleckler et al. study, the direct information from satellite observations is extremely limited given the breadth of available observations and only involves, in this case,

precipitation, cloud cover, sea ice, sea surface temperature, and the indirect inputs to model-influenced reanalysis quantities.

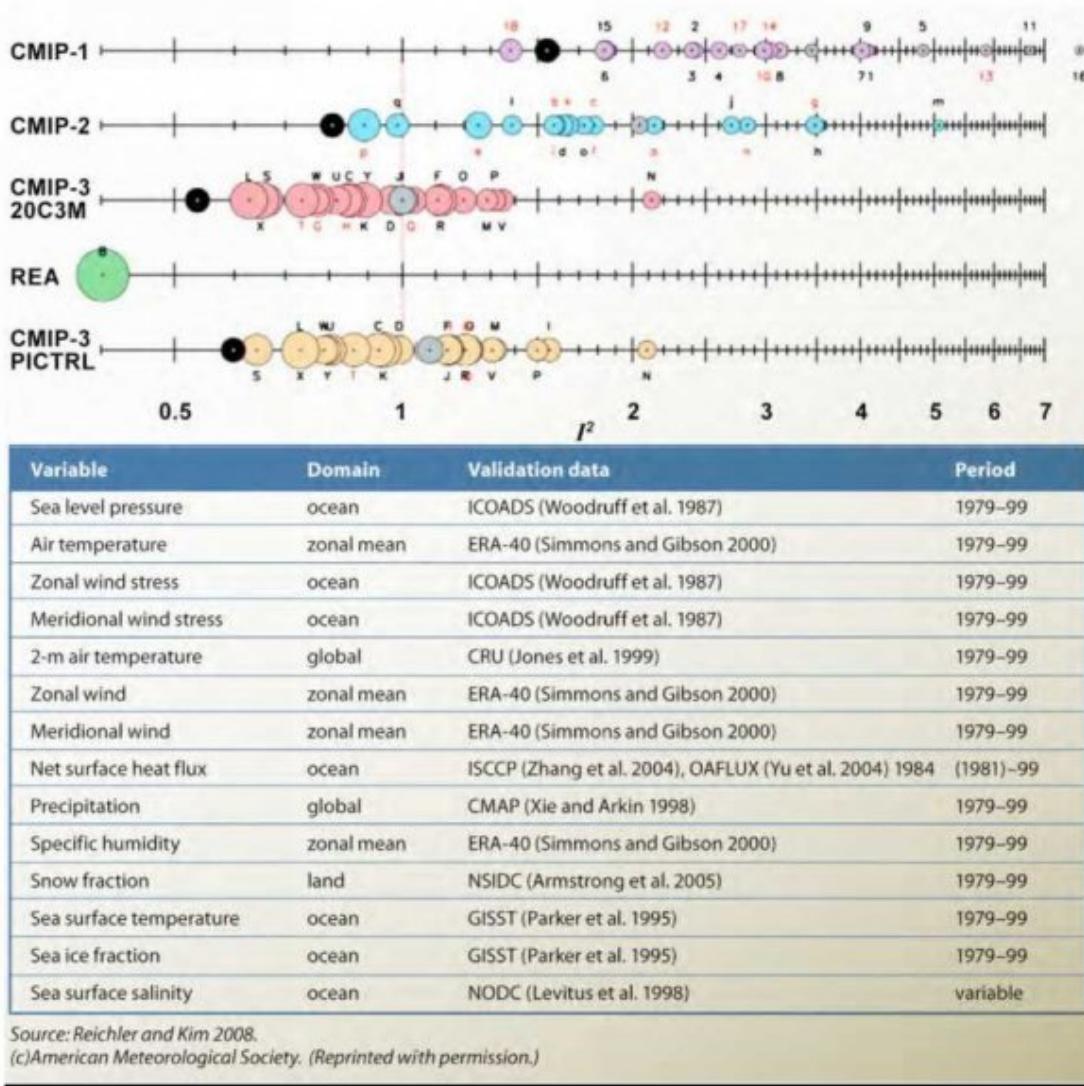


Figure A-4. Performance index I^2 for individual models (circles) and model generations (rows)¹⁵⁹

The utility of observations, particularly satellite observations, cannot be overstated for their use in model development and evaluation. Figure A-5 shows results of an analysis of 20th century CMIP3 model output adapted from Waliser et al. 160 that illustrates inter-model agreement in long-term annual and global mean values of the four quantities: precipitation, precipitable water, cloud fraction, and integrated cloud ice water path. Notable is that the inter-model agreement between precipitation, precipitable water, and cloud fraction is relatively good. These quantities have relatively long-lived (since late 1980s or before) global satellite records for which model development and evaluation have been able to constantly utilize (e.g., TRMM, GPCP, the Climate Prediction Center's Merged Analysis of Precipitation for rainfall; SSM/I, NASA Water Vapor Project for precipitable water; International Satellite Cloud Climatology Project for cloud fraction). In contrast, the inter-model agreement for the ice water path is quite poor. Even when the greatest outliers are removed, there is still a factor of six between the remaining largest and smallest modeled values. Fortunately, in the case of ice water path, more robust retrievals

have become available with the advent of CloudSat, and these large model uncertainties are expected to greatly improve.¹⁶¹

Given the role that GCMs and their simulations and projections play in the IPCC process, not only to the science of climate change but also possibly to decision support associated with some of the most socially-important impacts of global climate change, it is imperative to consider the above finding(s) more earnestly, and to define and take steps to develop and explore the use of more formal metrics and validation procedures in order to gauge the fidelity of the GCMs that contribute to synthesis assessments, such as IPCC.

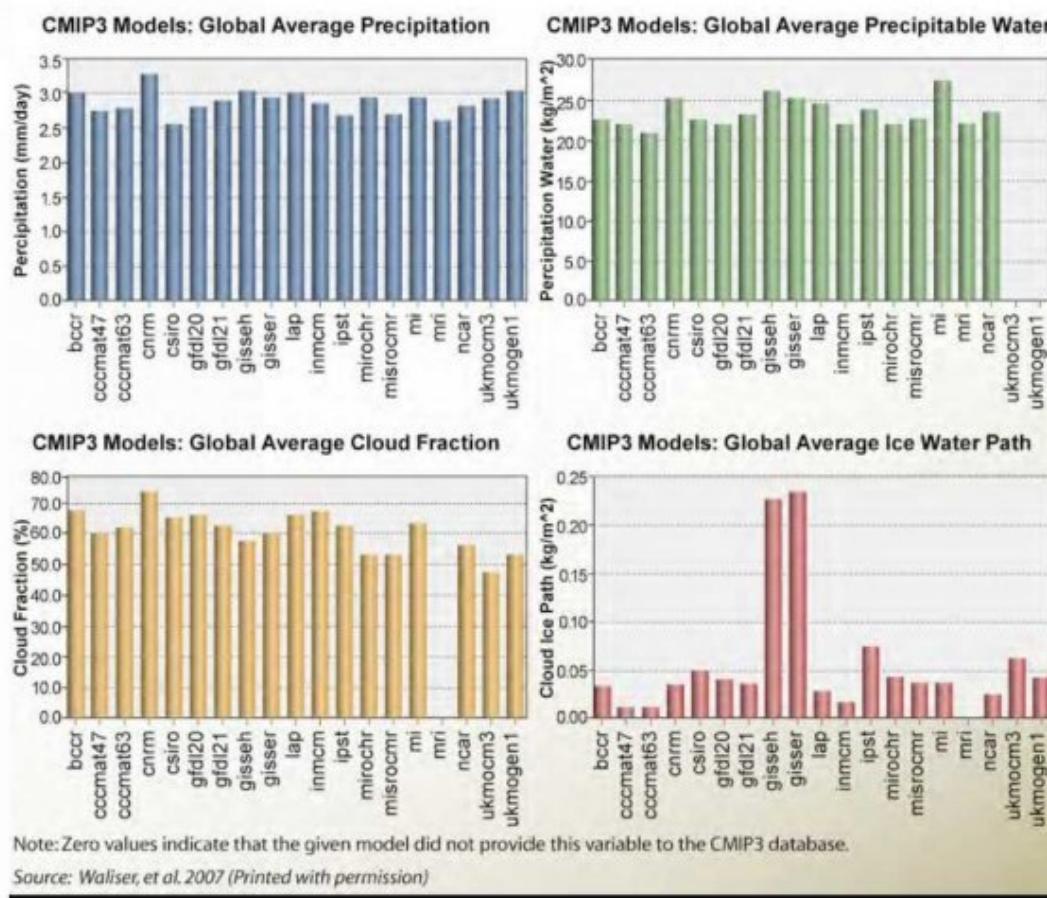


Figure A-5. Globally-averaged, annual mean values of hydrological quantities from the 1970–1994 period of the 20th century atmosphere-ocean coupled simulations assessed in the IPCC AR4

For example, the numerical weather prediction community routinely uses metrics to provide a uniform and quantitative methodology to evaluate models and their projections and track their improvement over time, with results openly published by the WMO. To date there is no analogue in the climate modeling community. To address this, the Working Group on Numerical Experimentation and the Working Group on Coupled Modeling with sponsorship from WMO's World Climate Research Program have jointly formed a Climate Metrics Panel. From 2010-2011, the task force was active in developing a proposal to start identifying and applying a set of metrics to climate model results with a particular near-term objective, CMIP5. The main questions that are motivating the use of routine climate metrics: Are climate models improving? If they are improving, then how rapid is the improvement? Which are more realistic?

Additionally, it is hoped that a diversity of routine metrics will provide useful summaries of overall model performance. Such metrics will in turn be useful to explore as a means to objectively weight the ensembles of climate projections provided as part of CMIP5 (e.g., for one greenhouse gas scenario, approximately twenty GCMs and possibly five ensemble members ~ one hundred). Note that similar considerations and metrics need to be developed for regional climate models that are routinely used for dynamical downscaling to scales more relevant to local and regional decision support.

Despite a growing body of models, two broad issues remain in their effective application to climate risk assessment: 1) model validation and scoring are needed so that when assessors evaluate the outputs of multiple models offering projections for a given region, they have some objective way of weeding out and/or weighting projections; and, 2) the lack of capacity of decision makers to effectively interpret and use the information.

The application of global satellite products to model development and evaluation leads to models that have more fidelity at representing the observed climate record.

The development and application of observation-based metrics provide a formal and uniform methodology to evaluate models, track their improvement over time, and potentially provide objective, skill-dependent weighting of their predictions and projections. This statement is already clearly demonstrated by the numerical weather prediction community.

A significant portion of NASA and other agency satellite data is being underutilized for model development and evaluation and, particularly, for use as observation-based climate model metrics.

Many processes within climate models could be better understood and modeled if new observational resources were made available.

Climate Data Record Production

In order to produce operational climate data records, significant effort is required to accumulate data associated with ECVs, rigorously quantify uncertainties, apply calibration corrections, and transform time-series of data into trends. Additionally, calibrated data can be rectified and presented as geolocated maps indicating the spatial and temporal distributions and evolutions of selected parameters.

To support transparency and reproducibility, these observational data sets must be accompanied by extensive metadata covering details on the sensing instrumentation, algorithms employed to retrieve geophysical parameters from the raw data, calibration curves, etc. Maintaining an archive and clearinghouse for these data including expert interpretation and support for users is a major component of any climate information system. NOAA's existing National Climatic Data Center, National Oceanic Data Center, and National Geophysical Data Center are several such assets and form the core of the NOAA Climate Service.

NASA's Earth Observing System Data and Information System manages and distributes data products through the Distributed Active Archive Centers¹⁶² spanning twenty-eight categories of ECVs covering the atmosphere, oceans, and land surface.

USGS's Earth Observations and Science Center¹⁶³ provides access to climate-relevant information including carbon cycle, drought, vegetation monitoring, land cover/land use, fire, wildlife impacts, and topography.

In terms of model outputs, in addition to the above outlets, various organizations and programs such as the IPCC¹⁶⁴ and the Program for Climate Model Diagnosis and Intercomparison¹⁶⁵ offer the results of individual and ensemble model simulations and projections.

In terms of the above data resources, data measurement, and archiving strategies, few efforts have systematically optimized observation formats, archives, and dissemination strategies for the specific use of climate model evaluation and improvement.

Decision support tools

The availability of robust climate data records, trends, and spatially resolved distributions of essential climate variables alone is not sufficient to support accurate assessment of climate change risks and decisionmaking. The concept of decision support tools recognizes the need for applications that help bridge the gap between climate science and societal benefit areas.

Climate decision support tools are funded and produced by government agencies (both research and operational entities), think-tanks, academia, aid organizations, and private industry.

In the framework of this report, decision support tools are treated as part of climate information systems which are arguably the best home for such capabilities. The following examples offer a noncomprehensive illustration of the scope and functions of several existing climate-relevant decision support tools.

The National Integrated Drought Information System¹⁶⁶ is managed by NOAA with support from other agencies and designed for the United States only to:

- Provide early warning about emerging and anticipated droughts
- Assimilate and quality control data about droughts and models
- Provide information about risk and impact of droughts to different agencies and stakeholders
- Provide information about past droughts for comparison and to understand current conditions
- Explain how to plan for, and manage, the impacts of droughts
- Provide a forum for different stakeholders to discuss drought-related issues

The Famine Early Warning System Network (FEWS NET) is a USAID-funded activity implemented by a partnership between USGS, NASA, NOAA, US Department of Agriculture, and Chemonics International, Inc. FEWS NET collaborates with international, regional, and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. FEWS NET has regional centers in Central Asia; the Caribbean; Central America; Eastern, Southern, and Western Africa; and the Middle East.¹⁶⁷

The Foreign Agricultural Service's Crop Explorer¹⁶⁸ features near-realtime global crop condition information based on the satellite imagery and weather data processed by the Production Estimates and Crop Assessment Division. The primary mission of this division is to produce the most objective and accurate assessment of the global agricultural production outlook and the conditions affecting food security in the world. Regional analysts use a Geographic Information System to collect market intelligence and forecast reliable global production numbers for grains, oil seeds, and cotton. Thematic maps of major crop growing regions are updated every ten days to depict the latest statistics pertaining to vegetative vigor, precipitation, temperature, and soil moisture. Time-series charts depict current and historical growing season data for specific agro-meteorological zones. Regional crop calendars and crop area maps are also available for selected regions.

The Regional Visualization and Monitoring System initiative, a USAID-funded activity implemented by NASA in collaboration with regional partners in Central America, Africa, and Central Asia, integrates satellite observations, ground-based data, and forecast models to monitor and forecast environmental changes and to improve response to natural disasters.¹⁶⁹

One feature common in many climate decision support tools is visualization, particularly the application of Geographic Information System techniques. The concept of risk mapping is frequently employed in focusing vulnerability assets in regions such as Africa.¹⁷⁰ In fact, most of the briefings given to this task force over the

course of the study presented a large number of maps constructed with Geographic Information System tools illustrating climate impacts and vulnerabilities of various regions. While the motivation for spatially resolved visualization is understandable, some caution in their interpretation is warranted. Most Geographic Information System tools employ one or more observational data sets and/or model outputs to visualization. This information is not necessarily applied consistently (e.g., as layers or as merged data sets) and significant errors can exist, both in terms of registering data to a given grid and in terms of differences between underlying data sets. Methods for representing and interpreting uncertainty or errors in Geographic Information System products are by no means consistent or widespread. Hence, there exists a risk of mixing gray data, data lacking verifiable pedigree or quantified uncertainties, with high reliability information.

The potential for policy getting ahead of the science is a topic of some concern within the scientific community. At the same time, it is recognized that decision makers cannot wait for zero uncertainty.

Findings on Climate Record Data Production

Despite the wealth of information available from multiple organizations there currently is no single clearing-house for climate data records and associated model outputs, nor identification or arbitration of discrepancies between them.

As with climate information systems writ large, there is no standard set of decision support tools or even standards for how they are designed, implemented, and used, nor are there conventions on who produces them.

There is a potential for well-presented but inaccurate gray data associated with Geographic Information System products to receive higher weighting by risk assessors than other, less intuitive, but more accurate information.

Information products used in climate assessment processes are often not accompanied by clearly marked quantitative uncertainty estimates to ensure appropriate weighting by decision makers.

Overarching Barriers for Climate Information Systems

In addition to issues with specific elements of climate information systems, there are several overarching barriers to deploying a robust, operational capability principally associated with:

- Funding priorities place an inordinate weight on control over knowledge
- US climate services focused on the United States, not international needs
- Inactive research to operations pathway for climate information
- Limited capacity in developing countries for information systems

Funding for climate information systems and synthesis assessment (knowledge), receives a small fraction of funding available for response actions (control). For example, only 0.4 percent of the African Development Bank's current adaptation budget (\$45 million out of \$5.9 billion) is allocated to knowledge and competency building.¹⁷¹ In the United States, the funding spread across NASA, NOAA, USGS, Department of Energy, National Science Foundation, Department of Agriculture, and other agencies for 2007-2009 allocated to research associated with adaption and mitigation was approximately 25 percent, or \$300 million per year, of the ~\$1.2 billion total USGCRP budget¹⁷² However, this again represents the climate information (knowledge) component of climate change risk management, not the response (control) aspect Risk managers have noted the need to create "well-designed and adequately resourced feedback loops to effectively incorporate new data and advancements in scientific understanding and support continual refinement and validation of analyses, impact projections, and effective response mechanisms."¹⁷³

This finding and the need to increase efforts to offer a broader global focus relevant to the needs of the defense, diplomacy, and development agencies was also noted in the recent progress report of the US Interagency Climate Change Adaptation Task Force.¹⁷⁴

A research to operations process has been employed for decades to develop and transfer scientific information systems from an exploratory science mode into operational capabilities. Research agencies such as NASA, the national laboratories, and their partners in academia serve as pathfinders for research and development of instrumentation, data products, and models that are gradually (over a decade or more for a given ECV) transferred into an operational environment by agencies such as NOAA or USGS driven by strategic planning. It is not clear if the US government is on such a path for a climate information system. The practical planning window for these agencies is roughly ten years, and the current horizon regarding climate observations is roughly 2020.

A fair concern often expressed in considering operational climate services is the need to remain flexible to discovery. The key point here is recognition of the need to start such a process.

Currently, efforts to address this gap are limited to projects funded by USAID, such as NASA's Regional Visualization and Monitoring System. These pilot efforts offer good test particles for the deployment of climate information products, technical infrastructure, and training in developing countries but are still limited in the scope, funding, and breadth of US science and technical capability employed. The Interagency Climate Change Adaptation Task Force recognized the same need and made the following recommendation: "Develop a Government-wide strategy to support multilateral and bilateral adaptation activities and integrate adaptation into relevant U.S. foreign assistance programs."¹⁷⁵

Synthesis assessment

The outputs of climate information systems and other information systems must be integrated and treated to synthesis assessment in order to translate biogeophysical data into metrics relevant to water, food, shelter, energy, security, health, and other societal impact areas. This requires the application of an interdisciplinary approach involving the physical sciences, social sciences, economics, and policy. Beyond studying current and past climate data and other data sets, synthesis assessment benefits from defining impact and response scenarios and running simulations to evaluate potential outcomes and risks.

The IPCC offers perhaps the best known example of synthesis assessment for climate change. Four IPCC assessment reports have been released to date: 1990, 1995, 2001, and 2007. The fifth assessment is currently underway and scheduled for publication in early 2015, with a goal of releasing an advanced copy by late 2014.

The process and time line for generating the IPCC synthesis assessments are illustrated in Figure A-6. Unlike an operational climate change risk management framework in which climate and other information systems produce sustained, operational inputs to a synthesis assessment function, the IPCC process is strictly limited to considering only information available in the peer-reviewed scientific literature at given cut-off dates. This is intended to maximize the credibility of the foundational information applied in the assessment. This requirement is both necessary and presents a risk for decision makers. On the one hand, a deliberative process to ensure that the climate information presented is scientifically robust is not amenable to rushing. The peer-review process is important. On the other hand, there is significant latency and perhaps major gaps in knowledge associated with a process strictly limited to peer-reviewed journal articles. Additionally, as illustrated, the IPCC assessment report must be reviewed and approved by a large number of governments prior to release. The risk here is that vital and relevant climate information can be discarded, leaving with the end-result being a diluted version of the complete story.

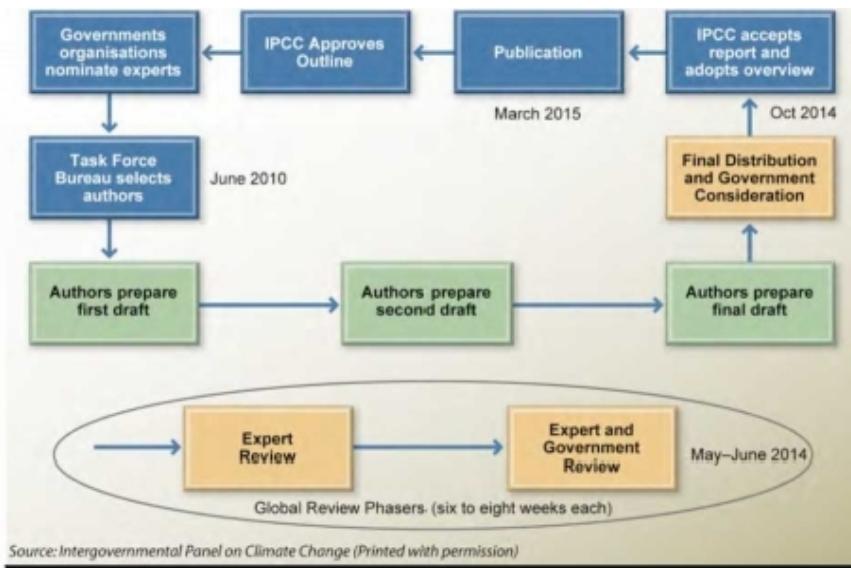


Figure A-6. IPCC Fifth Assessment process and timeline

The USGCRP is required under the Global Change Research Act of 1990 to provide a National Climate Assessment report every four years that includes an analysis of the effects of global change on natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity.¹⁷⁶ It also analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent twenty-five to one hundred years. So far, two such national assessments have been produced, one in 2000, the other in 2009. The next assessment is due in 2013 and will differ from the previous assessments by being "more focused on evaluating the Nation's progress in adaptation and mitigation building a long-term, consistent process for evaluation of climate-related risks and opportunities, including a national set of indicators of change; providing information that supports decision-making processes within regions and sectors of the United States; and evaluating the current state of scientific knowledge relative to climate impacts and trends."¹⁷⁷ Unlike the IPCC assessments, the USGCRP national assessment, other than noting global climate trends, is limited in scope to the United States. While the national assessment allows a deeper focus on regional and local issues in United States than the IPCC assessment, to a large extent, it does not address international issues.

Recently, synthesis assessments focused on specific priority areas have been conducted by organizations in the United States. Examples include the Environmental Indications and Warnings (EIW) Project implemented by the CIA Center on Climate Change and National Security, conducted under the auspices of the Measurements of Earth Data for Environmental Analysis program. The EIW seeks to monitor environmental stresses influenced by climate, using measurements and modeling of security indicators descriptive of the coupled human-environmental system. Initially, the focus of the EIW project is on freshwater availability, ultimately offering global coverage and sub-national resolution with monthly updates on forward projections. The EIW assessment includes a synthesis of climatic stresses (specific anomalies such as temperature, precipitation, soil moisture, and river flow), environmental factors (bio/geo/hydrosphere), socioeconomic and political factors to identify and risk-rate water resource hot spots.

Another example of a focused assessment includes a risk analysis by the Department of Energy's Sandia National Laboratories that assembled IPCC climate model ensemble projections for temperature and precipitation, used a hydrologic model to map those projections to future water availability and water production, then applied a macroeconomic model to estimate the potential economic consequences for the United States as a whole and individual states for the period 2010-2050.¹⁷⁸

The need for improved collection and integration of multiple information types (climate, economic, security, demographics, health, and other indicators) cannot be overstated. Figure A-7 illustrates the results of a synthesis analysis by Meier et al. that combined climatic data (precipitation) and other information (human deaths

and livestock losses) attributed to increasing conflict in the form of cattle raids in Uganda during the period of peak water stress before the start of the wet season.¹⁷⁹

This need is supported by the following recommendation from the National Research Council report, Informing Decisions in a Changing Climate. The "federal government [should] 'expand and maintain national observation systems to provide information needed for climate decision support. These systems should link existing data on physical, ecological, social, economic, and health variables to each other and develop new data and key indicators as needed' for estimating climate change vulnerabilities and informing responses intended to limit and adapt to climate change."¹⁸⁰

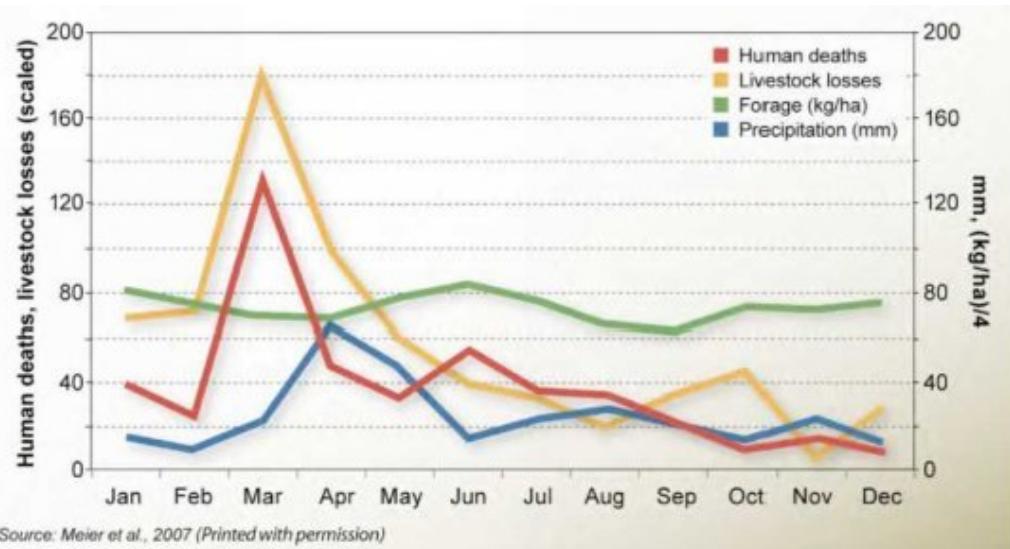


Figure A-7. Conflict impact and precipitation levels for Ugandan Karamojan

A complete and robust climate change risk management framework requires a reliable, sustained, and timely synthesis assessment component. The Interagency Climate Change Adaptation Task Force¹⁸¹ recognized this point and offers the following specific recommendations to:

- Develop scenarios within a range of climate change outcomes at spatial and temporal scales necessary to inform impact assessment and adaptive action
- Create user-friendly methods for assessing climate impacts, vulnerability, and risk, including models and tools to assess the environmental, social, and economic outcomes of alternative adaptation actions
- Provide guidance on the use and suitability of downscaled global climate model outputs
- Conduct frequent updates of regional characterizations and assessments of climate, including climate-driven variables (e.g., stream flow, flood, and drought)
- Expand research on relevant social and behavioral sciences to improve understanding of human responses to change
- Identify the social and ecological tipping points and thresholds (beyond which change is sudden and potentially irreversible) to help guide decisions regarding intervention and planning

- Develop methods and processes for identifying, defining, and managing for extremes, including low-probability, high-impact events
- Analyze climate change impacts in the context of multiple stressors and interacting systems (e.g., interactions of climate and air quality on human health in metropolitan areas)

It remains to be seen to what extent these recommendations will be implemented such that a synthesis capability, meeting the needs of the Department of Defense, will be available in the future.

Decision-making and integration

Effective climate change risk management depends both on the quality of the available knowledge (climate information systems and synthesis assessment process) and the process used to manage control and responses (decision-making). Climate change risk management introduces challenges that build on those encountered in more traditional decisionmaking. These challenges include fundamental uncertainties in climate information, the need to consider many low-likelihood, high impact risks, and the complexity and risk of competing action associated with asynchronous responses from a large number of management entities both in the United States and internationally.

Given the significant gaps in scientific understanding of climate change, it is likely that policy-relevant climate information systems may take a decade or more to deploy. In the meantime, risk managers are confronted with the need to move forward in the face of uncertainty.

As noted in a 2010 report by Sandia National Laboratories: "An imprecise prediction can be useful for comparing options to address a significant problem if we assume that such a prediction adequately defines the future relative to the choices to be made and, more importantly, represents a mutually agreed upon basis from which stakeholders can debate alternatives on common ground."¹⁸²

The treatment of low probability, very high impact risks whose probability density functions exhibit long tails is an area of concern for risk managers. Climate change presents a potentially large phase space of scenarios with the potential for far greater and more widespread impacts with arguably comparable likelihoods but with relatively poorly understood response options (Appendix B). This presents a challenge for risk management processes that probably warrant further study to enumerate specific gaps and mitigations.

The other barrier to effective decision-making in this arena is the size of the potential response space and the number of organizations involved in evaluating risk and taking action. In the United States alone, there are approximately ten agencies associated primarily with the generation of knowledge/information and at least fifteen associated with control/action, plus a few that overlap. The present lack of any overarching framework for coordination and integration represents a risk of asynchronous actions. Some potential barriers include:

- Challenges for interagency cooperation and coordination
- Interagency coordinating organizations such as the President's Office of Science and Technology Policy, USGCRP, USGEO, and the Interagency Adaptation Task Force not acting as delivering organizations, many relying on contributed efforts by many agencies which is an inefficient process
- Intra-agency issues such as conflicting visions within large departments and agencies, competition for funding, and a wariness of unfunded or underfunded mandates
- Lack of direct cabinet level representation from agencies responsible for delivering climate information systems (e.g., NASA, NOAA, USGS)
- Lack of an empowered integrated decision-making body; no climate equivalent of the National Security Council

The interagency adaptation working group had a similar finding:

Many programs across the Federal Government produce science that informs and supports climate change adaptation decision-making. Many of these efforts occur through the agencies of the USGCRP, while others have emerged in resource management or community development programs through agencies that have not historically focused on climate change. Currently, most of these activities are occurring independently of one another, leading to gaps and redundancies. These efforts would benefit from enhanced coordination on science at the Federal level, through agencies working together more closely to leverage existing capabilities. Coordination would help federally sponsored science identify, understand, and meet the needs of decision makers implementing adaptation strategies on the ground. The new Adaptation Science and Research Element within the USGCRP should develop a 'roadmap' that identifies existing adaptation science and service capabilities and gaps across Federally-sponsored programs. 183

Findings on Overarching Barriers for Climate Information Systems

Currently, climate observations, regional-scale models, decision-support tools, and synthesis assessments by the USGCRP and particularly by the NOAA and USGS contributions are primarily focused on the United States rather than an international perspective.

There remain many uncertainties in basic climate process understanding that present barriers to specifying an optimal, sustained information system with confidence, suggesting that an iterative or spiral development approach will be required.

There is limited scientific and technical capacity in the developing world to develop and maintain climate information systems.

The IPCC assessment process, while rigorous and comprehensive, suffers from latency and potentially, from the diluting influence of multinational politics on the ultimate findings.

Absent a focused effort to leverage and augment the IPCC and USGCRP assessment efforts, there exists a significant risk the synthesis assessment needs will not be met.

There is not a systematic effort to quantify and recognize the uncertainties embodied in climate and other information resources and the range of potential response options; this effort must be done consistently across a wide-range of decision-making organizations in such a way as to provide a level playing field for risk assessment and to ensure responses are harmonized.

Summary

Various organizations in the United States are working to address the general need for improved information to support climate change risk management. The USGCRP is currently undergoing a restructuring activity intended to improve its capability to support the climate change response efforts.184 The Climate Change Adaptation Interagency Task Force has broad participation of federal agencies and has identified numerous areas for improvement, including some relevant to the needs of DOD and other agencies concerned with international threats.185 NOAA and other individual agencies continue efforts to improve the relevance of their information to climate change risk management and decision-making.

Nevertheless, neither the needs of DOD for climate information systems and assessment processes, nor the gaps relative to current capabilities and planned future capabilities have been rigorously studied to date. Likewise, many of the overarching barriers identified here, and in other studies, are unlikely to be resolved without more attention.

Appendix B

Special Topics

This appendix elaborates on several wild card topics, each of which have the potential for placing additional demands on climate information systems and risk assessment processes beyond those discussed earlier.

Tipping Points

The term "tipping point" commonly refers to a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system; the term "tipping element" has been used to describe large-scale components of the Earth system that may pass a tipping point.¹⁸⁶ Figure B-1 illustrates potential large-scale tipping elements, ranging from changes in ENSO amplitude and frequency, to rapid loss of Arctic sea ice or key ice sheets (Greenland and Antarctica), to major biosphere perturbations in the Sahara, Amazon, and Boreal regions, each with significant global reach through teleconnections and potential instability due to positive feedbacks.

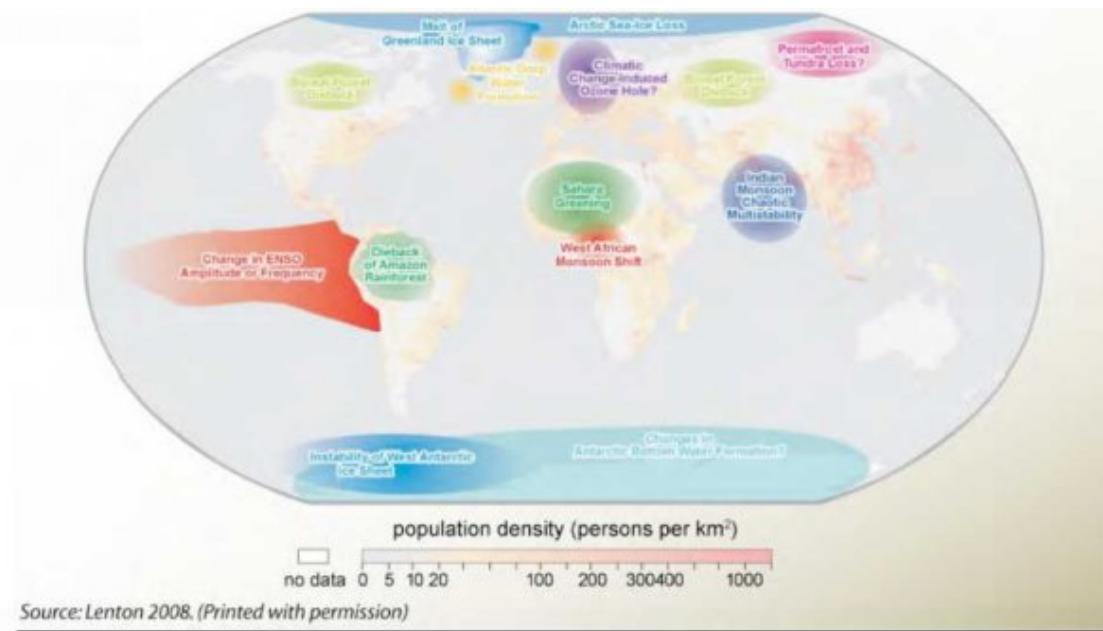


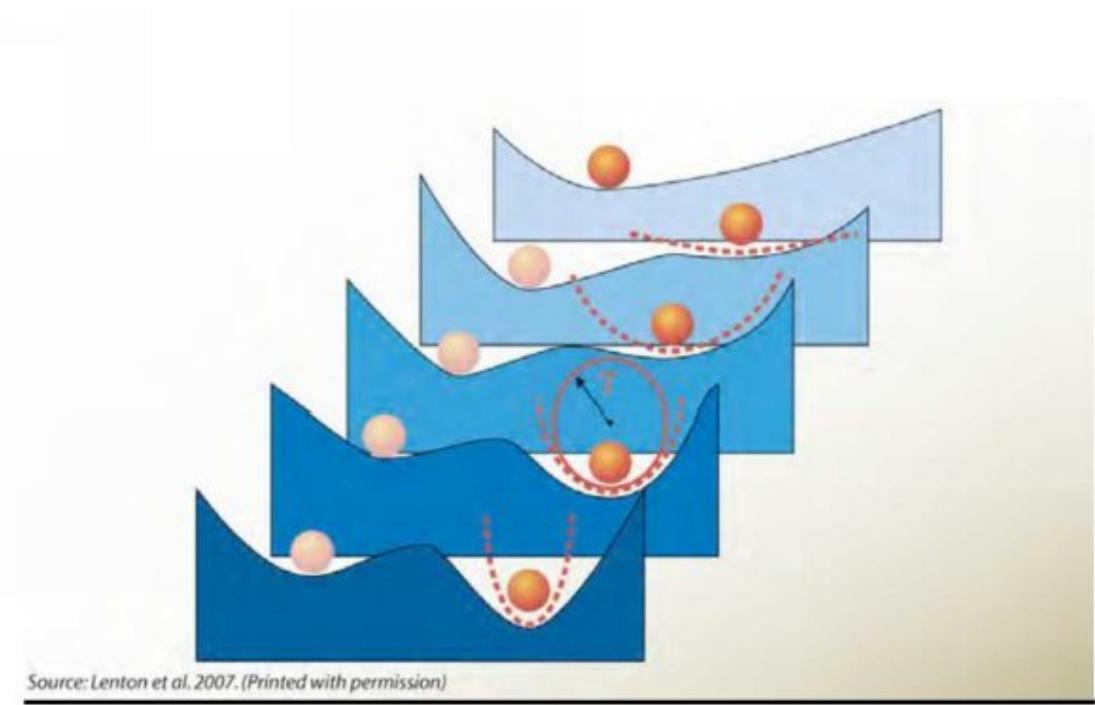
Figure B-1. Potential tipping elements and their approximate geographic scope

This topic has been recognized as a wild card for climate risk management. The National Research Council's (NRC) "America's Climate Choices" study found that:

...rather than smooth and gradual climate shifts, there is the potential that the Earth system could cross tipping points or thresholds that result in abrupt changes. Some of the greatest risks posed by climate change are associated with these abrupt changes and other climate "surprises" (unexpected changes or impacts], yet the likelihood of such events is not well known. Moreover, there has been comparatively little research on the impacts that might be associated with "extreme" climate change—for example, the impacts that could be expected if global temperatures rise by 10 °F (6 °C] or more over the next century.¹⁸⁷

The possibility for a given parameter to undergo a tipping point event, such that the climate system undergoes a qualitative shift into a new stability regime, is illustrated in Figure B-2, where, as described by Lenton et al. the potential wells represent stable attractors, and the ball, the state of the system. Under gradual anthropogenic forcing (progressing from dark to light blue potential), the right potential well becomes shallower and finally vanishes (threshold), causing the ball to abruptly roll to the left. The curvature of the well is inversely proportional to the system's response time to small perturbations.¹⁸⁸

The impact of such sudden transitions is twofold. One, the shift could place the climate system in a qualitatively different stability regime. For example, analysis of ice core data suggests such a tipping point event about twelve thousand years ago precipitated the rapid end of the Younger Dryas, an approximately thirty-year transition period of extreme climate variability, characterized by large changes in temperature and precipitation on timescales as short as three years.¹⁸⁹ There continues to be debate as to whether the Younger Dryas encouraged or impacted the advent of agriculture. It is not clear whether modern dependence on large-scale agriculture would be resilient to the rapid transients in temperature and precipitation observed during the Younger Dryas termination event.

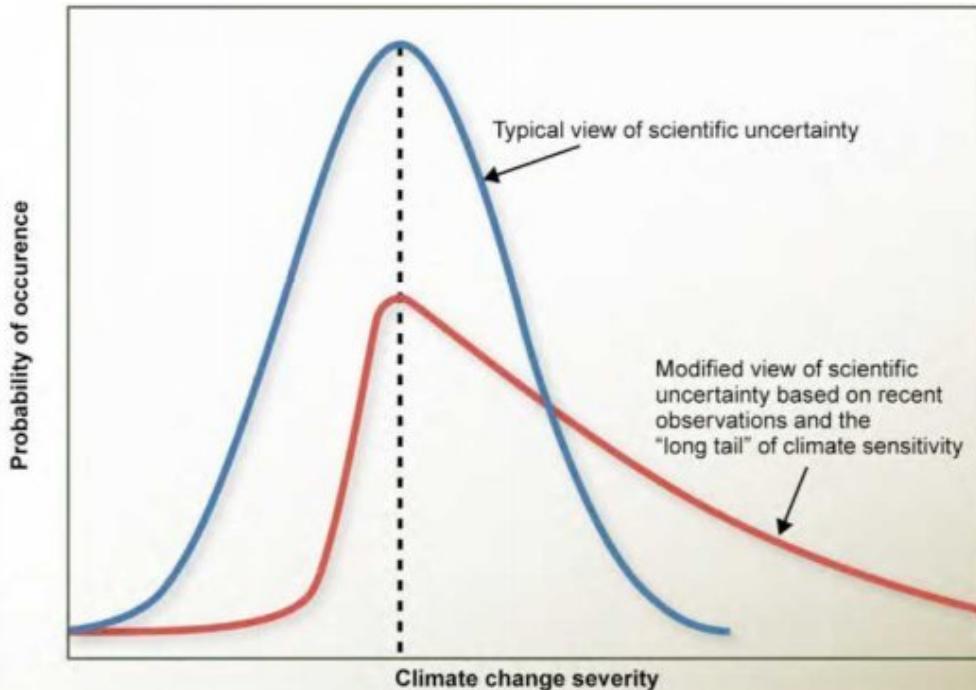


Source: Lenton et al. 2007. (Printed with permission)

Figure B-2. Concept view of a tipping point or threshold crossing event leading to an abrupt change in climate state and future stability

The duration of such climate epochs also illustrates the second factor of reversibility. While the 1300-year duration of the Younger Dryas might not be irreversible in geologic terms, it would certainly be considered irreversible on societal timescales. With regards to irreversibility, the NRC America's Climate Choices study found that "There is general scientific consensus that the Arctic, which is systematically losing summer sea ice thickness and extent on an annual basis, is expected to become permanently ice-free during summers by the middle of the 21st century, regardless of how future emissions change. This change to an ice-free summer Arctic is expected, in part, because of the positive feedback between warming and sea ice melting."¹⁹⁰

Another foundational issue in assessing the risk of climate tipping point scenarios is the long tail challenge. Figure B-3 illustrates the long tail distribution of potential climate change outcomes, driven by the skewed distribution of probabilities associated with the combined uncertainty in future anthropogenic greenhouse gas emissions and climate sensitivity to that forcing.¹⁹¹ The fact that the red curve overlays the traditional blue curve suggests the potential of underestimating the true likelihood of worst-case climate change scenarios. This could lead to neglecting observational data collection and modeling for such conditions as well as evaluation of the response options and development of contingency plans.



Source: Guleidge 2008. (Printed with permission)

Figure B-3. Tipping elements in the Earth's climate system

FINDING: Compared to more gradual climate change scenarios, the potential for tipping point events presents additional needs for climate observations (monitoring for early warning signs), models (non-linear processes), and risk assessment processes (managing longtail threats). These are needs that may not receive the priority they deserve.

Geoengineering

The full consequences of future climate change are not yet fully understood. A prevailing view contends that any mean surface warming above about 2°C from pre-industrial times will be dangerous, producing serious negative consequences for humans and natural systems. However, that number represents only one slice through the range of climate sensitivities. The resulting societal impacts are also quite uncertain. The safest and most obvious method of moderating such climate change is to take early and effective mitigation action to reduce emissions of greenhouse gases. However, global efforts to reduce these emissions have not yet been successful, and there is no evidence that the proposed reductions required to avoid reaching the potentially dangerous climate change will be achieved in the near or medium term future.

Additionally, a serious threat multiplier for climate change impacts is the persistence of CO₂ and other long-lived greenhouse gases in the atmosphere, many of which decay more slowly than long-lived radioactive isotopes of fission products from nuclear power plants (Figure B-4). The atmospheric decay times in the figure are based on a simple exponential decay model for Cesium-137 and use the Bern Carbon model for CO₂ decay. Both start with a unit impulse (normalized to 1.0) at time zero followed by decay per those models for 1,000 years. This irreversibility presents the threat that climate changes, much larger than currently predicted, could persist for many centuries (Figure B-5).

Given our inability to reach agreements to reduce emissions to mitigate climate change, and given the long-term consequences of adding greenhouse gases into the atmosphere today, a number of climate intervention concepts have been proposed. These concepts, referred to as geoengineering, can be divided into two broad classes: 1) Solar Radiation Management techniques that seek to increase the amount of the solar radiation reflected back

into space thus increasing the Earth's albedo by a small percentage to offset the effects of increased greenhouse gases; and, 2) Carbon dioxide removal techniques which aim to remove CO₂ from the atmosphere. (Figures B-4 and B-5)¹⁹²

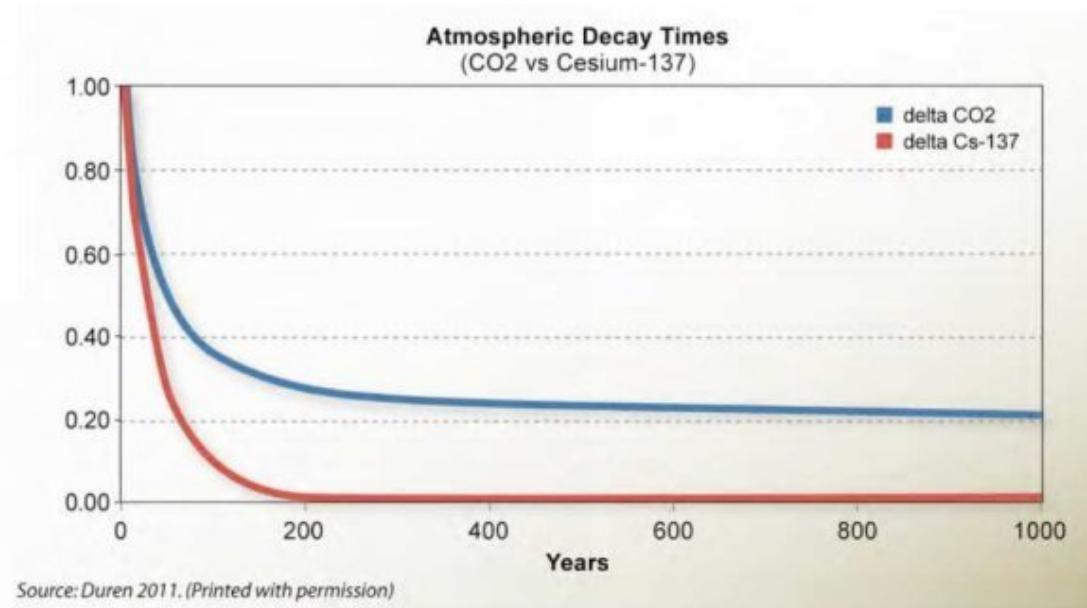


Figure B-4. Atmospheric decay times (CO₂ versus Cesium-137)

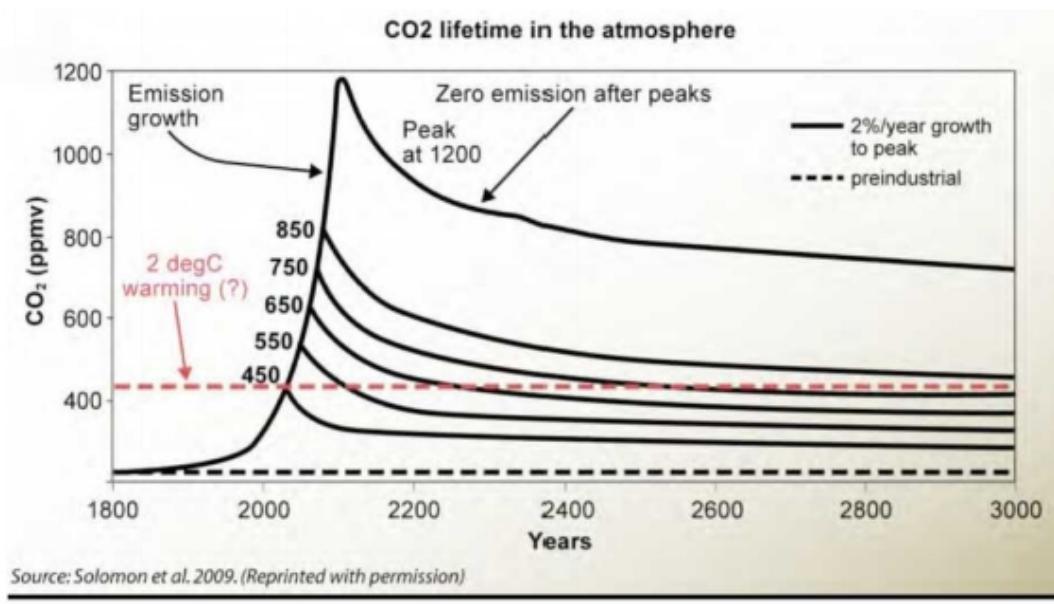


Figure B-5. CO₂ lifetime in the atmosphere

While such schemes have been discussed in scientific literature for decades, recent studies have focused considerable serious attention towards assessing the potential rewards and risks, including scientific, technical, governance, and sociopolitical issues. This includes the Royal Society's Geoengineering the Climate report¹⁹³ and the NRC's Advancing the Science of Climate Change report¹⁹⁴. In 2010, the US Government Accountability Office conducted a study in response to a request from Congress to assess the state of serious scientific research in

the United States, "Climate Change: A Coordinated Strategy Could Focus Federal Geoengineering Research and Inform Governance Efforts."¹⁹⁵

The general conclusion of these reports is that while most of the proposed geoengineering options are considered technically impractical or cost-prohibitive, some, such as stratospheric aerosol injection and boundary-layer marine cloud-seeding, are potentially feasible. These reports also conclude that the potential for unintended consequences for all geoengineering options has not yet received significant study. These reports find that a significant research program would be a necessary precursor to any sub-scale field experiments or full-scale deployment of geoengineering. For example, the Government Accountability Office "recommends that within the Executive Office of the President, the appropriate entities, such as the Office of Science and Technology Policy, establish a clear strategy for geoengineering research in the context of the federal response to climate change to ensure a coordinated federal approach."¹⁹⁶ To date there is no such research program in the United States despite related work in conventional carbon capture and sequestration by the Department of Energy.

There is a significant potential for unilateral geoengineering activity, both sub-scale experiments and full-scale deployment. For example, for several years China has demonstrated a propensity to attempt modifying weather in Beijing and other areas. Given the global scale teleconnections in the climate system, attempts to modify climate on regional scales has the potential for significant and unpredictable consequences in other parts of the world. Hence, efforts by one nation-state to improve their local conditions could negatively impact a neighboring or remote nation-state.

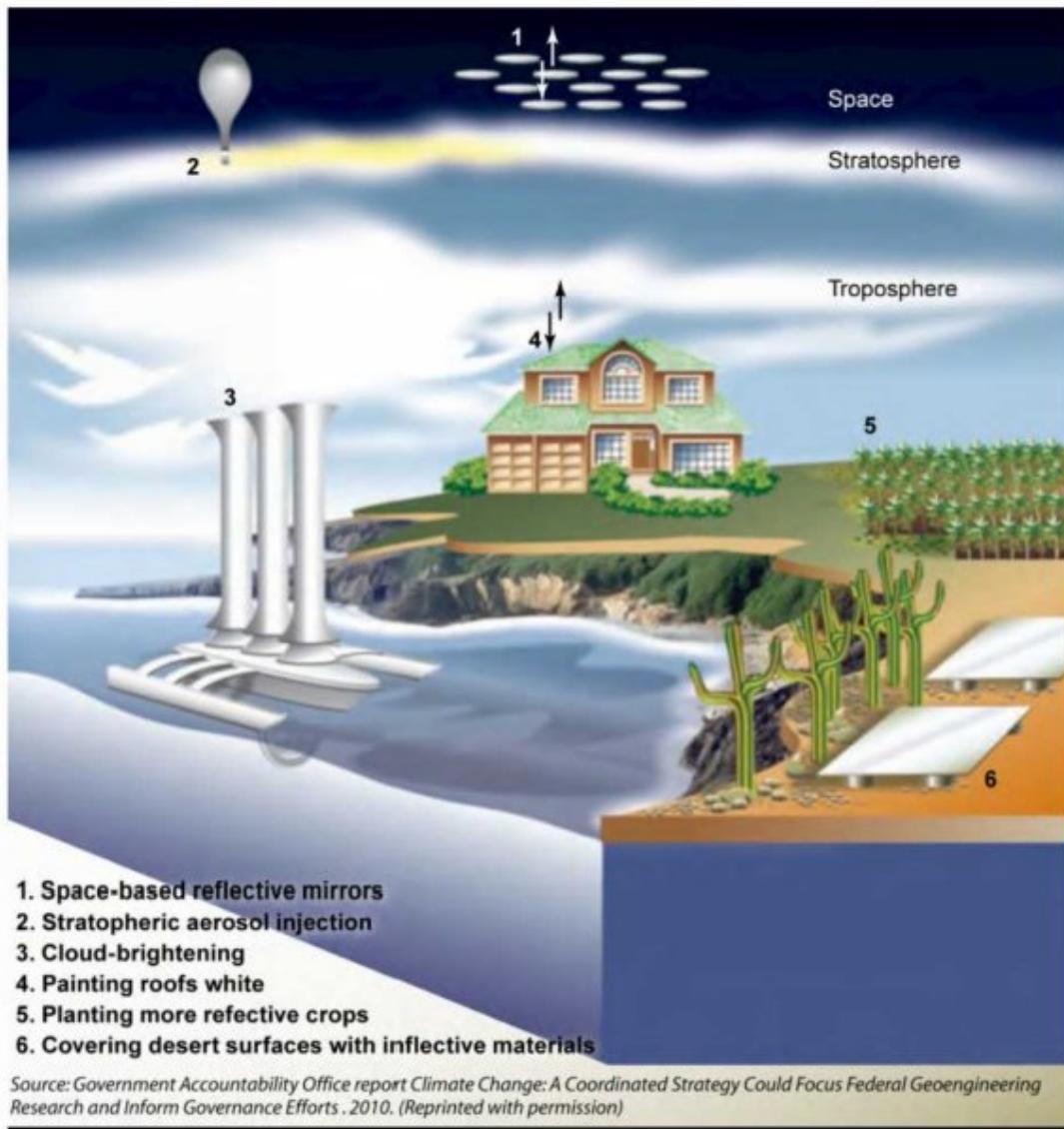
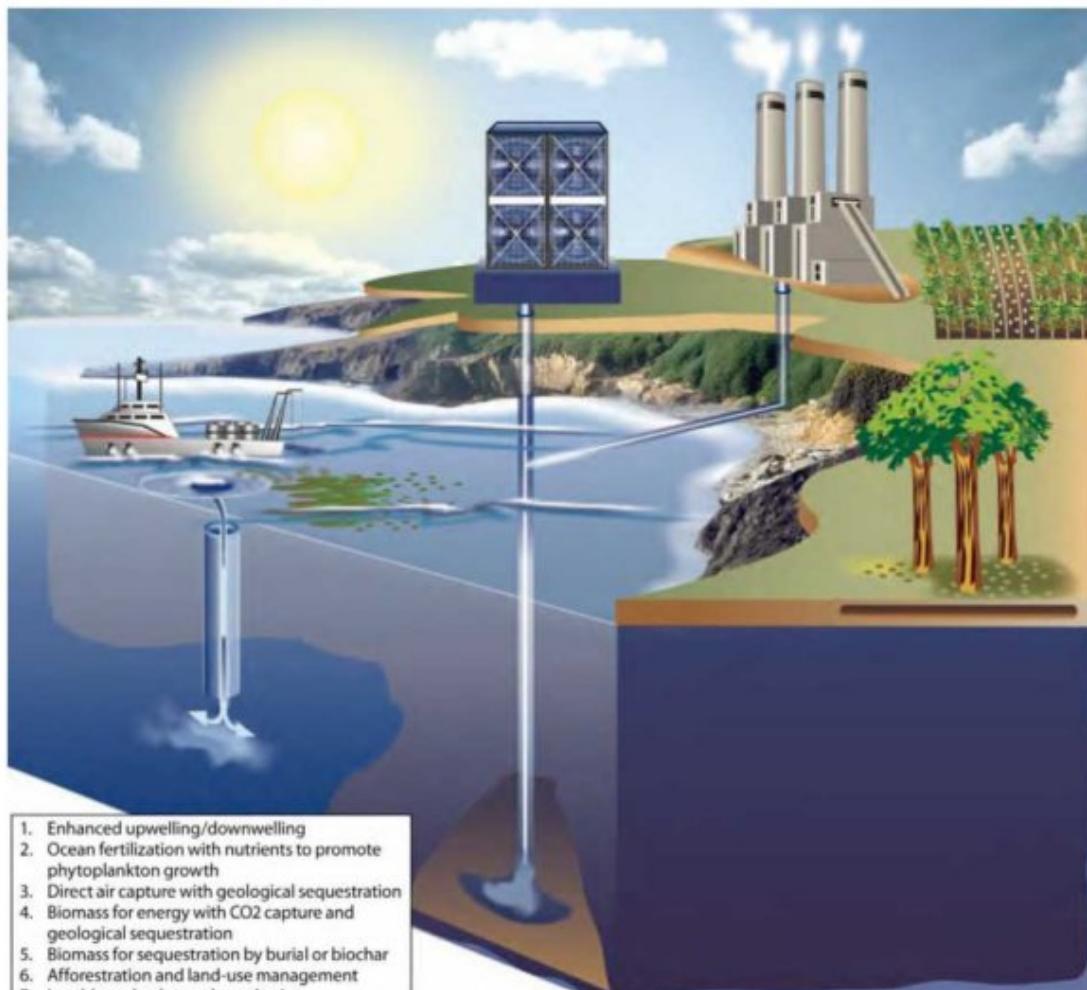


Figure B-6. Carbon dioxide removal geoengineering concepts

Solar Radiation Management geoengineering concepts indicate that corporations are already engaging in geoengineering research, in some cases leading to conflict. This threat is compounded given that the technology necessary to implement some of the geoengineering options could be trivial compared to developing nuclear weapons (Figure B-6). Geoengineering nonproliferation may become a real threat over the coming decades. This risk suggests a potential need for a US research activity focused on improving process understanding in areas that otherwise might not receive prioritization under general climate change science, for example, stratospheric sulphur cycle and impacts of continuous stratospheric aerosol injection on the ozone layer. It could also drive the need for sustained monitoring systems to detect evidence of unilateral geoengineering activity with precisions and spatio-temporal resolution beyond that required for traditional climate science (Figure B-7).



Source: Source: Government Accountability Office report *Climate Change: A Coordinated Strategy Could Focus Federal Geoengineering Research and Inform Governance Efforts*. 2010. (Printed with permission)

Figure B-7. Solar radiation management geoengineering concepts

Terms of Reference



ACQUISITION,
TECHNOLOGY
AND LOGISTICS

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

JUN 28 2010

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference -- Defense Science Board Task Force on Trends and Implications of Climate Change for National and International Security

Changes in the weather and the resulting physical environment that impacts the human condition create potentially profound effects on populations in parts of the world and present new challenges to global security and stability. Changing weather patterns can shift historical areas of flooding, drought, temperature and wind patterns which can impact agricultural output, change disease vectors, and alter geographical features, to name but a few of the effects. These changes will not occur overnight but they have important long-term implications for national security in that they can bring new or increased competition for resources (e.g., food, water, fuel, transportation paths, etc.), create potential for large population displacement and mass migrations, and possibly substantial increased population in previously barren areas that benefit positively from climate change. Failure to anticipate and mitigate these changes increases the threat of more failed states with all the instabilities and potential for conflict inherent in such failures. Of particular near-term concern is the African continent, where two-thirds of the states are identified internationally as fragile.

There is information available in U.S. government agencies, international organizations, and non-governmental organizations on some of these changes and their impact. However, there is no comprehensive set of data describing the extent of the changes, the trends, and realistic projections. There is no policy in the Department of Defense (DoD), no information sharing environment, no accepted set of analysis tools, nor an overall mitigation strategy pertaining to the implications to instability and human security caused by climate change. In addition, the roles DoD may be asked to play, and should play, in helping African militaries develop capabilities and capacities to address these issues or to mitigate the consequences of climate change as it regards their national security need to be outlined and understood.

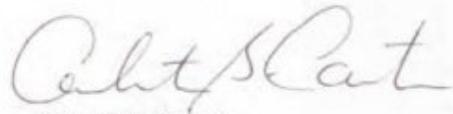
The Defense Science Board is therefore directed to create a task force with the following purposes:

- Bring together the information and views from multiple government and other organizations to provide a comprehensive picture of the current situation, known unknowns and emerging trends.

- Review and understand potential consequences of current change in the physical environment, identify potential analytical tools, and project example consequences of major trend lines on African national and international security.
- Make recommendations on the role that DoD should play in dealing with other agencies in the U.S. Government (USG) to mitigate potential consequences of environmental change in areas important to U.S. national security.
- Recommend steps to engage other government agencies in developing a shared understanding of the consequences of climate change for US national security, and determine where DoD may be best suited to address the relevant effects caused by changing weather patterns and physical environments.
- Recommend an overall structure and DoD process to populate a government-wide database to capture effects on USG programs to aid decision making to mitigate the effects on U.S. national and African partner security.

As the Under Secretary of Defense (Acquisition, Technology, and Logistics), I will co-sponsor the study with the Commander, United States Africa Command (AFRICOM). General Larry D. Welch, USAF (Ret), and Dr. William Howard will serve as the Task Force Co-Chairmen. Mr. Mike Owens, AFRICOM, will serve as the Executive Secretary and Major Michael Warner, USAF, will serve as the DSB Representative.

It is not anticipated that this Task Force will need to go into any “particular matters” within the meaning of Section 208 of Title 18, United States Code; nor will it cause any member to be placed in the position of acting as procurement official.



Ashton B. Carter

Task Force Membership

Chairs

NAME	AFFILIATION
Dr. William Howard	Private Consultant
Gen Larry Welch, US Air Force (Retired)	Institute for Defense Analyses

Task Force Members

Dr. Ted Gold	Private Consultant
Dr. Sherri Goodman	CNA
GEN Paul Kern, USA (Retired)	AM General
Dr. Christine Youngblut	Institute for Defense Analyses

Executive Secretary

Mr. Mike Owens	US Africa Command
----------------	-------------------

DSB Representatives

Mr. Brian Hughes	OUSD(AT&L)
Maj Michael Warner	OUSD(AT&L)

Government Advisors

Dr. Kent Butts	US Army War College
Mr. Riley Duren	Jet Propulsion Laboratory
Dr. Diane Evans	Jet Propulsion Laboratory
CAPT Tim Gallaudet	US Navy Task Force on Climate Change
Mr. David Goldwyn	State Department
Mr. Larry Kobayashi	Central Intelligence Agency
Mr. Leslie Poe	Central Intelligence Agency
Mr. R.C. Porter	Defense Intelligence Agency
LtCol Paul Schimpf, USMC	OUSD(P)
Ms. Courtney St. John	US Navy Task Force on Climate Change

Staff

Ms. Becky Bortnick Afergan	Strategic Analysis, Inc.
Ms. Kelly Frere	Strategic Analysis, Inc.
Ms. Teresa Kidwell	Strategic Analysis, Inc.
Mr. Ted Stump	Strategic Analysis, Inc.

Presentations to the Task Force

NAME	TOPIC
June 14, 2010	
MG Richard Sherlock US Africa Command, Director, Strategy, Plans, and Programs	Strategic Environment and Implications of Climate Change
CDR Esther McClure OUSD(P)	Climate Change and the Quadrennial Defense Review
Dr. Ashley Moran Strauss Center, University of Texas, Austin	DOD's (Minerva) Climate Change and African Political Stability Project
CAPT Timothy Gallaudet Office of the Oceanographer of the Navy	Navy's Climate Change Task Force
Dr. Sherri Goodman, Dr. Ralph Espach and Mr. Peter MacKenzie CNA	Regional Climate Security (China and Columbia)
Mr. Larry Kobayashi Central Intelligence Agency	Climate Change Center and Related Intel Community/Science Programs
Dr. Christine Youngblut Institute for Defense Analyses	Sudan Case Study
June 15, 2010	
Dr. Kent Butts National Security Issues, Branch Center for Strategic Leadership, US Army War College	Climate Change Impacts on State Stability, Implications for Combatant Commands and Multiagency Operations
July 15, 2010	
Mr. Mike Casciaro US Africa Command Deputy Operations and Logistics Directorate (J4), Deputy Plans and Policy Directorate (J5)	Mission, Organization, and Programs Overview
Dr. Jerome Delli Priscoli USACE	Water Security, Global Water Issues, and Climate Change
Dr. Susan Clark-Sestak Institute for Defense Analyses	Opportunities for Military Engagement on Environmental Issues
Dr. Robert R. Sands Expeditionary Skills Training Air Force Culture and Language Center Air University	Climate Change, Human Security and Transfrontier Conservation Areas: Lessons from the Field

NAME	TOPIC
Mr. Riley Duren Chief Systems Engineer Earth Science & Technology Directorate Jet Propulsion Laboratory	Global climate information systems: capabilities, gaps, and opportunities
August 18, 2010	
Mr. Artur Kolodziejki USAFRICOM Environmental Security Program	AFRICOM Environmental Security Program
Mr. Richard Cicone Mr. Thomas Parris	Water, Climate, and National Security
Ambassador Reno Harnish Director, Center for Environment and National Security Scripps Institution of Oceanography University of California at San Diego	Center for Environment and National Security
Mr. Elmer Roman Oversight Executive for Building Partnerships OUSD (AT&L)/DDR&E/Rapid Fielding Directorate Complex Systems/Joint Capabilities Technology Demonstrations	Partnering Earth Observations for People Living Environmentally (PEOPLE) JCTD (Interagency group including NASA)
Dr. Susan Clark-Sestak Institute for Defense Analyses	Presentation and Discussion
August 19, 2010	
Dr. Holmes Hummel Department of Energy	Report on Clean Energy Ministerial
November 8, 2010	
Mr. Jeff Heath Naval Facilities Engineering Command	Naval Facilities Engineering Command Capabilities
Dr. David Dean Office of the Under Secretary for Science, Department of Energy	Energy and Measurement, Reporting, and Verifying for Possible Climate Treaties
Dr. Anthony Okon Nyong African Development Bank	The Politics of Climate Change and Implications for Africa's Security
Dr. Susan Clark-Sestak Institute for Defense Analyses	FY11 Defense Environmental International Cooperation Program (DEIC)

November 9, 2010

Dr. Sam Baldwin Department of Energy	Energy and Climate Challenges: The Efficiency and Renewable Energy Opportunity
Col Shannon Beebe US Army	Why Climate Change Will NEVER Matter to US National Security
Ms. Cynthia Brady Office of Conflict Management and Mitigation, USAID	Climate Change and Conflict: USAID's Perspective

December 17, 2010

Dr. Kathleen D. White Global and Climate Change Institute for Water Resources US Army Corps of Engineers	Climate Change and US National Security: Issues and Opportunities in Africa
Dr. Jonathan Pershing Deputy Special Envoy for Climate Change US Department of State	Outcome of Cancun Climate Negotiations
Maj Mary Zajac National Guard Bureau J532, International Affairs	National Guard and Environment Security
Mr. James Turner Office of International Affairs and Senior Advisor to the NOAA Administrator	NOAA's Work to Meet Climate Challenges
Dr. Chester Knoblinsky NOAA Climate Program Office NOAA Climate Service Transition	The NOAA Climate Program
Mr. Tim Lattimer Central America & the Caribbean US Department of State	Climate Change and Security in Central America and the Caribbean: Views from the Field
Dr. Susan Clark-Sestak Institute for Defense Analyses	FY11 Defense Environmental International Cooperation Program

January 13, 2011

Colonel Noberto Cintron US Southern Command	US Southern Command Perspective
Mr. Rod Snider American Red Cross	American Red Cross and Climate Change
MG Bob Barnes Nature Conservancy	The Nature Conservancy and Climate Change

May 16, 2011

Dr. Kenneth Verosub	University of California-Davis
---------------------	--------------------------------

Glossary

AFRICOM	United States Africa Command
AOR	area of responsibility
AR4	4th Assessment Report (of the IPCC)
C	carbon
°C	Celcius
C4MIP	Coupled Carbon-Climate Cycle Model Intercomparison Project
CCAPS	Climate Change and African Political Stability (program at Strauss Center funded by DOD's Minerva Initiative)
CEOS	Committee on Earth Observation Satellites
CH4	methane
CIA	Central Intelligence Agency
Cm	centimeter
CMIP	Coupled Model Intercomparison Project
CMIP5	5th Coupled Model Intercomparison Project
CO2	carbon dioxide
COE	Center of Excellence for Disaster Management and Humanitarian Assistance (at US Pacific Command)
CORDEX	Coordinated Regional Climate Downscaling Experiment
DEIC	DOD Environmental International Cooperation Program
DESDynI	Deformation, Ecosystem Structure and Dynamics of Ice
DOD	Department of Defense
DOS	Department of State
DSB	Defense Science Board
ECMWF	European Center for Medium-Range Weather Forecasts
ECV	Essential Climate Variables
EIW	Environmental Indications and Warnings
ENSEMBLES	A common ensemble climate forecast system used to construct integrated scenarios of future climate change, including both non-intervention and stabilization scenarios
ENSO	El Niño Southern Oscillation
FEWS NET	Famine Early Warning System Network

FI	fossil intensive
FO	follow-on
GCM	Global Climate Models
GDP	Gross Domestic Product
GEMS	Global Environment Monitoring System
GPCP	Global Precipitation Climatology Project
GRACE	Gravity Recovery and Climate Change Experiment
Gt	gigation
H2O	water vapor
ICESat-2	Ice, Cloud, and Land Elevation Satellite-2 (This is the second-generation of the orbiting laser altimeter ICESat scheduled for launch in early 2016.)
IPCC	Intergovernmental Panel on Climate Change
JASON-1	Oceanography mission to monitor global ocean circulation, study the ties between the oceans and atmosphere, improve global climate forecasts and predictions, and monitor events such as El Niño conditions and ocean eddies
Km	kilometer
N2O	nitrous oxide
NARCCAP	North American Regional Climate Change Assessment Program
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NGO	nongovernmental organization
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NWP	Numerical Weather Prediction
O3	ozone
OI	optimum interpolation
OSD	Office of the Secretary of Defense
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
OUSD(P)	Office of the Under Secretary of Defense for Policy

PRUDENCE	Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects
RANET	Radio and Internet for the communication of hydro-meteorological information for rural development
RCM	Regional Climate Models
SMAP	Soil Moisture Active Passive
SOUTHCOM	United States Southern Command
SRES	Special Report on Emissions Scenarios
SSM/I	special sensor microwave/imager
SST	sea surface temperature
SWOT	Surface Water and Ocean Topography
TOPEX	TOPEX/Poseidon satellite
TRMM	Tropical Rainfall Measuring Mission
UNEP	United Nations Environmental Program
USACE	US Army Corps of Engineers
USAID	United States Agency for International Development
USGCRP	United States Global Change Research Program
USGEO	US Group on Earth Observations
USGS	US Geological Survey
WMO	World Meteorological Organization

FOOTNOTES

1. Strauss Center's program on Climate Change and African Political Stability Policy Brief. February 2011. Page 5. Accessed at: http://ccaps.strausscenter.org/system/research_items/pdfs/43/original.pdf?1299598361. This material is based upon work supported by, or in part by, the US Army Research Laboratory and the US Army Research Office.

2. A. Cazenave and R. S. Nerem, "Present-day sea level change: Observations and causes," *Reviews of Geophysics* 42 (2004), RG3001, 20 PP.

3. R. Schubert et al., *The future oceans—warming up, rising high, turning sour* (Berlin: German Advisory Council on Global Change, 2006).

4. The Global Climate Observing System is a joint undertaking of the World Meteorological Organization, the Intergovernmental Oceanographic Commission of the United Nations Educational Scientific and Cultural Organization, the United Nations Environment Programme, and the International Council for Science. As a system of climate-relevant observing systems, it constitutes, in aggregate, the climate observing component of the Global Earth Observation System of Systems.

5. Global Climate Observing System, *Implementation Plan for the Global Observing System for Climate in Support for the UNFCCC [United National Framework Convention on Climate Change]* (World Meteorological Organization, 2010).

6. Committee on National Security Implications of Climate Change for US Naval Forces, National Security Implications of Climate Change for US Naval Forces (Washington, D.C.: The National Academies Press, 2011).

7. R.M. Duren and C.E. Miller, "Towards Robust Global Greenhouse Gas Monitoring," *Greenhouse Gas Measurement and Management* (2011).

8. The US Group on Earth Observations is chartered by the Office of Science and Technology Policy to prioritize and offer guidance for elements of a US global observing system as part of our nation's contribution to the international Global Earth Observational System of Systems. USGEO plays a role in identifying critical gaps in US observational capability and makes recommendations for closing those gaps.

9. The US Group on Earth Observations, *Achieving and Sustaining Earth Observations: A Preliminary Plan Based on a Strategic Assessment* (2010).

10. The former National Polar-orbiting Operational Environmental Satellite System program is moving forward as the separate Joint Polar Satellite System and the Defense Weather Satellite System programs which will address some, but not all, of the ECVs. Most ECVs will continue to be delivered by exploratory science assets for the foreseeable future.

11. America's Climate Choices: Panel on Advancing the Science of Climate Change, *National Research Council, Advancing the Science of Climate Change* (Washington, D.C.: The National Academies Press, 2010).

12. <http://cmip-pcmdi.llnl.gov/cmip5/>

13. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds., "Summary for Policymakers," in *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press: Cambridge, United Kingdom and New York, NY, 2007).

14. Filippo Giorgi, Colin Jones and Ghassem R. Asrar, "Addressing climate information needs at the regional level: the CORDEX framework," *World Meteorological Organization Bulletin* 58:3 (July 2009).

15. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds., *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press: Cambridge, United Kingdom and New York, NY, 2007).

16. See: D.S. Arndt, M.O. Baringer, and M. R. Johnson, eds., "State of the Climate in 2009," *American Meteorological Society Bulletin* 91, no. 7 (2010): S1-S224; H. M. Fussel, "The risks of climate change: A synthesis of new scientific knowledge since the finalization of the IPCC Fourth Assessment Report (AR4)," *Background note to the World Development Report 2010* (Germany: Potsdam Institute for Climate Impact Research, 2010); C. Richardson (Chair), *Synthesis Report from Climate Change, Global Risks, Challenges and Decisions* (Copenhagen: University of Copenhagen, 2009); M. Rummukainen, et al., *Physical Climate Science since IPCC AR4: A brief update on new findings between 2007 and April 2010* (Denmark: Danish Meteorological Institute, 2010); R. van Dorland, et al., *News in Climate Science Since IPCC 2007: Topics of interest in the scientific basis of climate change* (Royal Netherlands Meteorological Institute (KNMI) and others, 2009); Netherlands Environmental Assessment Agency, *News in Climate Science and Exploring Boundaries: A Policy brief on developments since the IPCC AR4 report in 2007*, PBL 500114013 (The Netherlands: Netherlands Environmental Assessment Agency, 2009).

17. Solomon et al., eds., (2007).

18. Rummukainen et al. (2010).

19. J. Hanson, R. Ruedy, M. Sato, and K. Lo, "Global Surface Temperature Change," *Reviews of Geophysics* 48, RG4004 (2010) 29 PP. Copyright 2010 American Geophysical Union. Reproduced by permission of American Geophysical Union.
20. Solomon et al., eds. (2007) and Netherlands Environmental Assessment Agency (2009).
21. Solomon et al., eds. (2007).
22. S. Hastenrath, D. Polzin, and C. Mutai, "Diagnosing the Droughts and Floods in Equatorial East Africa during Boreal Autumn 2005-08," *Journal of Climate* 23 (2010): 813-817, DOI: 10.1175/2009JCLI3094.1.
23. A. Dai, "Drought under global warming: a review," *Climate Change* 2, no. 1(2011). 45-65,Doi: 10.1002/wcc.81.
24. vanDorland et al. (2009).
25. B.R. Mackenzie and D .Schiedek, "Daily ocean monitoring since the 1860's shows record warming of northern European seas, *Global Change Biology* 13, no. 7 (2007): 1335-1347.
26. A.P. Williams and C. A. Funk, "A westward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa," *Climate Dynamics* (2011),Doi:10.1007/s00382-010-0984-y.
27. Sep 2010 minus Aug 2010 = -0.028°C.
- 28.S. Rahmstorf, "A new view on sea level rise," *Nature Reports Climate Change* 4 (2010): 44-45.
29. See: J.L. Chen, C. R. Wilson, and B. D. Tapley, "Satellite gravity measurements confirm accelerated melting of Greenland ice sheet," *Science* 313 (2006): 1958-1960; D.C. Slobbe, R.C. Lindenbergh and P. Ditmar, "Estimation of volume change rates of Greenland's ice sheet form ICESat data using overlapping footprints," *Remote Sensing of Environment* 112 (2008): 4204-4213; I. Velicogna, "Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE," *Geophysical Research Letters* 36 (2009): L19503,Doi:10.1029/2009GL040222;andvanDorlandetal. (2009).
30. T.L. Mote, "Greenland surface melt trends 1973-2007: Evidence of a large increase in 2007," *Geophysical Research Letters* 34, no. 22 (2007).
31. B. Wouters et al., "GRACE observes small-scale mass loss in Greenland," *Geophysical Research Letters* 35 (2008), L20501, Doi:10.1029/2008GL034816.
32. E.J. Steig, D.P. Schneider, S.D. Rutherford, M.E. Mann, J.C. Comiso, and D.T. Schindell, "Warming of the Antarctic ice-sheet surface since the 1957 International Geophysical Year," *Nature* 457, no. 7228 (2009): 459-462, Doi:10.1038/nature07669, PMID 19158794.
33. E. Rignot, J.L. Bamber, M. R. van den Broeke, C. Davis, Y. Li, W. J. van de Berg, and E. van Meijgaard, "Recent Antarctic ice mass loss from radar interferometry and regional climate modeling," *Nature Geoscience* 1, no. 2 (2007): 106-110; and van Dorland et al. (2009).
34. Rignot et al. (2008).
35. Rignot et al. (2008).
36. United Nations Environment Programme, World Glacier Monitoring Service, *Global Glacier Changes: Facts and Figures* (2008).

37. F. M. Meier, et al., "Glaciers dominate eustatic sea-level rise in the 21st century," *Science* 317 (2007): 1064-1067.
38. See: J. Boe, et al., "September sea ice cover in the Arctic Ocean projected to vanish by 2100," *Nature Geoscience* 2 (2009): 341-343, Doi:10.1038/ngeo467; and M. Wang and J.E. Overland, "A sea ice free summer Arctic within 30 years," *Geophysical Research Letters* 36 (2009), L07502.
39. Netherlands Environmental Assessment Agency (2009).
40. J.C. Comiso et al., "Accelerated decline in the Arctic sea ice cover," *Geophysical Research Letters* 35 (2008), L01703, Doi:10.1029/2007GL031972.
41. J. Stroeve, M. M. Holland, W. Meier, T. Scambos, and M. Serreze, "Arctic sea ice decline: Faster than forecast" *Geophysical Research Letters* 34 (2007): 9501.
42. Netherlands Environmental Assessment Agency (2009).
43. K.E. Thornton, "An update on human-induced climate change," Testimony of Dr. Kevin E. Trenberth before the US Senate Committee on Environment and Public Works, July 22, 2008.
44. Thornton (2008).
45. K.M. Walter, S. A. Zimov, J. P. Chanton, D. Verbyla, and F. S. Chapin III, "Methane bubbling from Siberian thaw lakes as a positive feedback to climate warming," *Nature* 443 (2006): 71-75.
46. V.E. Romanovsky, S.L. Smith, S. L. and H.H. Christiansen, "Permafrost thermal state in the polar Northern Hemisphere during the international polar year 2007-2009: a synthesis," *Permafrost and Periglacial Processes* 21 (2010): 106-116, Doi: 10.1002/pp. 689.
47. "Warming World: Impacts by degree," based on the National Research Council report, *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia* (Washington, D.C.: The National Academies Press, 2010).
48. M. Rigby et al., "Renewed growth of atmospheric methane," *Geophysical Research Letters* 35 (2008), L22805, Doi:10.1029/2008GL036037.
49. E. A. G. Schuur, J. Bockheim, J. G. Canadell, E. Euskirchen, C. B. Field, S. V. Goryachkin, S. Hagemann, P. Kuhry, P. M. Lafleur, H. Lee, G. Mazhitova, F. E. Nelson, A. Rinke, V. E. Romanovsky, N. Shiklomanov, C. Tarnocai, S. Venevsky, J. G. Vogel, and S. A. Zimov, "Vulnerability of permafrost carbon to climate change: Implications for the global carbon cycle," *Bioscience* 58, no. 8 (2008): 701-714, Doi:10.1641/BS80807.
50. Rummukainen et al. (2010).
51. van Dorland et al. (2009) citing Dorrepaal et al. (2009), full reference not available.
52. A. Dai (2011).
53. E.J. Burke, S.J. Brown, and N. Christidis, "Modeling the Recent Evolution of Global Drought and Projections for the Twenty-First Century with the Hadley Centre Climate Model," *Journal of Hydrometeorology* 7 (2006): 1113-1125.
54. A. Dai, K.E. Trenberth, and T. Qian, "A global data set of Palmer Drought Severity Index for 1870-2002: Relationship with soil moisture and effects of surface warming," *Journal of Hydrometeorology* 5 (2004): 1117-1130.

55. J. Sheffield, Global drought in the 20th and 21st centuries: Analysis of retrospective simulations and future projections of soil moisture, PhD thesis (Princeton, New Jersey: Princeton University, 2008).
56. Burke et al. (2006).
57. The IPCC Special Report on Emissions Scenarios (SRES) scenarios are projections of future greenhouse gas emissions used in climate models. The scenarios are based on storylines, each of which makes different assumptions about future demographic, economic, and technological driving forces of greenhouse gas and sulphur emissions.
58. Arndt et al. (2009).
59. Trenberth (2008).
60. Arndt et al. (2010).
61. Determined using the GHCN-Monthly dataset for the following 3-month seasons: (a) Dec 2008 to Feb 2009, (b) Mar to May 2009, (c) Jun to Aug 2009, and (d) Sep to Nov 2009. Seasonal anomalies were determined relative to the 1961-90 means, with at least two-thirds (66%) of the years without missing data required during the base period. D. S. Arndt, M.O. Baringer, and M. R. Johnson, eds., "State of the Climate in 2009," Bulletin of the American Meteorological Society 91, no. 7 (2010): S1-S224. (c) American Meteorological Society. Reprinted with permission.
62. V. Alavian, H.M. Qaddumi, Eric Dickson, S.M. Diez, A. V. Danilenko, R.F. Hirji, G. Puz, C. Pizarro, M. Jacobsen, and B. Blankespoor, Water and Climate Change: Understanding the Risks and Making Climate-smart Investment Decisions (The World Bank, November 2009).
63. Alavian et al. (2009).
64. Taking the flow that is exceeded 10% of the time (q_{10}), which means there is a 90% chance in each time period of a flow lower than this. A decrease in q_{10} means that the likelihood of high flows and floods will increase. The relative changes from historical values provide an "indicator" of the projected change in floods.
65. F. Gutierrez et al., "Recent advances in landslide investigation: Issues and perspectives," Guest editorial, Geomorphology 124 (2010): 95-101.
66. S.J. Brown, J. Caesar, and C. A. T. Ferro, "Global changes in extreme daily temperature since 1950," Journal of Geophysical Research-Atmospheres 113 (2008).
67. A Sterl et al., "When can we expect extremely high surface temperatures?" Geophysics Research Letters 35 (2008), L14703, Doi:10.1029/2008GL034071.
68. See: K. Emanuel, "Increasing destructiveness of tropical cyclones over the past 30 years," Nature 436 (2005a): 686-688; D. W. Landsea, B. A. Harper, K. Hoarau and J.A. Knaff, "Can we detect trends in extreme tropical cyclones?" Science 313 (2006): 452-454; K. E. Trenberth and D.J. Shea, "Atlantic hurricanes and natural variability in 2005," Geophysical Research Letters 33 (2006), L12704 10.1029/2006GL026256; and P.J. Webster, G. J. Holland, J.A. Curry, and H.-R. Chang, "Changes in tropical cyclone number, duration, and intensity in a warming environment," Science 309 (2005): 1844-1846.
69. (A) The numbers of North Atlantic tropical cyclones for each maximum wind speed shown on the horizontal axis. (B) The proportional increase by cyclone (hurricane) category (1 - least intense; 5 - most intense) arising from increases in maximum wind speeds of 1, 3 and 5 m/s.

70. The 5-year running mean normalized Atlantic main development region SST indices from three different reconstructions of SST overlaid on Atlantic tropical cyclone counts. Blue curves are the three main development region SST reconstructions. The heavy red curve is the base-case tropical cyclone count. The light red curve is the unadjusted tropical cyclone count. The orange curves are the US land falling tropical storms and hurricane series counts from the North Atlantic hurricane database.
71. G.A. Vecchi and T.R. Knutson, "On Estimates of Historical North Atlantic Tropical Cyclone Activity" *Journal of Climate* 21 (2008): 3580-3600.
72. See: Rummukainen et al. (2010); U. Loptien et al., "Cyclone life cycle characteristics over the Northern Hemisphere in coupled GCMs," *Climate Dynamics* 31 (2008): 507532, Doi:10.1007/s00382-007-0355-5; and L. Bengtsson et al., "Will extratropical storms intensify in a warmer climate?" *Journal of Climate* 22 (2009): 2276-2301, Doi:10.1175/2008JCLI2678.1.
73. See: J.H. Yin, "A consistent poleward shift of the storm tracks in simulations of 21st century climate," *Geophysical Research Letters* 32 (2005), L18701, Doi:10.1029/2005GL023684; and G. Gastienau and B.J. Soden, "Model projected changes of extreme wind events in response to global warming," *Geophysical Research Letters* 36 (2009), L10810, Doi:10.1029/2009GL037500.
74. See: E.P. Salathe, Jr., "Influences of a shift in North Pacific storm tracks on western North American precipitation under global warming," *Geophysical Research Letters* 33 (2006), L19820, Doi:10.1029/2006GL026882; and J. Jiang, and W. Perrie, "Climate change effects on North Atlantic cyclones," *Journal of Geophysical Research Letters* 113 (2008), D09102, Doi:10.1029/2007JD008749.
75. Riley Duran. Presentation to the DSB Task Force, July 2010. Jet Propulsion Laboratory.
76. See: Solomon et al., eds. (2007) and Trenberth (2008).
77. A. Cazenave, K. Dominh., S. Guinehut, E. Berthier, W. Llovel, G. Ramilien, M. Ablain, and G. Larnicol, "Sea level budget over 2003-2008. A reevaluation from GRACE space gravimeter, satellite altimetry and Argo," *Global and Planetary Change* 65 (2009): 83-88.
78. S. Rahmstorf, "A new view on sea level rise," *Nature Reports Climate Change* 4 (2010): 44-45.
79. J.T. Overpeck and J.L. Weiss, "Projections of future sea level becoming more dire," *Proceedings of the National Academy of Sciences* 106 (2009): 21461-21462, Doi:10.1073/pnas.0912878107
80. Meehl et al., "How much more warming and sea level rise?" *Science* 307 (2005) 1769-1772.
81. N. Mabey, N., J. Gulleedge, B. Finel, and K. Silverthorne. *Degrees of Risk: Defining a Risk Management Framework for Climate Security* (London, UK: Third Generation Environmentalism Ltd, February 2011).
82. See: Solomon et al. (2009); D. Archer and V. Brovkin, "The millennial atmospheric lifetime of anthropogenic CO₂," *Climatic Change* 90, no. 3 (2008): 283-297; H.D. Matthews and K. Caldeira, "Stabilizing climate requires near zero emissions," *Geophysical Research Letters* 35 (2008), L04705; and M. Eby, K. Zickfeld, A. Montenegro, D. Archer, K. J. Meissner, and A. J. Weaver, "Lifetime of anthropogenic climate change: millennial time scales of potential CO₂ and surface temperature perturbations," *Journal of Climate* 22 (2009): 2501-2511.
83. See: G.K. Plattner, "Long-term commitment of CO₂ emissions on the global carbon cycle and climate," *IOP Conference Series: Earth and Environmental Sciences* 6 (2009). 042008. available online at <http://www.iop.org/EJ/toc/1755-1315/6/4>; and S. Solomon, G.K. Plattner, R. Knutti, and P. Friedlingstein,

"Irreversible climate change due to carbon dioxide emissions," Proceedings of the National Academy of Sciences 106 (2009): 1704-1709.

84. T.M. Lenton and H.J. Schellnhuber, "Tipping the scales," Nature Reports Climate Change 1 (2007): 97-98.

85. There is one more tipping element not shown, the Indian Summer Monsoon, because its critical threshold cannot be meaningfully related to global warming. The temperature ranges given here are from reviewing studies in the literature and conversations with individual experts.

86. A.R. Ganguly, K. Steinhaeuser, E.S. Parish, S.C. Kao, A.W. King, M. Branstetter, A. Sorokine, Climate Change Support for the United States Department of Defense (US DOD), 2010 Quadrennial Defense Review report (Oak Ridge National Laboratory Climate Change Science Institute, 2010). The research was funded by the US Office of the Secretary of Defense. The Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the US Department of Energy.

87. M.E. Shongwe, G.J. van Oldenborgh, B.J.J.M. van den Hurk, B. de Boer, C.A.S. Coelho, and M.A. van Aalst, Projected changes in extreme precipitation in Africa under global warming. Poster, Workshop on metrics and methodologies of estimation of extreme climate events, 27-29 September 2010, UNESCO headquarters, Paris, France.

88. M.E. Shongwe, G.J. van Oldenborgh, B.J.J.M. van den Hurk, and M. van Aalst, "Projected changes in mean and extreme precipitation in Africa under global warming, Part II: East Africa," Submitted Journal of Climate (2010).

89. International Bank for Reconstruction and Development, Water and Climate Change: Understanding the Risks and Making Climate-Smart Investment Decisions (The World Bank: Publication, November 2009).

90. Shongwe et al. (2010).

91. P. Meier, Doug Bond, Joe Bond, "Environmental influences on pastoral conflict in the Horn of Africa," Political Geography 26, no. 6 (2007): 716-735.

92. A. Agoumi, Vulnerability of North Africa Countries to Climate Change: Adaptation and Implementation Strategies for Climate Change (International Institute for Sustainable Development (2003).

93. R. Kasei and B. Diekkrtigger, "Drought frequency in the Volta Basin of West Africa," Sustainability Science 5 (2010): 89-97, Doi 10.1007/sll625-009-0101-5.

94. US Army Corps of Engineers, The Impact of Water as a United States Government Security Consideration for the US Africa Command (September 29, 2010). Report prepared for the US Africa Command.

95. A. Dai (2011).

96. RANET, Radio and Internet for the communication of hydro-meteorological information for rural development, "is a collaborative effort of many national hydro-meteorological services, nongovernmental organizations, and communities. These varied partners come together to make weather, water, and climate information available to rural and remote populations, which are often most in need of environmental forecasts, observations, and warnings." www.ranetproject.net [Accessedjuly22,2011].

97. Adapted from B. L. Turner II, Roger E. Kaspersonb, Pamela A. Matsone, James J. McCarthy, Robert W. Corell, Lindsey Christensen, Noelle Eckley, Jeanne X. Kaspersonb, Amy Luerse, Marybeth L. Martellog, Colin Polsky, Alexander Pulsipher, and Andrew Schiller, "A framework for vulnerability analysis in sustainability science," Proceedings of the National Academy of Sciences 100, no. 14 (July 8, 2003) 8074-8079.

98. International Bank for Reconstruction and Development, Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change (Washington, D.C.: World Bank, 2009).
99. US Army Corps of Engineers (2010).
100. UN Water, A Snapshot of Drinking Water and Sanitation in Africa (2008). A regional perspective based on new data from the World Health Organization/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. Prepared for AMCOM as a contribution to the 11th Summit of Heads of State and Government of the African Union With special theme: Meeting the Millennium Development Goal on Water and Sanitation 30 June to 1 July, 2008.
101. World Health Organization, Ten facts about water security (World Health Organization, 2009).
- 102 J. Delli Priscoli, "Water Security, Global Water Issues and Climate Change Water: Key to Regional Stability," Keynote speech at International Water Symposium, Korean Environment Institute, Climate Change Water Security, July 20, 2010, Korea Chamber of Commerce and Industry Seoul Korea.
103. UNEP/GRID-Arendal, Water availability in Africa, UNEP/GRID-Arendal Maps and Graphics Library, <http://maps.grida.no/go/graphic/water availability in Africa> (Accessed 29 July2011). Cartographer: Digout, Delphine, based on a sketch by Philippe Rekacewicz; UNEP/GRID-Arendal. Sources: United Nations Economic Commission for Africa (UNECA), Addis Ababa; Global Environment Outlook 2000 (GEO 2000), UNEP, Earthscan, London, 1999.
104. Suhas P. Wani, J. Rockstrom, and T. Oweis, eds., Rainfed Agriculture: Unlocking the Potential (United Kingdom: International Water Management Institute, 2009).
105. K.D. White, Army Corps of Engineers. Presentation to the Task Force on December 17, 2010. Based on M. vanAalst, M Hellmuth, and D Ponzi, "Come Rain or Shine: Integrating Climate Risk Management into African Development Bank Operations," Working Paper No 89 (Tunis: African Development Bank, 2007). Source: World Bank.
106. Africa Environment OutLook 2: Our environment, our wealth (United Nations Environment Programme, 2006).
107. The Water for the Poor Act was enacted in2005 by the Bureau of Oceans and International Environmental and Scientific Affairs within the Department of State. The Act authorizes the use of foreign aid to expand the role of global water and sanitation programs in US foreign policy. Additionally, it allows the secretary of state to create international programs that promote increased levels of clean water and sanitation around the world.
108. In Section 1207 of the FY 2006 National Defense Authorization Act, Congress authorized DoD to transfer up to \$100 million per year to the Secretary of State for "reconstruction, security, or stabilization assistance to a foreign country." Congress then reauthorized this authority in Section 1210 of the FY 2008 Defense Authorization Act. These funds have hence been informally referred to as "1207" or "1210" funds.
109. Peter Ashton, Aquatic Ecosystems Research Group, Natural Resources and the Environment, CSIR, Pretoria, South Africa. Presentation on Key Challenges Facing Water Governance in Africa, presented at: South African Institute of International Affairs Symposium: "The Second Scramble for Africa: Lifting the Resources Curse": SAIIA, Johannesburg, 29 November 2007. Data from: Food and Agriculture Organization of the United Nations (2005). Aquastat Database.
110. J. Delli Priscoli and A.T. Wolf, Managing and Transforming Water Conflicts (Cambridge University Press, 2008).

111. DOD/Combatant Commander Water Security Program Strategy, April 2010. Available from Erik Fleischner, HQUSACE LNO, United States European Command.
112. Mabey et al. (2011).
113. US Army Corps of Engineers (2010).
114. DOD/Combatant Commander Water Security Program Strategy, April 2010.
115. East Africa: Uganda, DR Congo Head Off Dispute as River Alters Border. allAfrica.com, November 9, 2009.
116. Presentation by Dr. K. White to the DSB Task Force, citing (Freeman, JAWRA2000).
117. White Paper on Defence, 1996.
118. For a discussion of the nature of puzzles and mysteries see: Malcom Gladwell, "Open Secrets" in What the Dog Saw and Other Adventures (New York, NY: Little, Brown and Company, 2009).
119. National Intelligence Council, North Africa: Impact of Climate Change to 2030: Geopolitical Implications (December 2009) p. 11.
120. G. Fischer, M. Shah, F.N. Tubiello, and H., van Velhuizen, "Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080," Philosophical Transactions of the Royal Society, 360 (1463): 2067-2083, Doi: 10.1098/rstb.2005.1744, November 2005.
121. P.L. Thornton, P.G. Jones, T. Owiyo, R.I. Kruska, M. Herrer, P. Kristjanson, A. Notenbaert, N. Bekele and A. Omolo, with contributions from V. Orindi, B. Otiende, A. Ochieng, S. Bhadwal, K. Anantram, S. Nair, V. Kumar, and U. Kulkar, Mapping climate vulnerability and poverty in Africa (2006). Report to the Department for International Development.
122. Cheung et al., "Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change," Global Change Biology 16 (2010): 24-35.
123. C. Nellemann, M. MacDevette, T. Manders, B. Eickhout, B. Svhuis, A. G. Prins, and B. P. Kaltenborn eds., The Environmental Food Crisis: The Environment's Role in Averting Future Food Crises (UNEP, February2009), <http://www.grida.no/publications/rr/food-crisis/>
124. K. D. White, US Army Corps of Engineers. Presentation to the DSB Task Force, December 17, 2010.
125. Susmita Dasgupta, Benoit Laplante, Siobhan Murray, and David Wheeler, Sea Level Rise and Storm Surges: A Comparative Analysis of Impacts in Developing Countries, Public Research Working Paper 4901 (World Bank, April 2009).
126. UN-HABITAT, African Cities at Risk due to Sea-Level Rise (Global Urban Observatory, 2008).
127. Henri E.Z. Tonnang, Richard Y.M. Kangalawe, and Pius Z. Yanda, "Predicting and mapping malaria under climate change scenarios: the potential redistribution of malaria vectors in Africa," Malaria journal 9, no. 111 (2010), Doi: 10.1186/1475-28759-111. Published online April 23, 2010.
128. S. Hales et al., "Potential effect of population and climate changes on global distribution of dengue fever: an empirical model," The Lancet 360 (2002): 830-834.

129. Joshua W. Busby, Todd G. Smith, Kaiba L. White, and Shawn M. Strange, Locating Climate Insecurity: Where are the Most Vulnerable Places in Africa? (Austin, Texas: Roberts. Strauss Center for International Security and Law, 2010). This material is based upon work supported by, or in part by, the US Army Research Laboratory and the US Army Research Office under contract/grant number W911NF-09-1-0077.

130. P. Watkiss, T. Downing, and J. Dyszynski, AdaptCost Project Analysis of the Economic Costs of Climate Change Adaptation in Africa (Nairobi: UNEP, 2010).

131. Attempts at geoengineering, on a global scale, to modify or reverse climate change are especially dangerous. The knowledge of the complete range of factors affecting Earth's climate is so rudimentary that climate engineering is virtually guaranteed to result in worse problems than any Mother Nature ever dreamed up.

132. James Rodger Fleming, Fixing the Sky: The Checkered History of Weather and Climate Control (New York, NY: Columbia University Press, September 2010).

133. Swedish Ministry of Defense, On Connecting Climate Change with Security and Armed Conflict (Department of Defence Analysis, September 2010).

134. Department of State, <http://www.state.gov/g/oes/hub/> [Accessed 8 August 2011].

135. Sherri Wasserman Goodman, Deputy Under Secretary of Defense for Environmental Security, Statement Before the Subcommittee on Installation and Facilities, May 13, 1993.

136. Lori Dengler, Strategic Implementation Plan for Tsunami Mitigation Projects, NOAA Technical Memorandum ERL PMEL-113 (National Oceanic and Atmospheric Administration, 1998)
www.pmel.noaa.gov/pubs/PDF/deng2030/deng2030.pdf [Accessed August 2011].

137. Examples of these studies include: America's Climate Choices (2011), National Security Implications of Climate Change for US Naval Forces (2011), Advancing the Science of Climate Change (2010), Limiting the Magnitude of Future Climate Change (2010), Adapting to the Impacts of Climate Change (2010).

138. White House, National Security Strategy, May 2010, p. 47.

139. President Barack Obama's Nobel Peace Prize Acceptance Speech, 2009.

140. Gladwell (2009).

141. America's Climate Choices: Panel on Informing Effective Decisions and Actions Related to Climate Change, National Research Council, Informing an Effective Response to Climate Change (Washington, D.C.: The National Academies Press, 2010).

142. Mabey et al. (2011).

143. At the time of this writing (March 25, 2011) operators at the Fukushima nuclear plant in Japan are still struggling to gain control of cooling systems of reactors and fuel storage pools damaged by a 46 foot tsunami triggered by an offshore magnitude 9.0 earthquake two weeks ago. According to press reports, the Fukushima plant's tsunami protection features (modest augmentation around a 13 foot natural seawall) were designed using a "deterministic" rather than probabilistic approach (i.e., based on recent historical experience with tsunamis rather than addressing reasonable worst-case scenario which transpired). The risk of underestimating events with so called "longtail" probabilistic distributions is exacerbated for climate change scenarios.

144. Lenton et al., "Tipping elements in the earth's climate system," Proceedings of the National Academy of Sciences 105, no. 6 (2008): 1786-1793.

145. Tsunami threat potential, which varies strongly with local tides, winds, topography, and bathymetry can arguably be amplified by rising sea levels.

146. See: Hoerling et al. (2004); S. Janicot, S. Trzaska, and I. Poccard, "Summer Sahel-ENSO teleconnection and decadal time scale SST variations," *Climate Dynamics* 18 (2001): 303-320; and Raicich et al. "Teleconnections Between Indian Monsoon And Sahelian Rainfall And The Mediterranean," *International Journal of Climatology* 23 (2003): 173-186.

147. Davis and Caldiera, "Consumption-based accounting of CO₂," *Proceedings of the National Academy of Sciences* (2010).

148. R.J.T. Klein, S. Huq, F. Denton, T.E. Downing, R.G. Richels, J.B. Robinson, and F.L. Toth, "Inter-relationships between adaptation and mitigation" in *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. (Cambridge, UK: Cambridge University Press, 2007) pp. 745-777.

149. Miles et al., "An approach to designing a national climate service," *Proceedings of the National Academy of Sciences* (2006).

150. <http://www.globalchange.gov/>; <http://www.wmo.int/pages/themes/climate>;
<http://www.earthobservations.org>

151. Morello, "Agency Proposes Climate Service to Spur Adaptation," *New York Times*, Feb 9, 2010, <http://www.nytimes.com/cwire/2010/02/09/09climatewire-agency-will-create-national-climate-service-63603.html>

152. Advertised products from the NOAA Climate Service include (for the US): Inundation maps for coastal communities that reflect the best available information on sea level rise and changing patterns of coastal storms; heat projections to help managers plan future energy and health services needs; climate and precipitation models to help farmers know the impact of a changing climate on their crops; relevant historical climate data and data from state-of-the-art climate models to inform investment and planning for businesses and local governments; routine vulnerability and risk assessments for climate-sensitive regions and sectors.

153. <http://www.noaa.gov/climate.html>

154. <http://www.doi.gov/whatwedo/climate/strategy/CSC-Map.cfm>

155. J. M. Murphy, D. M. H. Sexton, D. N. Barnett, G. S. Jones, M. J. Webb, and M. Collins, "Quantification of modelling uncertainties in a large ensemble of climate change simulations," *Nature* 430, no. 7001 (2004): 768-772.

156. P. Gleckler, R. Ferraro, and D. E. Waliser, Better use of satellite data in evaluating climate models contributing to CMIP and assessed by IPCC, Joint DOE-NASA workshop, Lawrence Livermore National Laboratory, October 12-13, 2010, EOS, In Press.

157. A value of -0.2 means that the model has an error 20% smaller than the typical model error for that quantity. Each grid square is split by a diagonal in order to show the relative error with respect to both the primary (upper left triangle) and the alternate (lower right triangle) reference data sets. Variables included: hfss and hfss - latent and sensible heat flux; rxxx - various TOA and surface quantities of long wave and shortwave radiation including cloud radiative forcing; ts, clt - surface temperature, total cloud cover; pr, prw and psl are precipitation, precipitable water and sea level pressure; remaining variables are surface stress and winds and winds, humidity, temperature and heights at a number of pressure levels.

158. T. Reichler and J. Kim, "How well do coupled models simulate today's climate?" *Bulletin of the American Meteorological Society* 89, no. 3 (2008): 303.

159. Best performing models have low 12 values and are located toward the left. Circle sizes indicate the length of the 95% confidence intervals. Letters and numbers identify individual models (not shown); flux-corrected models are labeled in red. Grey circles show the average 12 of all models within one model group. Black circles indicate the 12 of the multi-model mean taken over one model group. The green circle (REA) corresponds to the 12 of the National Centers for Environmental Prediction/National Center for Atmospheric Research reanalyses. (right) Climate variables and validation data.

160. See: D. Waliser, K. W. Seo, S. Schubert, and E. Njoku, "Global water cycle agreement in the climate models assessed in the IPCC AR4," *Geophysical Research Letters* 34, no. 16 (2007); and D. Waliser et al., "Cloud ice: A climate model challenge with signs and expectations of progress," *Journal of Geophysical Research-Atmospheres* 114 (2009).

161. K.E. Trenberth, A. G. Dai, R. M. Rasmusson, and D. B. Parsons, "The changing character of precipitation," *Bulletin of the American Meteorological Society* 84, no. 9 (2003): 1205.

162. NASA's Earth Observing System Data and Information System (<http://nasadaacs.eos.nasa.gov/>)

163. USGS's Earth Resources Observation and Science Center (<http://eros.usgs.gov/>)

164. IPCC's Data Distribution Center (<http://www.ipcc-data.org/>)

165. Program for Climate Model Diagnosis and Intercomparison (<http://www-pcmdi.llnl.gov/>)

166. National Integrated Drought Information System (<http://www.drought.gov>)

167. Famine Early Warning System Network (<http://www.fews.net>)

168. US Department of Agriculture Foreign Agriculture Service's Crop Explorer (<http://www.pecad.fas.usda.gov/cropexplorer/>)

169. Regional Visualization and Monitoring System (<http://www.servir.net/en/>)

170. Busby et al. (2010).

171. Anthony Nyong, Climate change & Africa's security: the role of the African Development Bank, presentation to the Defense Science Board Task Force on Climate Change, November 8, 2010.

172. United States Global Change Research Program, Our changing planet, Table 1. FY2007-2009 Climate change Science Program Budget by Goal and Focus Area (2010).

173. Mabey et al. (2011).

174. The White House Council on Environmental Quality, Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy (Washington, D.C.: Executive Office of the President, 2010).

1. The White House Council on Environmental Quality (2010).

176. <http://www.globalchange.gov/what-we-do/assessment/nca-overview>

177. "U.S. National Climate Assessment Objectives, Proposed Topics, and Next Steps," Federal Register 60, no. 210 (September 7, 2010).
178. George Backus, Thomas Lowry, Drake Warren, Mark Ehlen, Geoffrey Klise, Verne Loose, Len Malczynski, Rhonda Reinert, Kevin Stamber, Vince Tidwell, Vanessa Vargas, and Aldo Zagonel, Assessing the Near-Term Risk of Climate Uncertainty: Interdependencies among the US states, SAND2010-2052 (Albuquerque, NM: Sandia National Laboratory, May 2010).
179. Meier et al., Climate Change and Conflict (2007) pp. 716-735.
180. America's Climate Choices: Advancing the Science of Climate Change (2010).
1. The White House Council on Environmental Quality (2010).
 1. George Backus et al. (2010).
 1. The White House Council on Environmental Quality (2010).
184. United States Global Change Research Program, Our Changing Planet: The US Global Change Research Program for Fiscal Year 2011.
185. The White House Council on Environmental Quality (2010).
1. Lenton et al. (2008).
187. America's Climate Choices: Advancing the Science of Climate Change (2010).
188. Lenton and Schellnhuber (2007).
189. Alley et al., "Abrupt increase in Greenland snow accumulation at the end of the Younger Dryas event," Nature 362 (1993).
190. America's Climate Choices: Advancing the Science of Climate Change (2010).
191. Modified from Figure 2.4 on p. 35 of: Nick Mabey, Jay Gulledge, Bernard Finel, and Katherine Silverthorne, "Degrees of Risk: Defining a Risk Management Framework for Climate Security," February 2011.
192. Susan Solomon, Gian-Kasper Plattner, Reto Knutti, and Pierre Friedlingstein, Physical Sciences: Environmental Sciences: Irreversible climate change due to carbon dioxide emissions," Proceedings of the National Academy of Sciences 106, no. 6 (2009): 1704-1709. Published ahead of print January 28, 2009.
193. Geoengineering the climate: science, governance and uncertainty (Royal Society, 2009).
194. America's Climate Choices: Advancing the Science of Climate Change (2010).
195. Government Accountability Office, Climate Change: A Coordinated Strategy Could Focus Federal Geoengineering Research and Inform Governance Efforts, GAO-10-903 (September 2010).
196. Government Accountability Office (2010).

* * * * *

The Department of Defense and Climate Change: Initiating the Dialogue

ONR

SERDP

ERDC

Office of the Oceanographer of the Navy

This document has been cleared for public release

A Workshop to Inform Future Coordination within the DoD Research Community and between the Research and Policy Communities

Proceedings and Recommendations

January 2012

Workshop convened July 19-21, 2011, Aurora, Colorado

Workshop planned by and report prepared by the Office of Naval Research, Strategic Environmental Research and Development Program, U.S. Army Corps of Engineers, Engineer Research and Development Center, and Office of the Oceanographer of the Navy, Task Force Climate Change

Table of Contents

Preface

Executive Summary

Chapter 1

Introduction

Chapter 2

Plenary and Breakout Session Summaries

2.1 Plenary Summaries

2.2 Breakout Session Summaries

Chapter 3

Workshop Synthesis: Major Findings and Emergent Themes

3.1 The Context for a Response to Climate Change in the Department of Defense

3.2 Internal Capacity, External Partnerships, and Outreach

3.3 Blueprint for a DoD Climate Change Research Agenda

3.4 The Need for a Policy-R&D-End-User Dialogue

3.5 Notes on Implementation

Chapter 4

Workshop Recommendations

4.1 Visioning Future Workshops

4.2 Establishing an Ongoing Dialogue

4.3 Establishing a DoD Climate Change Science Technical Workgroup

4.4 Articulating a Path Forward: General Recommendations/Precautions

4.5 Forging External Partnerships

Appendix A

Workshop Materials

A1 Workshop Charge

A2 Workshop Agenda

A3 Breakout Session Charges

Appendix B

List of Participants

Appendix C

Glossary

Appendix D

List of Acronyms/Abbreviations

Appendix E

Compendium of Department of Defense Research and Development Programs Related to Climate Change

Appendix F

Federal Climate Change Research and Development and Response Drivers and Network

Appendix G

Breakout Session Summaries

G1 Service Breakout: Army/Air Force

G2 Service Breakout: Navy

G3 Coastal Environments

G4 Cold Region Environments

G5 Inland and Arid Region Environments

G6 Vulnerability and Impact Assessment

G7 Adaptation and Mitigation Science

Footnotes

Preface

For the Department of Defense (DoD) the implications of climate change and associated climate variability permeate all aspects of the Department's missions and responsibilities: operational, military readiness, maintaining infrastructure to support the mission, compliance, and stewardship. Although from one perspective climate change is simply an added stressor layered atop already existing stressors, its broad reach, tendency to exacerbate the effects of other stressors, and in some cases its capability to lead to irreversible changes in physical and biological systems compels a new way of responding to its challenge. The time horizons relevant to climate change processes and impacts to be considered in planning and decision making become extended—perhaps significantly. Rather than addressing the implications of climate change as an isolated policy and management concern, it may be more effective to weave its issues into any number of existing planning documents and decision processes. The risk envelope, including associated degrees of uncertainty, that must be considered in view of climate change is greatly expanded. Most importantly, the complexity of climate change and the potential costs of risk management actions, or even no action, compel an adaptive decision making framework that includes establishing and sustaining a process and dialogue involving policy makers, end users, and the research community. Such an ongoing dialogue can assist DoD policy makers in understanding the nature of decisions potentially affected by climate change, their spatial and temporal domains, and the appropriate climate change scenarios and climate-related information— informed by the best available science—to consider when making a range of decisions. Moreover, it provides an avenue of assessing and managing the potential regret of inaction to avoid sustained, severe, and widespread impairments to DoD missions. To start this dialogue, and to help frame a path forward, several organizational elements of DoD's research and development community convened a workshop in July 2011 involving both DoD researchers and policy makers, as well as other key elements of the federal climate change research and climate services community. This report represents both a synopsis of the workshop discussions, as well as a synthesis of ideas arising from the workshop that are offered in the spirit of moving the dialogue and the development of relevant technical capabilities forward.

Executive Summary

Department of Defense (DoD) policy calls for a strategic approach to the challenges posed by global climate change and climate variability. The February 2010 Quadrennial Defense Review recognized that climate change will affect the Department in two broad ways:

- First, climate change will shape the operating environment, roles, and missions that DoD undertakes.
- Second, the DoD will need to adjust to the impacts of climate change on its facilities and military capabilities.

To assist the Department in responding to the above challenges, the focus of this workshop was twofold: first, to establish a DoD network of funding entities and research centers and laboratories involved in climate change-related research and demonstration and second to identify the role that DoD's research and development

(R&D) community could serve to (1) assist DoD policy makers by providing the technical foundation for advancing new policies related to climate change and (2) provide DoD resource, infrastructure, and operational managers the needed science information, models, and tools needed to implement the effects of policy "on the ground." The workshop emphasized that climate change, including changes in climate variability, should be viewed in the broader context of global change phenomena that affect the ability of DoD to accomplish and sustain its missions into the future.

The workshop included a workshop introduction, plenary sessions, and breakout sessions. Plenary sessions included briefs from federal non-DoD participants regarding the US Global Change Research Program, National Climate Assessment, and the emerging effort at the federal level to provide climate information services and how DoD may relate to these activities. Policy perspectives on the role of and need for climate change science were provided by the Office of Secretary of Defense (OSD), military Services, and US Army Corps of Engineers Civil Works representatives during additional plenary sessions. Facilitated breakout sessions occurred on each of the three days of the workshop. These sessions enabled assessing climate change information needs from a number of different perspectives.

Workshop participants noted that specific step-down policy and guidance regarding climate change vulnerability, impact, or risk assessment and adaptation generally has yet to be issued at the Department level. This includes but is not limited to defining bounding assumptions and their temporal and spatial scales, such as sea level change, climate change, and extreme event scenarios, to guide vulnerability, impact, and risk assessments, as well as development of adaptation strategies and actions. As a result, the plenary sessions and policy panel discussion highlighted the need for and challenged the DoD R&D community to assist with providing technical support to the policy community that would meet their needs. Besides defining the technical bounds of policy-relevant information related to climate change, workshop participants also noted that the R&D community has a responsibility to translate the implications of the science and technology needed by policy makers and to provide the end-user (installation managers and operational units) with actionable information.

The Department possesses a range of science and engineering capability relevant to understanding and analyzing the vulnerabilities, threats, and risks that climate change poses to DoD assets, infrastructure, and future missions. Future development and coordination of this capability, across OSD, the Services, and the Corps Civil Works program will enable DoD to capitalize on its corporate technical capacity and effectively leverage the technical capacity in other agencies and organizations.

Workshop participants developed an initial blueprint for a DoD climate change research agenda. Research needed to support DoD's response to climate change involves both fundamental and applied science, as well as translation of that science into actionable information for policy makers and end-users. On a thematic basis, research and translation needs can be divided into climate system modeling, physical forcings and environmental process modeling, assessment and adaptation methodologies/strategies. DoD's R&D community will often not be the primary provider for all research needs, but will still serve a vital role in fulfilling DoD-specific research and translation needs. DoD sponsored research should be responsive to user-defined needs.

Policy and guidance have yet to be firmly established to support both tactical and strategic planning in the face of climate change. What the Department needs is a robust, scientifically defensible approach that transparently communicates risks to the end-user and helps policymakers develop guidance to promote mission sustainability in the face of climate change. Although R&D on built and natural infrastructure response to climate change has progressed in recent years, a coherent vision of installation and operational military vulnerabilities has not been compiled. Policy awareness is emerging, but its growth and maturity to meet both strategic and tactical DoD needs would be best served by an ongoing and interactive dialogue between the policy and R&D communities. Adaptive, risk-based decision frameworks that assess vulnerabilities, impacts, and risks, as appropriate, are needed and should be developed jointly and iteratively between the R&D and policy communities to incorporate climate change into tactical and strategic planning activities, with prioritization based on the types of decisions to be made and their spatial and temporal aspects.

The workshop resulted in five primary recommendations:

1. The Department, inclusive of the military Services and U.S. Army Corps of Engineers, Civil Works program, has an ongoing need to assess the state of the science, practice, and policy needs relative to understanding the mission challenges raised by climate change and the framing of appropriate responses to such challenges, including their spatial and temporal aspects.

2. The DoD R&D and policy communities should establish those mechanisms necessary to maintain an ongoing dialogue.

3. To support DoD's Climate Change Adaptation Planning Task Force—whose establishment by OSD(Installations & Environment) is underway—DoD should consider establishing a DoD Climate Change Science Technical Workgroup that can interact directly with the Task Force on matters of climate change science-policy intersection. At least one member of the Workgroup should be a member of the Task Force and serve a liaison function.

4. The DoD R&D community must provide defensible science, models, and tools to support DoD and the Services' needs regarding climate change and extreme event forecasting ability to meet operational needs, vulnerability and impacts assessments based on robust climate change scenarios, adaptation science, and mitigation.

5. We do not have the resources to respond to the challenge of climate change alone. DoD should establish new and strengthen existing relationships with the federal R&D community, in part by participating in inter-agency research coordination efforts, to leverage resources, avoid redundancy, and highlight the Department's research needs.

Chapter 1

Introduction

Department of Defense (DoD) policy calls for a strategic approach to the challenges posed by global climate change and climate variability. The February 2010 Quadrennial Defense Review (QDR) recognized that climate change will affect the Department in two broad ways:

- First, climate change will shape the operating environment, roles, and missions that DoD undertakes.
- Second, the DoD will need to adjust to the impacts of climate change on its facilities and military capabilities.

The QDR also recognized that DoD must develop policies and plans to manage the effects of climate change on its operating environment, missions, and facilities, including addressing the potential impacts to DoD natural and built infrastructure at permanent installations that support DoD's national security mission and to adapt as required. And finally, the QDR highlighted the need for DoD to regularly reevaluate climate change risks and opportunities and to work collaboratively with outside partners to meet the challenges posed by climate change.

In addition to DoD policy, Executive Order (EO) 13514, Federal Leadership in Environmental, Energy, and Economic Performance, directed Federal agencies to assess both their vulnerabilities to climate change and the need for possible adaptation strategies. This EO, among many of its provisions, established the Interagency Climate Change Adaptation Task Force and mandated that each agency develop, implement, and annually update a Strategic Sustainability Performance Plan (SSPP). The required content of the SSPP compelled each agency to initially articulate how it would "evaluate agency climate-change risks and vulnerabilities to manage the effects of climate change on the agency's operations and mission in both the short and long term." The initial DoD SSPP was submitted to and approved by the Council on Environmental Quality (CEQ) during the summer of 2010.

More recently, under the authority of EO 13514 the CEQ issued Federal Agency Climate Change Adaptation Planning Implementing Instructions in March 2011 that mandated each agency submit, concurrent with

their updated SSPP, a separate Climate Adaptation Plan by June 2012. An intermediate step to this plan is a Department-level analysis of key vulnerabilities to climate change due to CEQ by March 2012.

Separate from these policy drivers, but at this point in time uniquely related to these drivers, the DoD is participating as a member agency of the US Global Change Research Program (USGCRP) and on an interagency task force associated with the National Climate Assessment (NCA), which is an every four-year assessment mandated by the Global Change Research Act of 1990 of the state of climate science and the potential impacts of global change, primarily climate change, at the national scale. Both of these efforts enable DoD to air its concerns relative to the effects of global change on its missions and to influence and keep abreast of the state of the science and future research priorities.

With the preceding as a backdrop, the focus of this workshop was first on establishing a DoD network of funding entities and research centers and laboratories involved in climate change-related research and demonstration and second on identifying the role that DoD's research and development (R&D) community could serve to (1) assist DoD policy makers by providing the technical foundation for advancing new policies related to climate change and (2) provide DoD resource, infrastructure, and operational managers the science information, models, and tools needed to implement the effects of policy "on the ground." The workshop emphasized that climate change, including changes in climate variability, should be viewed in the broader context of global change phenomena that affect the ability of DoD to accomplish and sustain its missions into the future. Specific workshop objectives are contained in the workshop charge, which is included as part of Appendix A1.

The workshop was held July 19 through July 21, 2011 in Aurora, Colorado. This report is a summary of workshop proceedings and resultant findings, implications, and recommendations as developed by the workshop organizers. Workshop organizers included: the Office of Naval Research (ONR), which also was the sponsoring entity; Department of Defense, Strategic Environmental Research and Development Program (SERDP); Navy Task Force Climate Change (TFCC); and US Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC). Workshop participants included both members of the DoD climate change R&D community and Office of Secretary of Defense (OSD), military Services, and USACE Civil Works policy community representatives. Select members of the federal non-DoD research community also participated. The complete list of participants is provided in Appendix B.

The workshop included a workshop introduction, plenary sessions, and breakout sessions (see the complete workshop agenda in Appendix A2). Plenary sessions included briefs from federal non-DoD participants regarding the USGCRP, NCA, and the emerging effort at the federal level to provide climate information services and how DoD may relate to these activities. Policy perspectives on the role of and need for climate change science were provided by OSD, military Service, and USACE Civil Works representatives during additional plenary sessions. Facilitated breakout sessions occurred on each of the three days of the workshop. These sessions enabled assessing climate change information needs from a number of different perspectives that included: Service-specific needs, biophysical region (i.e., coastal environments, cold region environments, and inland and arid region environments), functional area (i.e., vulnerability assessment, impact assessment, adaptation science, and mitigation science). Charges specific to each breakout session are provided in Appendix A3.

The remainder of this report is divided into a series of chapters and supporting technical appendices. Chapter 2 provides brief summaries of the plenary sessions, policy panel discussion, and breakout sessions that highlight the key points and findings. Chapter 3 provides an overarching synthesis of the workshop's main findings and emerging themes, whereas Chapter 4 focuses on the key recommendations for continuing the dialogue between the DoD R&D and policy communities plus other specific recommendations. Appendices include: background information on and summary information from the workshop (i.e., charges, agenda, and breakout session summaries; Appendix A); list of participants (Appendix B); glossary (Appendix C); list of acronyms/abbreviations (Appendix D), DoD R&D organization summaries (Appendix E); a network wiring diagram to facilitate an understanding of how DoD relates to ongoing federal efforts, such as the USGCRP, NCA, and the Adaptation Task Force, and key points of contact within DoD (Appendix F), and breakout session summaries (Appendix G).

Chapter 2

Plenary and Breakout Session Summaries

The workshop format consisted of both plenary and breakout sessions. In the sections below, brief overviews of the plenary presentations are provided followed by a synopsis of the breakout session discussions. A more complete description of each breakout session discussion is provided in Appendix G.

2.1 Plenary Summaries

The workshop used several different sets of plenary sessions and a final panel discussion to (1) introduce workshop participants to the purpose and scope of the workshop, (2) provide context as to how the Department of Defense's (DoD) climate change, research and development (R&D) efforts fit into the broader federal enterprise, and (3) provide the perspectives of Office of Secretary of Defense (OSD), military Services, and US Army Corps of Engineers (USACE), Civil Works offices responsible for climate change-related policy development within their respective organizations. Presentations summaries are included within the day that they occurred during the workshop.

2.1.1 Day 1

Dr. Charles L. Vincent (Navy: ONR) and Dr. John Hall (OSD: SERDP/ESTCP)—These speakers delivered the opening welcome to the workshop and provided their perspectives on the purposes of the workshop and what they hoped to achieve. Importantly, they each outlined during their presentations and throughout the workshop their respective organizational roles in representing DoD in regards to the US Global Change Research Program (USGCRP; Dr. Vincent) and the National Climate Assessment (Interagency Task Force and Federal Advisory Committee) and Adaptation Science Workgroup (Dr. Hall). Appendix F attempts to graphically depict these complex organizational relationships. Dr. Hall also presented a conceptual framework for coordination among the R&D, policy, and end-user communities (see section 4.2 for one example illustration).

Dr. Tom Armstrong (USGCRP; via teleconference)—Dr. Armstrong provided an overview of the USGCRP. This included a recounting of its history, vision and mission, its organizational structure and program functions, and a vision for climate services. He then provided a description of the new decadal USGCRP strategic planning effort, including the goal structure of the new plan and the timeline for its preparation, review, and revisions prior to final approval. Dr. Armstrong then concluded with an overview of the National Climate Assessment (NCA).

Ms. Maureen Sullivan (OSD: I&E, Environmental Management)—Ms. Sullivan posed two fundamental questions to the audience that needed to be addressed by DoD in responding to climate change: Focus on what assets? Focus on what scenarios of climate change? She then went on to describe the current drivers for DoD action: the February 2010 Quadrennial Defense Review and the March 2011 Council on Environmental Quality (CEQ)-issued Federal Agency Climate Change Adaptation Planning Implementing Instructions. Ms. Sullivan briefly described DoD assets at risk from climate change and then described the near-term actions that DoD is taking to respond. She concluded with a challenge to the R&D community to identify what they needed from the policy community to assist DoD in rising to the challenge.

Mr. Frank DiGiovanni (OSD: TRS)—Mr. DiGiovanni described the role of his office, why it is concerned with climate change and its potential impact on military readiness, and his goal to pose for the audience some readiness-focused climate change research and development thoughts. He challenged the audience that to be adaptive, including under climate change, one must question the norm and be able to function at high levels of ambiguity [uncertainty]. He summarized some potential range, training, infrastructure, and operational issues and offered that to adapt from a readiness perspective may require new types of training infrastructure and new ways of training. Mr. DiGiovanni posed the question whether the Department's climate change adaptation strategies can draw from human adaptation models. He concluded with a call for developing leading indicators of change regarding impacts to readiness, following an iterative approach to learning that includes robust feedback mechanisms, and solving problems within the correct context—context matters.

Mr. James Dalton (USACE: Engineering and Construction)—Mr. Dalton provided the US Army Corps of Engineer (USACE), Civil Works program perspective on the challenges climate change poses to USACE missions,

especially water resource management. He provided an overarching vision that engineers in the Corps must be able to successfully perform their missions, operations, programs, and projects in an increasingly dynamic physical, socioeconomic, and political environment. Climate change has caused a shift in the decision paradigm from equilibrium to dynamic—stationarity is dead. Mr. Dalton then provided an overview of the Corps' efforts to conduct a nation-wide screening-level assessment of vulnerability to climate change across its eight business lines and their pilot adaptation studies. He concluded with a summary of next steps and short list of engineer needs relative to climate change information.

2.1.2 Day 2

CAPT Tim Gallaudet (Navy: Oceanographer of the Navy)—CAPT Gallaudet provided a mini-overview of climate change phenomena and then presented the fundamental challenge: the scientist-public disconnect in the understanding of climate change and what to do about it. He then described the Navy's initial efforts regarding climate change leading to the establishment of Task Force Climate Change in May 2009, their major concerns with respect to climate change impacts, and their current approach for responding. CAPT Gallaudet provided an overview of the Navy's current vision for an installation vulnerability assessment. With respect to Arctic issues and climate change, he indicated that policy development will lead to capability development within the context of how climate change may affect those capabilities.

Mr. Daniel Kowalczyk (Air Force: SAF/IEE)—Mr. Kowalczyk described the Air Force's approach to planning for climate change. The Air Force is planning for impacts across three broad areas: installations and the built environment; roles, missions, and the operating environment, and natural environment and stewardship responsibilities. Mr. Kowalczyk outlined the Air Force's manner of addressing climate change through a planning framework focused on four key areas: mitigation, adaptation, collaboration, and education. Their adaptation component included a qualitative vulnerability assessment from the QDR that indicated risk to Air Force installations but perhaps not to the degree of the other Services. He also described a recent projected-climatology tool under development by the US Air Force's 14th Weather Squadron. This tool will enable direct comparisons between climate conditions projected to occur at installations for the 2030 to 2050 time period to locations that have that same climate today. This will facilitate conceptualization by military planners and policy makers of the impacts potentially occurring under climate change and to better plan adaptive strategies.

Mr. Tom Mooney (Army: ODASA(ESOH))—Mr. Mooney provided the Army's perspective on climate change by first describing the vast amount of assets under Army control and the Army's sustainability vision that also accounts for the challenge of climate change. He then described how the Army has incorporated its strategic response to climate change through its Army Sustainability Campaign Plan, issued May 2010. One task of the plan involves developing guidance for conducting installation/facility level vulnerability and risk assessments to analyze global climate change (GCC) impacts to mission and programming for GCC adaptation and mitigation measures, whereas a second task mandates completing the preceding assessments during scheduled updates of installation/facility-level management plans and programming for GCC adaptation and mitigation measures in future Program Objective Memorandum (POM) cycles.

Panel Discussion (Sullivan, Gallaudet, Kowalczyk, and Mooney)—The panel was posed several questions and the following represents a summary of the unattributed responses and audience feedback. Some bullets may represent the contribution of more than one person when a particular point received comment. The questions ranged from greatest needs to inform policy formulation to how to craft a strategic message on what is important to the role of the joint staff. The responses can be summarized as follows:

- Need basic science information at the regional scale to support vulnerability assessments at the regional and local scales in a manner that is understandable and actionable.
- Need to explain the fidelity of the information developed and used for assessments and planning.
- Maintain technical accuracy but translate information within a comprehensive but accessible context that policy formulators understand.

- Need to have a relationship with the R&D community through the right venues that can facilitate a two-way communication of information.
- New processes not necessarily needed. Need participation in existing mechanisms. Ensure right people connected.
- Need the research arms of OSD and the Services to develop a strategic message on what is important and how to translate the information to interested/affected parties.
- Joint staff not currently heavily involved in addressing initial climate change challenges, but the concept is of interest and would need Administration support to engage. Perhaps consider initial engagement through J4 (engineer-programs offices).
- Develop scientific questions that need to be answered to make mission decisions; account for the operational needs of the future.
- Possible partners for strategic sustainability: State Department, US Agency for International Development, Combatant Commands, and US overseas embassies. Consider impacts on human populations and likely responses.
- State more clearly by sector:
 - * What types of answers are needed to make decisions?
 - * Over what timeframe are answers needed?
 - * How much uncertainty can be tolerated in solutions?
- Explain climate change R&D needs in terms of DoD priorities:
 - * Prevail in current conflicts
 - * Prepare for future conflicts.
- Update assets to endure through climate change impacts.
- Context matters in the climate-society interface. Adaptation is a process and not a single decision. Need to develop decision calendars—timelines for decisions.

Dr. Eileen Shea (NOAA, National Climate Data Center)—Dr. Shea's main theme was climate services for society: challenges and opportunities. She began by articulating what an ability to effectively anticipate and respond to climate change requires. Dr. Shea then described how climate change already is affecting society and what it means to adapt to climate change. She then addressed the federal role in adapting to climate change, with an emphasis on meeting the rising demand for climate services and the National Oceanic and Atmospheric Administration's (NOAA) vision for doing so. Dr. Shea then put the issue of climate information provisioning into a broader federal perspective and the recent federal efforts to better coordinate information provisioning and form eight regional hubs that align with the geopolitical regions used by the NCA to conduct regional assessments. She concluded with some shared lessons on meeting stakeholder climate science and service needs.

2.2 Breakout Session Summaries

The workshop used a combination of military Service breakout and thematic breakout sessions to explore climate change information needs. Service breakouts took place on day 1 and the thematic sessions on Days 2 and

3. Synopses of discussions are provided in the following sections. Narratives generally follow the sequence of questions articulated in Appendix A3 for the particular session. See Appendix G for more detailed accounts.

2.2.1 Day 1

Service Breakout: Army/Air Force—The Army and Air Force are both engaged in organizational activities with respect to the generation and use of climate change information. Within the Army, the five elements currently engaged include the Army Installation Management Command (IMCOM), Office of the Assistant Secretary of the Army for Installations, Energy, and the Environment (ASA(IE&E)), Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)), Office of the Assistant Secretary of the Army for Civil Works (ASA(CW)), and U.S. Army Engineer Research and Development Center (ERDC). Within the Air Force, climate change is currently being addressed within the Office of the Assistant Secretary of the Air Force (Installations, Environment, and Logistics; SAF/IE). Within SAF/IE, the Deputy Assistant Secretary of the Air Force (Environment, Safety, and Occupational Health; SAF/IEE) is leading climate change-related initiatives. With the exception of ASA(ALT), each of the preceding organizations are interested in and should receive updates on opportunities to participate in regional assessment activities associated with the National Climate Assessment.

Both the Army and USACE are currently investing in research related to assessing the impacts of climate change and their management. The ASA(ALT) supports environmental research related to the management of technology development and Army operations, which includes consideration of climate change impacts relevant to Army missions. The U.S. Army ERDC holds the lead role for conducting environmental research supporting both the Army's military and civil works missions, including climate change. As such, ERDC is currently conducting research to expand the Army's and USACE's capabilities to assess and manage risks related to climate change and variability. The USACE Institute for Water Resources is supporting the ASA(CW) through the development of policy and guidance for using existing science on coastal and inland hydrology, sea level change, flood frequency analysis, reservoir sedimentation, and droughts and other climate related topics. See Appendix E for a description of specific R&D activities underway within the Army.

Army and Air Force needs/requirements for climate change information relate to developing relevant process information, analytics for informing assessments and decision making, and reliable approaches for projecting future conditions. Requirements for process information relate to the need to: (1) use physical lines-of-evidence that can be measured currently to improve the modeling of climate processes at the regional scale, (2) reduce the uncertainty associated with the relationship between greenhouse gas (GHG) emissions and future consequences, and (3) understand the impacts of climate variables on the performance of DoD systems (e.g., ships, aircraft, sensors, etc.). The needs regarding analytics supporting assessments and decision making concern: (1) methods for characterizing and quantifying the implications of uncertainty in modeling and prediction for decision making, (2) improving methods for downscaling information and model predictions to scales that are relevant for the decisions under consideration, and (3) tools that support the development and evaluation of robust adaptive risk management strategies and plans. The need to improve capabilities for reliable prediction of future conditions under the influence of climate relate to: (1) predicting future energy and water conditions (including water quality, quantity, and demand) in relation to installations and future operational environments and (2) identifying environmental tipping points relevant to global and regional security and to managing built and natural infrastructure at installations.

The Army and Air Force expect to use climate change information in the following ways:

- Increasing the situational awareness of senior leadership on climate change phenomena and potential Service vulnerabilities and global risks at the strategic level.
- Risk assessment and identification of management actions that can be taken to reduce risks to the portfolio of Service assets, infrastructure, and missions at the full range of scales: globally, regionally, and locally.
- Technology transfer of tools and data to end users within operational organizations and at installations to support the development of local strategies and plans to address the projected consequences of climate change, including adverse effects caused by extreme events.

Service Breakout: Navy—The Navy's Task Force Climate Change (TFCC) is the principal Navy organization responsible for developing policy, requirements, and identifying Navy research requirements regarding climate change science, mitigation, and adaptation. All Navy components have representatives on TFCC who identify their organization's needs and questions regarding climate change science and research. These needs exist on spatial scales from sub-regional to global and on operational scales from tactical to strategic. As a result, a wide range of needs exist, including the development and implementation of mission/ operational/campaign plans, infrastructure/facilities plans, education and outreach, policy development, development of Naval platforms, weapons and sensors, and the investments associated with these efforts.

Improvements are needed in the climate science and climate information necessary for addressing these Navy requirements, including: (1) developing models with higher temporal and spatial resolution; (2) developing a range of model types (e.g., statistical, dynamical, statistical-dynamical, multi-model); (3) improving the physics in physical models of sea ice, ice sheets, the atmosphere, the ocean, permafrost, and coastal zones; (4) reducing and quantifying the uncertainties of these physical models; (5) providing probabilistic output from climate models and in climate assessments; (6) improving understanding of abrupt climate change scenarios and likelihood; (7) improving modeling of geoengineering deployment and associated global system response; and (8) addressing the wide variety of adaptation science interest areas for the Navy, such as improving surface ship/system operational performance in cold regions and adapting coastal installations to sea level rise.

The Navy has several ongoing and planned activities related to climate change vulnerability and impact assessment, adaptation science, mitigation, and climate modeling. Organizations sponsoring or contributing to this work include the Office of Naval Research (ONR), the Naval Research Lab (NRL), the U.S. Naval Academy (USNA), the Naval Postgraduate School (NPS), the Naval War College (NWC), the Naval Facilities Engineering Service Center (NAVFAC ESC), TFCC/Oceanographer of the Navy, and the OSD's Strategic Environmental Research and Development Program (SERDP).

Although current Navy research efforts address these needs to varying degrees, new research is needed in: data access, management, and fusion; decision support; risk and uncertainty quantification; adaptation science; applications of operations analysis to climate change impacts/scenarios; and effective visual representation of climate data and predictions.

The greatest impediments to progress in supporting Navy climate change needs are the lack of availability of resources, educated personnel, and perception of the importance of climate change impacts on national security. In addition, it is important to define the scope of climate change and climate variability for Navy research and applications. Some important elements to consider when defining this scope are temporal and spatial scales of variability, valid periods for prediction, rate of change (e.g., abrupt climate change), high priority regions, spatial and temporal interactions within the climate system (e.g., teleconnections), and geoengineering.

2.2.2 Day 2

Coastal Environments—Increased knowledge is required of how climate change effects will transform coastal hazards and system drivers. In addition, understanding vulnerabilities and risks is needed for installation management and for natural systems and training under climate change drivers and hazards. Finally, knowledge also is needed on civil works infrastructure conditions and associated performance that installations depend on that also may be impacted by climate change.

Improvements are needed in model coupling for computational efficiency and representation of non-linear/dynamic feedback of climate change, scenario-driver influences on quantification of solutions. Techniques for characterization of uncertainties that propagate through the assessment process are required for further development. The importance of using iterative approaches at different scales for alternative solution development and refinement must be emphasized and enhanced. Inventory of new climate change knowledge development (e.g., seasonal-scale variations in forcing) is required, beyond linking existing knowledge for executing vulnerability and risk assessments to support the ability to examine adaptations. The capability to work at multiple scales with existing methods/models and evolving them and the underpinning science are enablers that should be pursued. Significant improvements are needed in ecological modeling with guidance on how to sustainably assist natural

processes in coastal marshes that can enable such marshes to keep up with sea level change. Identification is required on the tipping points in installation mission impairment that result in going from minor to catastrophic impacts, as well as for natural asset functionality.

Improved capabilities of earth systems instrumentation and greater span of deployments for data collection are critical to enabling quantitative assessments. Increasing the amount of computing power available to DoD scientists would be very supportive for achieving enhanced model resolution and run cycle times. Methodological approaches to explore the effects of non-linear feedbacks of systems and process models on risk assessment are required.

Cold Region Environments—This breakout session explored the science and technology requirements for DoD in cold region environments and how to best transition such science and technology to the operational level and into programs of record. The most critical gaps regarding assessing and responding to risks for natural and built infrastructure in cold region environments include the lack of skillful predictive capability, incomplete understanding of the physical processes, the lack of skillful downscaling processes, and inadequate data sets. The physical phenomena that are most important but least understood include currents, sea ice, storm frequency and intensity, bathymetry, shoreline and geoid characterization, and permafrost.

To best transition science and technology to the operational level and into programs of record, existing programs designed for this purpose should be used. Examples of general DoD/Navy processes include OSD's Joint Capability Technology Demonstration (JCTD) process, the Navy Trident Warrior (TW) events for Fleet experimentation, and use of Joint Urgent Operational Needs Statements (JUONS) by the Combatant Commanders. Examples specific to environmental observation and prediction include the Naval Oceanography Enterprise's Rapid Transition Program (RTP), the Administrative Modeling and Oversight Panel (AMOP), the Naval Oceanographic Partnership Program (NOPP), and the Oceanographic and Atmospheric Master Library (OAML). Other mechanisms include efforts led by OSD's SERDP, USACE's Cold Regions Research and Engineering Laboratory (CRREL), the Navy's ONR and NRL, National Ocean Council (NOC), Unified Facilities Criteria (UFC) process, Defense Science Board (DSB), Naval Studies Board (NSB), State Department's Arctic Policy Group (APG), Center for Naval Analyses (CNA), and National Research Council (NRC). All of these organizations have conducted studies that have informed DoD programs of record on cold region science and technology requirements.

Inland and Arid Region Environments—Inland regions of the US, particularly those in the arid Southwest, are projected to experience acute responses to climate change in the next century. As evidenced by recent trends, the Southwest is warming more rapidly than many other regions of the nation. The warming has led to declines in spring snowpack and Colorado River flows. Increases in summertime temperatures will exacerbate urban heat island effects and alter the hydrologic cycle. When combined, these threats foretell serious water supply crises in the decades to come. These trends are projected to continue or even accelerate under the higher end emission scenarios. Key concerns for the area include:

- increasingly scarce water supplies leading to conflicts between competing users;
- increasing temperature, droughts, and wildfires transforming the landscape;
- shifts in biodiversity and species composition (i.e., loss of indigenous species unable to adapt to the new setting or unable to adapt quickly and invasive species encroachment); and
- changes in timing and frequency of flooding.

For the military these changes can be considered a significant challenge to military readiness. In order for inland military leaders to adaptively manage their installations and assure mission performance into the future, critical scientific gaps in our understanding and knowledge of climate change and ecosystem response must be addressed. In the absence of policy and guidance, and lacking a cohesive understanding of natural ecosystem response to climate change, threats to infrastructure and weapons systems overshadow an installation manager's

abilities to operate adaptively. Risk-based strategies and tools that help installation managers visualize ecosystem response to a variety of "What-if" scenarios are desperately needed to tactically and strategically respond.

Numerous scientific, engineering, and technological gaps must be addressed to inform decisions within this risk-informed decision making framework. Developing ecosystem response models that can characterize or capture the variability of these inland systems (given uncertain inputs from the climate models) is required. Infrastructure response models also are needed. Hydrologic modeling that indicates the frequency and magnitude of expected flooding, as well as 3-D groundwater modeling, is needed to characterize the threat to current military operations. Many of these technologies (models and decision support systems) exist, but have never been applied to the climate change problem. Other tools/models will need to be devised to address the unique challenges of adaptive management in the face of an uncertain future. Flexibility will be the key to developing useful tools to meet the challenge of dynamic climate change.

But first, installation managers need science-informed, defensible policies and guidance, tailored specifically to their 'decision-space' with directions on how to incorporate climate change and environmental response into decision making at multiple decision-making levels. These frameworks must be flexible/pliable so that the design criteria and specifications can be adapted as more information becomes available in the future. Thus, new guidance should tie to Master Plans and other similar documents and incorporate the following details:

- accepted levels of confidence and degrees of acceptable uncertainty;
- planning horizons;
- identification of credible emission scenarios to use and their sources that drive the climate models to generate anticipated "x, y, & z" environmental responses;
- identification of what the end-user or installation manager should consider (i.e., precipitation, temperature, etc.);
- contractual qualifications/capabilities; and
- incorporation of monitoring and iteration (adaptive management).

2.2.3 Day 3

Vulnerability and Impact Assessments—Scientifically underpinned and strategically orchestrated modeling of changes in climate that potentially impact DoD installations must clearly describe how and under what scenarios DoD installations are vulnerable and could be adversely impacted by climate change. Tools that elicit value-laden responses of decision makers, based on this information, are needed to distinguish impacts on a relative basis and to rank negative and positive impacts to mission functions and supporting assets/capabilities for individual installations. These tools should employ indicators for describing system performance at successively higher levels in a framework that is able to cut across installation and command missions by type and by region on a geographic basis. Outputs should elevate the most certain and urgent potential losses and opportunities to sustaining performance of mission-critical infrastructure/training settings that are most effectively, efficiently, and expediently addressed via risk reduction and adaptation. Understanding is also needed on where to strategically focus investigative resources in successive tiers/iterations of vulnerability assessment, following the general approach described above, to scope where impact assessment is required within installation systems to sustain missions. Finally, identification of critical gaps in knowledge and understanding is an output requirement on climate science relevant to supporting future, continued vulnerability assessment.

Comprehensive impact assessment, as it relates to climate change variability and extremes, requires the ability to describe systems-scale performance in a probabilistic manner for objectives of interest from the present time into the long term, considering plausible future scenarios about key drivers with remaining uncertainties in scientific understanding. As a result, sufficient scientific understanding is needed to model the following in support of quantitative impact assessment at installations:

- projected changes in climate variability and extremes for the timeframes of concern at sites considered;
- characterized climate changes to the system considering current/planned practices;
- predicted changes in system forcings attributable to projected changes in climate; and
- definition of boundary conditions under a changing climate regarding interaction with external systems in which the installation is dependent.

An inventory of science, models, and tools that are available with explanation of their strengths and weakness is needed by the impact assessment community to support this work.

Policy and technical guidance should include those factors that will aide decision makers in advancing studies for identifying and acting upon the potential for large-scale, frequent, and long-duration likelihoods of loss to installation mission performance, as well as strategic opportunities for exploitation in further advancing missions. These include evolving national and international governance, identifying and articulating policy goals and objectives and how those translate from the strategic down to the tactical level, describing the types of policy decisions that need to be made and on what timelines, and providing the means for mission managers to effectively engage researchers in a role of technical support.

For research activities to be highly relevant and richly successful in addressing climate change for installation sustainability, they are best integrated systematically into the installation operations for deep, continuous engagement of their community of practice. This would sufficiently engage end-users for practically developing and implementing vulnerability and impact assessments that work to achieve aims.

Adaptation and Mitigation Science—Given the uncertainties of changing climatic conditions, and the potential vulnerabilities of Defense missions and assets to these changes, a key capability needed by Defense decision makers is a framework that provides relevant new condition data that is linked to Defense missions and assets. This framework may include many elements: such as structured human interactions, database updates and automated analysis, and visualizations and consequence analysis. It also should be relevant at multiple scales, as changing conditions need to be viewed and understood in multiple timeframes and against various short- and long-term response scenarios.

Natural systems that may be impacted sooner than later or to a greater extent include: shorelines, coastal fringe systems, groundwater and surface hydrology, sea ice, coastal erosion, ice sheets, and arctic land surfaces (tundra, permafrost, and methane release issues). Issues of concern include the stability of these systems in changing climatic conditions, threats to protected species under changing conditions, and changes in ecosystem dynamics, especially those changes that impact mission activities. Dialogue is needed with regulatory agencies responsible for various natural systems that might be impacted: such as for wetlands, endangered species, and protected marine ecosystems and species. In addition, the rapid implementation of renewable energy technologies, in part to reduce dependencies on fossil-based fuels, is having ecological impacts that need to be better understood.

For new facilities (and infrastructure) and for existing facilities that are being upgraded, changing climatic conditions are anticipated during their design life. Current engineering parameters, however, do not include any such considerations. As a result, a pathway is needed to develop an acceptable approach to update these engineering design parameters. For the most part, the guiding principles for smart planning increase climate resilience in facilities and infrastructure, and they should be applied at both the facility and the campus level. In addition, planning should incorporate regional and local data relevant to changing conditions: climate, land use, population, and other change factors. Facility research should seek to build climate resilience into future construction materials.

Because adaptation requires a strong linkage between data, analysis, and operational changes, R&D activities need to be closely integrated with operational activities. This can be accomplished by various bridging strategies, such as reach-back, staff exchanges, cross-teams (field operations, managers and technical teams) and social media that link stakeholders in collaborations on data analysis and the implications for operational

adjustments. In addition, science and technology outcomes need to be tailored to fit into operational processes, by sharing the plan documents, spreadsheets, maps, and visuals used to make the operational decisions with the R&D capability developers and targeting their outcomes to more directly link to these operational decisions.

Climate change occurs over a long time line, so every update and iteration of a plan is an opportunity to insert new data, new analysis, and planned observations or adaptations. This needs to be done across all plans impacted by changing climatic conditions (master planning, strategic planning, sustainability planning, natural and cultural resource management planning, training planning, infrastructure assessment, etc.) and these plans all need to interact in a dynamic fashion, in which updates to one plan are linked and coordinated, as they are made, across all other impacted plans. To accomplish this, policy and guidance documents need to be updated, to routinely require such adjustments, and to incorporate capabilities to establish useful feedback across plans that help guide users through multiple planning adjustments.

The specific policy and technical guidance needed by Defense organizations will vary over time, and the most logical way to ensure that the appropriate strategies, models, tools, and technical input are available to Defense organizations is to establish, in support of a Defense working group on climate change adaptation, necessary technical participation through technical support committees or otherwise. These committees need to have strong linkages with the USGCRP and the NCA, as well as with other agencies that are gathering, analyzing, and providing technical data on changing climatic conditions. Members of technical committees should include key R&D organizations across the Department of Defense that are engaged in adaptation-related topics.

Chapter 3

Workshop Synthesis: Major Findings and Emergent Themes

The unique nature of this workshop—the bringing together of those individuals involved with climate change policy development from the Office of Secretary of Defense (OSD), military Services, and US Army Corps of Engineers (USACE) Civil Works program, the Department and Services' research and development (R&D) community, and external federal partners in an initial dialogue—reaffirmed that climate change matters to the Department of Defense (DoD) and an effective response will require close and continuous integration between the DoD policy and R&D communities, as well as effective partnering with other federal agencies via a whole-of-government approach. The various workshop plenary and breakout sessions, supplemented by the policy panel and general discussions that occurred throughout the workshop, highlighted a number of major findings and emergent themes that are synthesized and summarized in this section. To best develop and portray this synthesis, the information that follows is subdivided into thematic categories rather than by type of session as in Section 2.

3.1 The Context for a Response to Climate Change in the Department of Defense

The current policy drivers for DoD action with respect to climate change are the February 2010 Quadrennial Defense Review and the March 2011 Council on Environmental Quality (CEQ)-issued Federal Agency Climate Change Adaptation Planning Instructions. In addition, DoD articulated its broad strategy for evaluating climate-change risks and vulnerabilities in its initial Strategic Sustainability Performance Plan (SSPP), dated June 2010, in response to Executive Order (EO) 13514, Federal Leadership in Environmental, Energy, and Economic Performance.¹ The CEQ instructions require DoD to submit a Department-level analysis of key vulnerabilities to climate change by March 2012, as well as a Climate Adaptation Plan by June 2012 concurrent with DoD's updated SSPP.

Beyond the preceding, workshop participants noted that specific step-down policy and guidance regarding climate change vulnerability, impact, or risk assessment/management and adaptation generally has yet to be issued at the Department level. This includes but is not limited to defining bounding assumptions and their temporal and spatial scales, such as sea level change, climate change, and extreme event scenarios, to guide vulnerability, impact, and risk assessments, as well as development of adaptation strategies and actions. One limited exception is the broad requirement imposed by DoD Instruction 4715.03, Natural Resources Conservation Program (dated February 14, 2011) that requires installation Integrated Natural Resources Management Plans (INRMP) to assess

the impacts of climate change to natural resources and to take steps to ensure the long-term sustainability of those resources. But again specifics as to how to proceed are not provided.

As a result, the plenary sessions and policy panel discussion highlighted the need for and challenged the DoD R&D community to assist with providing technical support to the policy community that would meet their needs for determining:

- which climate change and other types of scenarios to consider for planning and action and over what temporal and spatial scales;
- which infrastructure/assets, operational, and readiness considerations to focus on first and where;
- leading indicators of change to readiness, built infrastructure, and ecosystems and their implementation and use; and
- in what contexts to consider climate change.

The contexts under which climate change must be considered are many and complex. To provide adequate technical support, the R&D and policy communities must take into account the interconnections/interdependencies associated with climate change science, policy, geopolitics, and national security. For climate change science, interconnections exist between spatial scales (e.g., local, regional, global), temporal scales (e.g., intra-seasonal, annual, inter-annual, decadal, and longer), environmental domains (e.g., air, ocean, land, and space), and regions (e.g., tropics, mid-latitudes, and polar regions). For the relation of climate change to policy, geopolitics, and national security, interdependencies exist due to political, economic, and demographic factors, as well as local governance, scientific literacy, and media orientation factors. Finally, climate change occurs in the context of other anthropogenic stressors. Often, climate change will potentially exacerbate the effects of these other stressors, sometimes in non-linear ways. Adaptation to climate change often may be accomplished by increasing an asset or ecosystem's resilience to a non-climate stressor.

Besides defining the technical bounds of policy-relevant information related to climate change, the R&D community also has a responsibility with translating the implications of the current and planned science and technology needed by policy makers and the end-user (installation managers and operational units) so that they have actionable information. The uses of climate change information within DoD include three broad areas:

- Increasing the situational awareness of senior leadership on climate change phenomena, vulnerabilities, and risks, including at the global and strategic levels.
- Risk assessment and identification of management actions that can be taken to reduce risks to the portfolio of DoD missions, assets, and infrastructure at the full range of scales: globally, regionally, and locally.
- Technology transfer of tools and data to operational end users at installations to support the development of local strategies and plans to address the projected consequences of climate change, including adverse effects caused by extreme events.

3.2 Internal Capacity, External Partnerships, and Outreach

The Department possesses a range of science and engineering capabilities relevant to understanding and analyzing the vulnerabilities, threats, and risks that climate change poses to DoD missions, assets, and infrastructure. Future development and coordination of these capabilities, across OSD, the Services, and the USACE Civil Works program will enable DoD to capitalize on its corporate technical capacity and effectively leverage the technical capacity in other agencies and organizations.

In addition, research to support and inform DoD climate change assessment, adaptation, and mitigation efforts must leverage partnerships and the whole of government. In view of increasing fiscal constraints within

DoD, climate change research must be planned and conducted in coordination and collaboration with other efforts across the U.S. government and scientific/academic communities to avoid redundancy and to increase efficiency. For example, continuous engagement and coordination with the activities of the US Global Change Research Program, in particular with the associated National Climate Assessment (NCA) and adaptation science/planning efforts, is paramount. The recent emphasis on these activities has been to improve assessment methodologies, provide credible climate, environmental, and socioeconomic scenarios, and enhance climate information transfer to end users and policy makers. The Department should continue to remain engaged in these efforts and make sure its needs and concerns are addressed through the sustained assessment process that is now the focus of the NCA.

Finally, research to support and inform DoD climate change assessment, adaptation, and mitigation efforts must ensure linkages to education and outreach. The DoD relies on the support of the U.S. public for all of its endeavors. To ensure public support for DoD climate change-related research, and for implementing resultant adaptation and mitigation strategies, the DoD should conduct proactive strategic communication efforts, support associated education programs, and conduct targeted public outreach regarding the impact of climate change on national security, readiness, and stewardship requirements.

3.3 Blueprint for a DoD Climate Change Research Agenda

Research needed to support DoD's response to climate change involves both fundamental and applied science, as well as translation of that science into actionable information for policy makers and end-users. On a thematic basis, research and translation needs can be divided into climate system modeling, physical forcings and environmental process modeling, assessment and adaptation methodologies/strategies. The Department R&D community will not be the primary provider for all research needs, but will still serve a vital role in fulfilling DoD-specific research and translation needs. DoD sponsored research should be responsive to user-defined needs.

Climate (Earth) System Modeling—Research to support and inform DoD climate change-related efforts must address necessary improvements to the science regarding climate physics that operate over multiple spatial and temporal scales. In addition, geoengineering, and its use to alter the behavior of the climate system, is an emerging area of investigation that DoD should at least remain aware of its progress and implications. Science improvements required to inform DoD climate change decisions, whether undertaken by DoD or others, include: reducing and quantifying the uncertainties of earth system models—including, when appropriate, improving probabilistic output for climate models and resultant assessments; developing higher temporal and spatial resolution climate models; and improving model physics for a wide variety of phenomena (especially the contribution of ice sheet retreat/melt to sea level rise and the influence of abrupt climate change on Arctic ice retreat). In addition, understanding the appropriate use and non-use of statistical and dynamical (regional climate models) downscaling techniques is a vital component of climate change model research when attempting to right-size climate information for decision making purposes.

Physical Forcings and Environmental Process Models—Physical processes (i.e., forcing functions) that represent how earth systems respond to changes in weather and climate need to be considered at regional and local scales. Beyond local sea level change, storm surge, and inland flooding during large precipitation events, consideration should be given to changes in physical process-based hazards including wind, sediment movement (erosion / sedimentation), and constituent releases, movements, fate, and effects. Natural systems respond to these forcings, and how they do so is important in understanding their adaptive capacity. As a result, continued improvements are needed in the representation of biotic and abiotic components of environmental process models that are relevant to DoD geophysical settings and ecosystems. In particular, research is needed to understand and attribute relevant ecosystem response endpoints related to climate change to on-the-ground effects that can be used to monitor sites, identify tipping points (critical thresholds), and/or assess impacts to mission critical capabilities and assets.

Assessment and Adaptation Methodologies/Strategies—Given the complexities involved in relating future climate to effects on DoD missions, assets, and infrastructure, new policies and analytical capabilities will be needed to support coherent assessments and adaptation strategies that minimize costs and risks to mission critical functions over time. This will require defining at the policy level the key decisions the military is contemplating at appropriate spatial and temporal scales, which will then enable scoping the technical assessments that are needed. In addition, technical guidance is required for distinguishing the types of assessments that are needed and

appropriate—screening level versus detailed and vulnerability versus impact versus risk (see Appendix C for definitions)—and the data requirements and performance standards expected for each. Appropriate and scientifically credible climate change and other scenarios also must be defined to drive the assessments. Models and decision support systems should facilitate planners and managers to conduct "What-if" scenario analysis in a transparent, meaningful manner.

The preceding must be applicable to installations globally: that is, any guidance must account for the different biophysical settings, native ecosystems, and regional expressions of climate and physical forcings encountered by installations while maintaining appropriate levels of regional consistency in approach and assumptions. In brief, guidance should reflect systematic climate change risk reduction that is scale dependent and, as such, considers common assumptions that are applicable across large spatial scales while acknowledging the unique risk and management issues that may occur regionally/locally. Detailed impact assessments may be needed at installations characterized as highly vulnerable to climate change effects for identification of mission impairment tipping points and associated networked mission assets/capabilities.

Adaptation science is in its infancy. Existing knowledge on built and natural infrastructure responses to physical forcings provides a starting point, but new knowledge is needed to understand how natural and built infrastructure will respond to climate change and affect the adaptive capacity of infrastructure systems to maintain desired functions with and without intervention. A framework and supporting processes to stage adaptation must be devised to account for uncertainty in the climate projections and their effects, guard against excessive and unneeded costs, avoid maladaptive responses, and manage risks to ensure continued mission sustainability. Guidance on effective communication and technical transfer of information to installation management personnel will improve opportunities that new knowledge is employed in identifying potential adaptation strategies.

3.4 The Need for a Policy-R&D-End-User Dialogue

Policy and guidance have yet to be firmly established to support both tactical and strategic planning in the face of climate change. What the Department needs is a robust, scientifically defensible approach that transparently communicates risks to the end-user and helps policymakers develop guidance to promote mission sustainability in the face of climate change. Although R&D on built and natural infrastructure response to climate change has progressed in recent years, a coherent vision of installation and operational military vulnerabilities has not been compiled. In the absence of comprehensive and coherent policy and guidance, current OSD- and Service-led R&D initiatives have taken a no-regrets, but mostly uncoordinated, type approach to the problem rather than developing and adhering to a comprehensive, across the Department strategic approach. As a result, the current focus has been on critical areas of interest (sea level rise, permafrost melt, inland flooding, Pacific Islands, etc.) that are viewed by OSD or Service R&D programs as vulnerable in the near-term or for which long-term infrastructure planning decisions are involved.

Policy awareness is emerging, but its growth and maturity to meet both strategic and tactical DoD needs would be best served by an ongoing and interactive dialogue between the policy, end-user, and R&D communities. Adaptive, risk-based decision frameworks that assess vulnerabilities, impacts, and risks, as appropriate, are needed and should be developed jointly and iteratively among these communities to incorporate climate change into tactical and strategic planning activities, with prioritization based on the types of decisions to be made and their spatial and temporal aspects. Policy and guidance also should be established to effectively incorporate adaptive management principles into all military planning and operations in the face of climate change. Finally, policy and guidance will need to be clear, flexible, iterative, and adaptive themselves to ensure appropriate consistency and currency while providing the Services the opportunity to decide how to best implement the requirements in the most efficient and effective manner.

Climate change adaptation involves responses to observed and projected trends that require observations and analyses of data relevant to this trend, as well as projections of the future range of trend possibilities. These observations and trend analyses have been (and are being) conducted by the R&D community; however, observations and trend analyses are often only available over relatively short timeframes, when observations are needed to track and analyze trends over long timeframes. Moreover, usable science is needed to link information on changing conditions to Defense assets and operations by identifying vulnerabilities, assessing the potential impacts, and crafting strategies to adapt to these changes. This requires very close linkages and frequent

interactions between the R&D community and those who manage and maintain Defense assets and plan and conduct Defense missions. Some keys to accomplishing the preceding are:

- Structure R&D activities and experts to be well connected and frequently interacting through a variety of means (reach-back, cross-over panels, cross-over assignments, technical advisory panels for adaptation committees, clear integration of new information, linkages to impacts and actions in plans and budget requests, etc.)
- Focus first on built and natural systems with relatively near-term vulnerabilities.
- Integrate resilience into adaptation strategies to enhance the sustainability of assets and missions under a range of potential future conditions.

3.5 Notes on Implementation

In addition to the dialogue mentioned in the previous section, workshop participants identified a number of specific suggestions for implementation of climate change-related policies and guidance. These can be summarized as follows:

- Develop a process and guidance for climate change-based installation operations research studies, pilot projects, documentation of lessons learned/best practices, and technical assessment product transition to the field (communication, training, support, guidance, resources, and program development).
- Specify in the Program Objective Memorandum (POM) the integration of climate change studies into current (established) policies and practices (e.g., Master Plans, INRMPs, Environmental Management Systems, etc.). Plan to review, identify, and recommend changes to commonly used planning and policy documents to accommodate climate change-related concerns and issues.
- Coordinate incorporation of the science and practices for addressing climate change issues into recognized accreditations (e.g., National Institute of Standards and Technology, etc.).
- Consider that of the many advantages of climate change research to the DoD, one of the most important is in providing observational and predictive information concerning relevant phenomena, at relevant temporal and spatial scales, that is useful for developing cost-benefit, risk, and return-on-investment assessments for planning operations and making resourcing decisions.

Chapter 4

Workshop Recommendations

The workshop plenary and breakout sessions, as well as the numerous discussions that these sessions generated, resulted in many ideas, findings, and recommendations. Various components of this report attempted to capture and summarize the preceding. Chapter 3 attempted a synthesis of the sessions and discussions to arrive at major findings and key emergent themes. Here the focus is on the main workshop recommendations using a brief summary format.

4.1 Visioning Future Workshops

The Department, inclusive of the military Services and U.S. Army Corps of Engineers, Civil Works program, has an ongoing need to assess the state of the science, practice, and policy needs relative to understanding the mission challenges raised by climate change and the framing of appropriate responses to such challenges, including their spatial and temporal aspects. Workshops (both in-person and virtual) can be a primary and helpful tool to accomplish such assessments.

Workshops may attempt to leverage the activities of the other federal agencies (see section 4.5); however, internal workshops will be necessary to ensure incorporation of current science into Department of Defense (DoD) processes and policy and to support the development and maintenance of required DoD capabilities. Conveners of future workshops may include coordinated efforts among those entities that planned and executed the current workshop and other DoD components.

Workshops should be of alternate formats and technical scope depending on the need at the time and held in some form no less frequently than once every two years. Organizers should be cognizant of costs involved and look to leverage other already planned meetings or use virtual technologies to convene participants when feasible. Workshop formats may include:

- Mostly just the DoD research and development (R&D) community. These workshops would explore DoD-relevant science gaps and to coordinate future internal research efforts to address these gaps. These types of workshops may benefit from periodically including other federal agency and academic scientists to broaden the discussion and expertise.
- The DoD R&D community and installation end users. These workshops can serve to better understand the state of the practice and user driven research needs. These workshops also can include identifying demonstration and transition issues to improve the utility of scientific information to the end-user community.
- The DoD R&D and policy communities (similar to the current workshop). These workshops would help these communities maintain an ongoing dialogue to ensure DoD-sponsored and conducted science is policy relevant and could assist policy makers in understanding the state of the science as one input to their policy decisions.
- Combinations of the preceding, though the planning and execution for such workshops would be more difficult than any of the others.

4.2 Establishing an Ongoing Dialogue

The DoD R&D and policy communities should establish those mechanisms necessary to maintain an ongoing dialogue.

Climate change and climate variability, including extreme events, add new challenges to DoD's policy and decision making. Besides its direct effects, climate change often exacerbates other environmental stressors, but more importantly it extends the temporal scale of decision making beyond what is traditional and adds increased amounts of uncertainty to projected futures and the effects of any decisions taken in response. Still, an action not taken because of uncertainty is itself a decision that ultimately has consequences. Because of DoD's operational and readiness missions, the enormity and complexity of its infrastructure, and the spatial distribution of its assets and operations, no other agency is faced with the breadth and complexity of decision making that climate change poses for DoD.

For these types of situations, a new paradigm of science-policy interaction and organizational cultural change is needed. Although research that is unaligned with policy (i.e., not immediately relevant) may at times provide an insurance against research and policy being too myopic, aligning research and policy development at the early stages can provide scientific grounding for decision making. As policy matures, alignment ensures that research is relevant and has direct utility for the identified needs of the Department. When the policy issues are clear, research can then best be directed to understanding the relevant impacts of climate change on DoD and crafting effective and efficient responses. Research also can be used to identify new problems and vulnerabilities that have yet to be considered or incorporated into policy, which provides one mechanism for minimizing surprises.

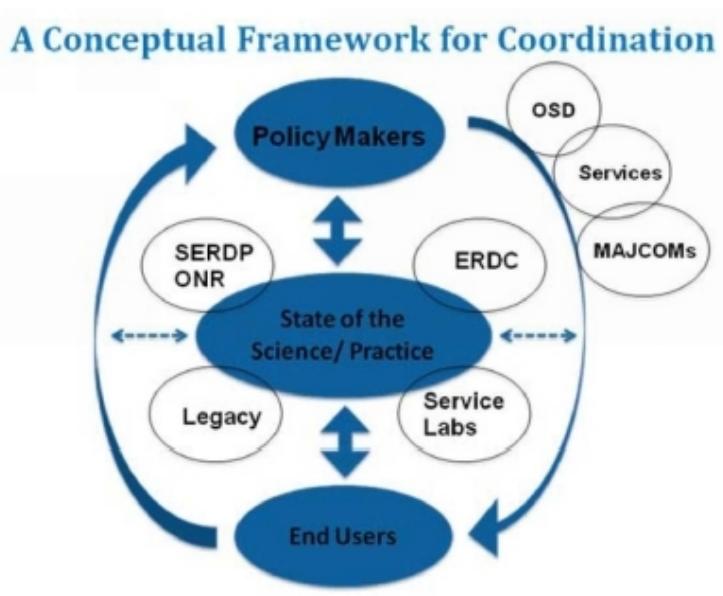
The figure below—modified from one shown during a plenary session—shows in graphic form a conceptual framework for coordination between the R&D, end-user, and policy communities. Decisions/policies and actions are made and implemented at different levels of the DoD/Service hierarchy. What they share in common in the framework is the two-way and necessarily iterative nature of the communication links. Both of

these aspects are critical. The complexity of the science and policy challenges requires mutual, adaptive learning among the communities. It also may require learning of a unique nature: that is, by incorporating social and organizational research that can assist an organization the size and complexity of DoD to better integrate emerging knowledge into its decision processes and transcend traditional stovepipes and current ways of thinking and acting, which themselves may be maladaptive under future climate change and climate variability.

4.3 Establishing a DoD Climate Change Science Technical Workgroup

To support DoD's Climate Change Adaptation Planning Task Force—whose establishment by OSD(I&E) is underway—DoD should consider establishing a DoD Climate Change Science Technical Workgroup that can interact directly with the Task Force on matters of climate change science-policy intersection. At least one member of the Workgroup should be a member of the Task Force and serve a liaison function.

This recommendation is an important, though not the only, step towards establishing the ongoing dialogue discussed in section 4.2 above. The initial focus of the Task Force is on responding to the Federal Agency Climate Change Adaptation Planning Implementing Instructions issued by the Council on Environmental Quality (CEQ) in March 2011 that mandated each agency submit a Climate Adaptation Plan by June 2012. In addition, an intermediate step to this plan is a Department-level analysis of key vulnerabilities to climate change due to CEQ as a final analysis during March 2012. A Technical Workgroup can be of assistance to the Task Force in developing the DoD response.



The role, however, of the Task Force and the Workgroup and the interactions between these entities should not end with the response to CEQ. Their formation and sustenance provides an opportunity for DoD to craft and implement a larger and more in-depth vision for how it will respond and adapt to climate change in a manner that meets its needs and the complexity and breadth associated with its missions and assets at appropriate spatial and temporal scales.

The DoD Climate Change Science Technical Workgroup should be composed of senior managers/staff from the appropriate DoD/Service environmental and engineering R&D funding organizations, laboratories, and academic centers. The U.S. Army Corps of Engineers, Civil Works program should have standing membership on the Workgroup, whereas membership by other federal agencies can be considered on a case by case basis when appropriate expertise may be needed.

4.4 Articulating a Path Forward: General Recommendations/Precautions

The DoD R&D community must provide defensible science, models, and tools to support DoD and the Services' needs regarding climate change and extreme event forecasting ability to meet operational needs, vulnerability and impacts assessments based on robust climate change scenarios, adaptation science, and mitigation.

In serving a role as an "honest broker" in technical matters related to climate change, the DoD R&D community can provide the technical voice regarding the "right" pace, spatial scale, and assumptions (e.g., change scenarios) for those vulnerability and impact assessments, whether they be high-level screening assessments or detailed and complicated assessments, that DoD and the Services choose to pursue. In addition, it can provide a similar function with respect to adaptation and mitigation strategies. The end result would be to assist DoD and the Services in avoiding unnecessary costs, inconsistent assumptions, and potentially maladaptive responses.

The preceding requires close coordination between the R&D and policy communities. Both communities must understand the needs of the user community. In addition, the R&D community plays a central role in translating what the science means to the policy makers and how it can be implemented by the user community. The DoD R&D community must understand its role with respect to policy development and implementation and be an available resource to the policy and end-user communities.

Finally, the R&D community can assist the policy community with identifying appropriate mechanisms for implementation of technical guidance. This could occur, for example, via integration of climate change studies into current (established) policies and practices (e.g., Master Plans, Integrated Natural Resources Management Plans, Environmental Management Systems, etc.). The R&D community can assist with reviewing, identifying, and recommending changes to commonly used planning and policy documents to accommodate climate change-related concerns and issues.

4.5 Forging External Partnerships

We do not have the resources to respond to the challenge of climate change alone. DoD should establish new and strengthen existing relationships with the federal R&D community, in part by participating in inter-agency research coordination efforts, to leverage resources, avoid redundancy, and highlight the Department's research needs.

The Department has been a long-standing member of the U.S. Global Change Research Program and has been an active participant in the 2013 National Climate Assessment and the sustained assessment process. In addition, DoD is playing an active role in the federal adaptation planning effort. These efforts have broadened DoD's interaction with the federal climate change R&D community and must continue as the shift in emphasis goes from a focus on improving the climate models to making actionable information regarding climate change and climate variability accessible to those that need to make assessment, adaptation, and mitigation decisions regarding climate change. The workshop was enriched by the participation of federal partners and such interactions should continue in the future. As centers for climate change information develop and mature, integration with the rest of the federal community will gain in importance while at the same time DoD must ensure its own unique needs are met through a sustained DoD R&D enterprise.

Appendix A1

Workshop Charge

Coordination Workshop on Climate Change-Related Research and Development Activities within the Department of Defense

July 19-21, 2011 Aurora, CO

Workshop Charge Statement

Background: The February 2010 Quadrennial Defense Review (QDR) recognized that climate change will affect the Department of Defense (DoD) in two broad ways:

- First, climate change will shape the operating environment, roles, and missions that DoD undertakes.

- Second, the DoD will need to adjust to the impacts of climate change on its facilities and military capabilities.

The QDR also recognized that DoD must develop policies and plans to manage the effects of climate change on its operating environment, missions, and facilities. In addition, the QDR committed DoD to completing a comprehensive assessment of all of its [permanent] installations to assess the potential impacts of climate change on its missions and to adapt as required. And finally, the QDR highlighted the need for DoD to regularly reevaluate climate change risks and opportunities and to work collaboratively with outside partners to meet the challenges posed by climate change.

Given the above, the focus of the workshop is first on establishing a DoD network of funding entities and research centers and laboratories involved in climate change-related research and demonstration and second on identifying the role that DoD's research and development (R&D) community can serve to (1) assist DoD policy makers by providing the technical foundation for advancing new policies related to climate change and (2) provide DoD resource, infrastructure, and operational managers the needed science information, models, and tools needed to implement the effects of policy "on the ground."

Objective: The DoD Research and Development (R&D) community must determine how its limited research and demonstration funds can best be invested to improve DoD's ability to respond to the challenges of climate change, both in the near- and long-terms. To strategically guide future investments and facilitate long-term cooperation and coordination among workshop participants, this workshop will:

(1) initiate establishing a communication network among the DoD R&D community working on climate change-related issues;

(2) identify the current range of research and demonstration activities related to climate change that the DoD R&D community is actively pursuing or planning;

(3) conduct a preliminary assessment of the current state of DoD policy and implementation needs relative to climate change and how well current activities align;

(4) identify the relationship of the DoD R&D community to the US Global Change Research Program and other Federal efforts to provide climate change-related information and identify opportunities for enhanced coordination;

(5) develop an initial roadmap for a path forward to guide future investments across the DoD R&D community;

Approach: The workshop, to be held at the Embassy Suites Hotel in Aurora, CO, July 19-21, 2011, will be an invitation-only forum of about 50-70 participants. Invitees to the workshop will include senior program managers and researchers from the DoD R&D community, invited non-DoD Federal guests, and senior policy staff from the Services, Corps of Engineers, and the Office of the Secretary of Defense, Installations and Environment OSD (I&E). Elements of the workshop will include plenary presentations and two to four breakout sessions on relevant topics.

Product: The workshop activities, deliberations, and findings will be summarized in a workshop report that will serve as an initial guide to ongoing and currently planned investments in climate change-related research and demonstration. In addition, an initial wiring diagram that depicts the emerging DoD climate change-related R&D community will be prepared.

Sponsors: This event is sponsored by the Office of Naval Research, which is providing all of the logistical support. The Strategic Environmental Research and Development Program is providing technical assistance.

APPENDIX A2 WORKSHOP AGENDA

Department of Defense Climate Change Coordination Workshop			
Tuesday July 19, 2011			
0800-0830	Workshop Registration & Coffee		
0830-0845	Workshop Opening & Welcome	Dr. Charles L. Vincent Dr. John Hall	Navy: ONR OSD: SERDP/ESTCP
0845-0930	Why this workshop?	Vincent/Hall	ONR/SERDP
0930-1015	USGCRP/NCA Overview	Dr. Tom Armstrong	USGCRP, Director
1015-1045	Break		
1045-1115	Perspective OSD: Installations and Environment	Ms. Maureen Sullivan	OSD: I&E, Environmental Management
1115-1145	Perspective OSD: Training Readiness and Strategy	Mr. Frank DiGiovanni	OSD: TRS
1145-1215	Perspective USACE Civil Works	Mr. James Dalton	USACE: Chief of Engineering and Construction
1215-1315	LUNCH		
1315-1330	Break Out Session 1 Charge	Vincent/Hall	ONR/SERDP
1330-1545	Service Coordination Break Out Sessions: Compile Current/Planned/Needed R&D	Army/Air Force Navy	Dr. Todd Bridges, USCAE CAPT Tim Gallaudet, Navy
1545-1615	Break / Session Chairs Prepare Breakout Group Report Outs		
1615-1715	Report Outs by Service	TBD	Session Chairs
1715-1745	Open Discussion/Next Day Overview	Vincent/Hall	ONR/SERDP
1745	Adjourn for the Day		
1800	Reception-Light hors d'oeuvres / Posters		

Department of Defense Climate Change Coordination Workshop			
Wednesday July 20, 2011			
0800-0830	Coffee		
0830-0845	Policy & End User Needs: Intro Perspective Navy: Task Force Climate Change	Vincent/Hall CAPT. Gallaudet	ONR/SERDP Oceanographer of the Navy
0845-0915	Perspective Air Force: Environment, Safety, and Occupational Health	Dan Kowalczyk	Air Force ODAS: ES&OH
0915-0945	Perspective Army: Environment, Safety, and Occupational Health	Mr. Tom Mooney	ARMY ODAS: ES&OH
0945-1015	Panel Discussion (include OSD speakers from day before)	Vincent/Hall facilitate	N/A
1045-1115	Break		
1115-1200	Climate Services	Dr. Eileen Shea	NOAA
1200-1315	Lunch		
1315-1320	Breakout Session 2 Charge	Vincent/Hall	ONR/SERDP
1320-1545	Breakout Session 2 : Cross Cutting Themes 1	Breakout Group	Session Chairs
		A - Coastal Environments	Mr. William Curtis, USACE
		B - Cold Region Environments	CAPT Tim Gallaudet, Navy
		C - Inland & Arid Region Environments	Ms. Kelly Burks-Copes, USACE
1545-1615	Break / Session Chairs Prepare Breakout Group Report Outs		
1615-1715	Report Outs on Cross Cutting Themes 1	TBD	Session Chairs
1715-1745	Open Discussion / Next Day Overview	Vincent/Hall	ONR/SERDP
1745	Adjourn for the Day		

Department of Defense Climate Change Coordination Workshop			
Thursday July 21, 2011			
0800-0830	Coffee		
0830-0835	Breakout Session 3 Charge	Vincent/Hall	ONR/SERDP
0835-1045	Breakout Session 3 : Cross Cutting Themes 2	Breakout Group	Session Chairs
		A - Vulnerability and Impact Assessment	Dr. Edmond Russo, USCAE
		B - Adaptation and Mitigation Science	Mr. William Goran, USACE
		C - Climate Science	This session was eliminated
1045-1115	Break / Session Chairs Prepare Breakout Group Report Outs		
1115-1215	Report Outs on Cross Cutting Themes 2	TBD	Session Chairs
1215-1245	Next Steps and Workshop Wrap Up	Vincent/Hall	ONR/SERDP
1245-1400	Lunch		
1400-1730	Workshop Documentation (Planning Committee and Session Chairs)		
1730	Adjourn		

Appendix A3

Breakout Session Charges

Breakout session 1: service Breakouts

Charge/Example Questions to Discuss

- 1) Who (person or office) in your Service is interested in and should receive updates on the US Global Change Research Program (USGCRP) or may want to present needs or questions to the DoD USGCRP representative so he can query USGCP relative to the federal investment in climate change science and its relevance to the DoD/military Services? (The goal is to develop the basis of a communication "wiring" diagram, so names, email, office symbol would be useful in the listing.)
- 2) The next National Climate Assessment is now underway with a target date of a 2013 report to Congress. Included may be updates to or new assessments at the regional scale. Who (person or office) in your Service is interested in and should receive updates on opportunities to participate in regional assessment activities? (The goal is to provide a list of interested offices/participants by region through the DoD Interagency National Climate Assessment Task Force representatives.)
- 3) What research or activities is your Service, either internally or though extramural funding, actively conducting or planning to conduct that are related to climate change vulnerability and impact assessment, adaptation science, mitigation, or climate modeling? (The goal would be a list of what is underway or planned, where/who, and the requirement being addressed.)
- 4) What do you see as the current requirements or demands for climate information from your Service that will drive the need for future research? (The goal is a list of future needs, research required, by whom.)
- 5) How do you envision your Service using climate information: are their new needs for research or information translation to support these efforts?

Services self-select breakout group Chairs. (Dr. Todd Bridges, USACE, chaired the Army/Air Force session and CAPT. Tim Gallaudet, Navy, chaired the Navy session.)

Breakout session 2

Cross-Cutting Theme 1: Regional Research and Development Needs

Charge/Example Questions to Discuss

Overall charge: As climate change advances, DoD will be required to maintain readiness and operate in new and changing environments. This breakout session will examine several of these environments, which are subject to rapid change or long-term infrastructure planning needs, to determine R&D needs specific to each.

Group A - Coastal Environments

Charge: Coastal environments will be one of the most sensitive to climate change as they are exposed to the effects of sea level rise, potentially enhanced storm activity, ecosystem shifts, and salt water intrusion into groundwater supplies. Many DoD locations are located in coastal environs that provide valuable operational, training, testing, and ecosystem services in strategic locations.

Relevant questions include:

- 1) What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure from local sea level rise, storm surge, and inland flooding during large precipitation events?

- 2) What technical needs are relevant to evaluating and distinguishing among alternative adaptation strategies for increased storm frequency and/or intensity for both built and natural infrastructure?
- 3) What scientific and technology advances are needed to develop reliable predictions concerning future changes in coastal ecosystems under the combined effects of climate and land use change and how those ecosystem changes will affect military infrastructure, readiness, and operations?
- 4) What policy and technical guidance is needed for determining which climate and sea level rise scenarios should be used and at what spatial scales to drive risk assessment and response in coastal environments?

Session Chair: Mr. William Curtis, USACE

Group B - Cold Region Environments

Charge: Changes in cold region environments may affect DoD readiness and operations. The Navy in particular identified the Arctic as its near-term climate change concern, including possible changes in mission and required capabilities. Continued access to and use of training lands by the Army is contingent on permafrost conditions, which are subject to degradation under a warming climate. A relatively broad understanding of research needs has been developed for this region but a gap in translating needed information into requirement.

Relevant questions include:

- 1) How can science and technology developments from the research community be best transitioned to the operational level and into programs of record?
- 1) What is the best mechanism to ensure operational planning documents and programs of record are informed on a regular basis by science and technology developments?
- 2) What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure in cold region environments, in particular as a result of thawing permafrost, poorly understood coastal erosion processes, and altered fire and hydrologic regimes?
- 3) What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive risk assessment and response in cold region environments?

Session Chair: CAPT Tim Gallaudet, Navy

Group C - Inland Regions, with a Focus on Arid Regions

Charge: Climate change is expected to produce increased warming and altered precipitation patterns in inland regions, especially in the arid Southwest US. Even if mean precipitation increases, rainfall variability and cycles of drought and extreme precipitation events will likely increase. The preceding changes will affect the nature of flooding events, the quantity and quality of water, energy usage patterns, fire regimes, and ecosystem shifts.

Relevant questions include:

- 1) What are the critical science gaps concerning climate change and land use impacts occurring within inland environments that are most relevant to military installations and their activities?
- 2) What science, engineering, or technology gaps should be addressed to advance our ability to inform decisions about the risks climate change poses to military infrastructure and training and testing capacity in inland regions?

- 3) What technology developments are needed to support military adaptation to climate change in inland regions?
- 4) What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure in inland region environments, in particular as a result of extended drought, more extreme precipitation and wind events, and altered fire and hydrologic regimes?
- 5) What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive risk assessment and response in arid region environments?

Session Chair: Ms. Kelly Burks-Copes, USACE

Breakout session 3

Cross-Cutting Theme 1:

Vulnerability and Impact Assessment/Adaptation/Climatology

Research and Development Needs

Charge/Example Questions to Discuss

Overall charge: The 2010 Quadrennial Defense Review identifies the need for DoD to complete a comprehensive assessment of all installations to assess the potential impacts of climate change on its missions and adapt as required. In its initial Strategic Sustainability Performance Plan submitted to the Council on Environmental Quality in 2010, DoD identified a three-phase strategy to address its climate change risks and vulnerabilities. As a result, this session, in contrast to the regional focus of cross-cutting theme 1, looks at addressing climate change from a process perspective that shares many commonalities independent of region or resource or mission at risk. Group A will assess the processes of vulnerability and impact assessment. Group B will assess the processes of adaptation and mitigation. Vulnerability and impact assessment and adaptation are concerned with the question: what are we adapting to? Given the built-in inertia in the climate system that will compel some level of adaptation regardless of future emission reductions, mitigation concerns itself with reducing future adaptation liabilities. Finally, the military Services require better short-term and decadal predictions of changing climate phenomena to serve their operational purposes, sometimes in environments such as the Arctic that have complex ocean, ice, and atmospheric interactions. As such, DoD also plays a role in developing needed climate science, which will be in part the subject of Group C.

Group A - Vulnerability and Impact Assessment

Charge: Vulnerability of a military mission or of an installation's built and natural infrastructure to climate change is based on exposure (the location of concern is projected to experience some change in climate or an associated change such as sea level rise), sensitivity (the mission or infrastructure functionality would be sensitive to such a change), and adaptive capacity (degree to which the mission or infrastructure can or cannot accommodate to the change without significant functional impairment). Impact assessment considers a specific pathway of analysis that includes assumptions about climate drivers, whether probabilistic or scenario-based, environmental models, and impact assessment models, the last of which can be specific to military infrastructure, readiness, and operations. Having a clear understanding of potential impacts can provide a foundation for identifying necessary adaptation strategies.

Relevant questions include:

- 1) What scientific understanding, models, and tools are needed to conduct vulnerability assessments of DoD installations, especially if such assessments are conducted as a high level screen across installations or regions versus within installations or regions?

- 2) What scientific understanding, models, and tools are needed to conduct comprehensive impact assessments for vulnerable missions and installations?
- 3) What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive vulnerability and impact assessments?
- 4) How can science and technology developments from the research community relative to vulnerability and impact assessment be best transitioned to the implementation level and into operational practice?

Session Chair: Dr. Edmond Russo, USACE

Group B - Adaptation and Mitigation Science

Charge: The science of adaptation in the context of climate change is nascent, though it can build on a rich understanding from the engineering, ecological, and physical science disciplines as to how human and natural systems respond to environmental disturbances and stressors. When faced with uncertainty about the potential impacts of climate change, improving the resilience to stress of DoD natural and built infrastructure can be a no-regrets adaptation strategy. Because the future may present novel climates, built and natural systems may be exposed to climate extremes and variability never experienced. For natural systems we need a deeper understanding of how they respond to dynamic environments and for built infrastructure we may need to consider new design tolerances. Adaptation and mitigation are linked and strategies to reduce emissions may have unintended consequences that affect adaptive capacity.

Relevant questions include:

- 1) What scientific understanding, models, and tools are needed to advance the development of adaptation strategies?
- 2) What are the critical natural systems—whether they serve as protective barriers for other infrastructure or are needed for stewardship purposes—for which we need improved understanding of their dynamics under climate change to enhance their adaptive capacity and resilience?
- 3) What design features of DoD's built infrastructure should be assessed and modified for improving their adaptive capacity to a changing climate?
- 4) How can science and technology developments from the research community relative to adaptation be best transitioned to the implementation level and into operational practice?
- 5) What is the best mechanism to ensure planning documents and programs of record are informed on a regular basis by science and technology developments related to adaptation?
- 6) What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive the development of adaptation strategies, models, and tools?

Session Chair: Mr. William Goran, USACE

Group C - Climate Science (This particular breakout session ended up not being convened)

Charge: The military Services must be able to continue to operate as climate changes. Some environments, such as the Arctic, are areas of rapid change and will have complex responses to climate that may be poorly characterized by existing global models. DoD conceivably can have missions or activities anywhere in the world. Although much thought has been given to issues such as the Arctic and sea level changes, the spectrum of potential issues is vast and very site specific. The USGCRP has had a large and robust effort directed at long term climate change as related to human activity presumably forcing changes and is now beginning to look at issues related to

downscaling of the larger patterns to regional and local scenarios and possible socio-economical impacts. These analyses will naturally address a broad range of issues relevant to many agencies and consequently may be of direct use to DoD. A major need of the Services will be climatologies that will be useful for meeting the Services' mission. This group will consider the types of climatologies that the services need in terms of time span (seasonal forecast to decadal forecast, for example) and spatial extent.

Relevant questions include:

- 1) Can we now specify regions/locations of highest interest and specify the temporal horizon?
- 2) Given the understandable uncertainty in climate forecasts, how can scientists best inform policy on the range of expectation and assure consistency in provision of information?
- 3) Do critical gaps exist that DoD sees in the climate science and particular its ability to deliver useful climatologies?
- 4) How can evolving policy and evolutionary science better inform each other on the intersection between climate science and DoD policy so that the appropriate climatologies can be provided in a timely way?
- 5) What are the critical partnerships that DoD must forge to get the information it needs?

Session Chairs: Dr. Scott Harper, Navy/Dr. Martin Jeffries, Navy

APPENDIX B LIST OF PARTICIPANTS

Alan Anderson USACE ERDC-CERL 217.373.7233 alan.b.anderson@usace.army.mil	Elizabeth Ferguson USACE ERDC-EL 601.634.4008 elizabeth.a.ferguson@usace.army.mil	Martin Jeffries ONR 703.696.7825 martin.jeffries@navy.mil
Anne Andrews OSD SERDP/ESTCP 703.696.3826 anne.andrews@osd.mil	Reinhard Flick TerraCosta Consulting Group/Scripps 858.945.4262 rflick@ucsd.edu	John Jensen NOAA NCDC 828.271.4848 john.a.jensen@noaa.gov
Jeffrey Arnold USACE IWR 703.428.9092 jeffrey.r.arnold@usace.army.mil	Orlando Florez ONR/Mandex 703.696.4508 orlando.florez1.ctr@navy.mil	Daniel Kowalczyk SAF/IEE 703.697.1198 daniel.kowalczyk.ctr@pentagon.af.mil
Todd Bridges USACE ERDC-EL 601.634.3626 todd.s.bridges@usace.army.mil	Edward Franchi NRL 202.404.8690 edward.franchi@nrl.navy.mil	David Kriebel USNA 410.293.6432 kriebel@usna.edu
Kelly Burks-Copes USACE ERDC-EL 501.634.2290 kelly.a.burks-copes@usace.army.mil	CAPT Timothy Gallaudet US Navy 619.654.0008 timothy.gallaudet@navy.mil	LtCol Joseph Kurtz Air Force 14th Weather Squadron 828.271.4201x1001 joseph.kurtz@afccc.af.mil
Simon Chang NRL 831.656.4721 simon.chang@nrlmry.navy.mil	Richard Gardner NAVFAC ESC 805.982.3584 richard.a.gardner@navy.mil	Shun Ling NAVFAC ESC 202.433.8765 shun.ling@navy.mil
Susan Cohen NAVFAC ESC 910.451.7900 susan.cohen@usmc.mil	William Goran USACE ERDC-CERL 217.373.6735 william.d.goran@us.army.mil	Wieslaw Maslowski NPS 831.656.3162 maslowsk@nps.edu
William Curtis USACE ERDC-CHL 501.634.3040 william.r.curtils@usace.army.mil	John Hall OSD SERDP/ESTCP 703.696.2125 john.hall@osd.mil	Esther McClure OSD Policy 703.697.4837 esther.mcclure@osd.mil
James Dalton USACE 202.761.8826 Contact through: sharon.edmonds@usace.army.mil	Scott Harper ONR 703.696.4721 scott.l.harper@navy.mil	John McCormack NRL 202.767.3380 john.mccormack@nrl.navy.mil
Frank DiGiovanni OSD TRS 703.695.2618 frank.digiovanni@osd.mil	Tim Hayden USACE ERDC-CERL 217.373.5859 timothy.j.hayden@usace.army.mil	Timothy McHale NAVFAC ESC 805.982.4805 timothy.mchale@navy.mil

Thomas Douglas USACE ERDC-CRREL 907.378.7900 thomas.a.douglas@usace.army.mil	Paul Hess ONR 703.696.9776 paul.hess@navy.mil	Thomas Mooney ODASA ESOH 703.695.7825 thomas.mooney3@conus.army.mil
Harrell Moore II NORAD-USNORTHCOM 719.554.3292 hal.moore@northcom.mil	Larry Rodgers NORAD USNORTHCOM 719.554.5255 larry.rodgers@northcom.mil	Maureen Sullivan OSD I&E 703.695.7957 maureen.sullivan@osd.mil
Tom Murphree NPS 831.656.2723 murphree@nps.edu	Edmond Russo USACE ERDC-CHL 601.634.2067 edmond.j.russo@usace.army.mil	Robin Tokmakian NPS 831.656.3255 rtt@nps.edu
Melinda Peng NRL 831.656.4704 melinda.peng@nrlmry.navy.mil	Eileen Shea NOAA National Climatic Data Center 828.271.4384 eileen.shea@noaa.gov	Charles Vincent ONR 703.696.4508 linwood.vincent@navy.mil
Jackie Richter-Menge USACE ERDC-CRREL 603.646.4266 jacqueline.a.richter-menge@usace.army.mil	John Simms IV NOAA National Ice Center 301.817.3977 john.simms@noaa.gov	John Weatherly USACE ERDC-CRREL 603.646.4741 john.w.weatherly@usace.army.mil

Appendix C

Glossary

Key terms associated with the workshop and used in this report are provided below. Where appropriate the source citation is provided. Some definitions may be edited from the original to maintain a consistent editorial style. In addition, some terms are further annotated to provide additional context.

Adaptation—Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects (NRC 2010).

Adaptive capacity—Ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (Parry et al. 2007).

Built infrastructure—Basic equipment, utilities, productive enterprises, installations and services essential for the development, operation, and growth of an organization, city, or nation (based on Parry et al. [2007] definition of infrastructure). All building and permanent installations necessary for the support, redeployment, and military forces operations (e.g., barracks, headquarters, airfields, communications, facilities, stores, port installations, and maintenance stations (based on JP1-02 [2001] definition of infrastructure).

Climate—In a narrow sense is usually defined as the 'average weather,' or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (Parry et al. 2007).

Climate change—Refers to any change in climate over time, whether due to natural variability or as a result of human activity. [Anthropogenic] climate change, as defined by the United Nations Framework Convention on

Climate Change, refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (based on Parry et al 2007).

Climate (change) scenario—Plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A 'climate change scenario' is the difference between a climate scenario and the current climate (Parry et al. 2007).

Climate system—Defined by the dynamics and interactions of five major components: atmosphere, hydrosphere, cryosphere, land surface, and biosphere. Climate system dynamics are driven by both internal and external forcing, such as volcanic eruptions, solar variations, or human-induced modifications to the planetary radiative balance, for instance via anthropogenic emissions of greenhouse gases and/or land-use changes (Parry et al. 2007).

Climate variability—Refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability[^], or to variations in natural or anthropogenic external forcing (external variability) (Parry et al. 2007).

Downscaling—Method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses (Parry et al. 2007).

For climate information downscaling can be accomplished by either statistical or dynamical (regional climate model) means.

Extreme weather event—Event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' differ, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called 'extreme weather' may differ from place to place. Extreme weather events may typically include floods and droughts (Parry et al. 2007).

Impact assessment—Practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of climate change [and climate variability] on natural and human systems (Parry et al. 2007).

The preceding implies a form of quantitative assessment, in which some degree of specificity in the associated climate, environmental (biophysical) process, and impact models, accompanied by an evaluation of the uncertainties involved, is a necessary and integral contribution to reported outcomes. Likely requires high quality and spatially granular data. Impact assessment may lead to identification of adaptation strategies that can reduce system vulnerabilities.

Likelihood—Likelihood of an occurrence, an outcome, or a result, when this can be estimated probabilistically (Parry et al. 2007).

Mitigation—Intervention to reduce the causes of changes in climate, such as through reducing emissions of greenhouse gases to the atmosphere (NRC 2010). An anthropogenic intervention to reduce the anthropogenic forcing of the climate system, which includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks (Parry et al. 2007).

The preceding definitions differ substantively from and shouldn't be confused with the 40 CFR 1508.20 definition of mitigation, which considers a hierarchical approach and includes the concepts of avoiding environmental impacts, minimizing impacts, rectifying the impact, reducing or eliminating the impact over time, and compensating for the impact.

Natural (green) infrastructure—Concept that highlights the importance of the natural environment in decisions about land-use planning. In particular, an emphasis is placed on the 'life support' functions provided by a network of natural ecosystems, with an emphasis on interconnectivity to support long-term sustainability. Examples include clean water and healthy soils (Wikipedia; accessed 14 August 2011).

In a DoD context, the concept can be extended to include those features of the land and water environments, including their biota and associated ecological processes, that directly or indirectly support military readiness or serve protective functions for built infrastructure during extreme weather events. In the first case, natural ecological systems often provide needed training landscapes and training realism. These can range from the permafrost-controlled ecological systems of Alaska to the barrier islands off the coasts of several military installations. In the second case, coastal wetlands and barrier islands serve to protect mainland areas from the effects of storms.

Resilience—Capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment (NRC 2010). Ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, capacity for self-organization, and capacity to adapt to stress and change (Parry et al. 2007).

Risk—Combination of the magnitude of the potential consequence(s) of climate change impact(s) and the likelihood that the consequence(s) will occur (NRC 2010).

Sensitivity—Sensitivity is the degree to which a system may be affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise) (Parry et al. 2007).

Vulnerability—Degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes (NRC 2010). Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (Parry et al. 2007).

Vulnerability assessment—Practice of identifying and evaluating the effects of climate change and climate variability on natural and human systems so as to understand system sensitivities and capacity to adapt (defined herein).

As one possible approach to distinguish a vulnerability assessment from an impact assessment, the above definition and the preceding one for vulnerability together can be interpreted to imply a form of qualitative assessment or at least a less rigorous quantitative assessment, in which the degree of specificity in the climate, environmental (biophysical) process, and impact models, even when accompanied by an evaluation of the uncertainties involved, is not as stringent as for an impact assessment. Moreover, from this perspective, data requirements, including their spatial granularity, can be more relaxed than what is required for an impact assessment. Vulnerability assessments, when defined this way, may best be tied to an initial screening process that may lead to the more detailed impact assessments for those locales and systems identified as most vulnerable or critical to mission.

References:

JP1-02. 2001 (as amended through 31 October 2009). Department of Defense Dictionary of Military and Associated Terms. p. 262.

National Research Council. 2010. Adapting to the Impacts of Climate Change, America's Climate Choices: Panel on Adapting to the Impacts of Climate Change.

Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, eds. 2007. Contribution of Working Group II [Impacts, Adaptation, and Vulnerability] to the Fourth Assessment Report of the

Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 976 pp. Appendix I Glossary.

Appendix D

List of Acronyms/Abbreviations

AMOP Administrative Modeling and Oversight Panel

APG Arctic Policy Group (led by Department of State)

ASA(ALT) Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology

ASA(CW) Office of the Assistant Secretary of the Army for Civil Works

ASA(IE&E) Office of the Assistant Secretary of the Army for Installations, Energy, and the Environment

BROMEX BRomine, Ozone, and Mercury Experiment

CEQ Council on Environmental Quality

CESM Community Earth System Model

CNA Center for Naval Analyses

CONUS Continental US

CRREL Cold Regions Research and Engineering Laboratory

DEM Digital Elevation Map

DoD Department of Defense

DSB Defense Science Board

EO Executive Order

ERDC Engineer Research and Development Center

ESMF Earth System Modeling Framework

ESPC-RDO Earth System Prediction Capability-Research, Development, and Operations

ESTCP Environmental Security Technology Certification Program

FEMA Federal Emergency Management Agency

GCC Global Climate Change

GCM General Circulation Model

GHG Greenhouse Gas

HQ Headquarters

HYCOM Hybrid Coordinate Model

IMCOM (Army) Installation Management Command

INCATF Interagency National Climate Assessment Task Force (now Workgroup)

INRMP Integrated Natural Resources Management Plan

JCTD Joint Capability Technology Demonstration

JUONS Joint Urgent Operational Needs Statements

NAVFAC ESC Navy Facilities Engineering Command Engineering Service Center

NAVSEA Naval Sea Systems Command

NCA National Climate Assessment

NDIA National Defense Industrial Association

NCCCO Navy Climate Change Coordination Office

NMFWA National Military Fish and Wildlife Association

NOAA National Oceanic and Atmospheric Administration

NOC National Ocean Council

NOPP National Oceanographic Partnership Program

NPS Naval Postgraduate School

NRC National Research Council

NRL Naval Research Lab

NSB Naval Studies Board

NSF National Science Foundation

NUMA Non-hydrostatic Unified Model for Atmosphere

NUOPC National Unified Operation Prediction Capability

NWC Naval War College

OAML Oceanographic and Atmospheric Master Library

ODASA(ESOH) Office of the Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health)

OPNAV Office of the Chief of Naval Operations

OSD Office of the Secretary of Defense

OSD(I&E) OSD(Installations and Environment)

OSD(TRS) OSD(Training Readiness and Strategy)

ONR Office of Naval Research

PACFLT Pacific Fleet

POM Program Objective Memorandum

PSP Polar Science Program

QDR Quadrennial Defense Review

REC Regional Environmental Coordinator

RCM Regional Climate Model

R&D Research and Development

RTP Rapid Transition Program

SAF/IE Office of the Assistant Secretary of the Air Force (Installations, Environment and Logistics)

SAF/IEE Deputy Assistant Secretary of the Air Force (Environment, Safety and Occupational Health)

SAME Society of American Military Engineers

SERDP Strategic Environmental Research and Development Program

SSPP Strategic Sustainability Performance Plan

STEM Science, Technology, Engineering, and Mathematics

TFCC Task Force Climate Change

TFCC ESC Task Force Climate Change Executive Steering Committee

TW Trident Warrior

UFC Unified Facilities Criteria

USACE U.S. Army Corps of Engineers

USFF U.S. Fleet Forces

USGCRP U.S. Global Change Research Program

Appendix E

Compendium of Department of Defense Research and Development Programs Related to Climate Change

US Department of Defense

Strategic Research and Development Program (SERDP), Resource Conservation and Climate Change Program Area

Climate change will play a significant role in the Department of Defense's (DoD) ability to fulfill its mission in the future. It will affect both built and natural infrastructure, which will impact readiness and environmental stewardship responsibilities at hundreds of installations across the nation. SERDP investments are developing the understanding and tools necessary to identify vulnerable assets, assess impacts, and determine appropriate adaptive responses.

Climate-related effects already are being observed at DoD installations in every region of the United States and its coastal waters. These physical changes include:

- rising temperature and sea level
- increases in both heavy downpours and the extent of drought
- thawing permafrost
- shifts in growing seasons
- lengthening ice-free seasons in the oceans and on lakes and rivers
- earlier snowmelt
- altered river and stream flows.

The direction, degree, and rate of these changes will differ by region, as will the impacts to the military's infrastructure and capabilities. SERDP investments are improving the understanding of the potential impacts of climate change and developing effective adaptation and mitigation strategies that will enable DoD to respond appropriately.

SERDP investments are focused on the following:

Vulnerability and Impact Assessment—Quantifying climate change impacts requires understanding how physical drivers, such as sea level rise and extreme weather events, will change. It also involves determining which components of DoD infrastructure are potentially vulnerable to these changes and how they could be affected. Another essential aspect is an improved understanding of how species and ecosystems associated with DoD lands and waters will respond to climate change in the context of other stressors. The primary emphasis of research is the development of region-specific tools and models to better predict the impacts both to the features that protect coastal areas and to the built infrastructure of installations, ranges, and the surrounding communities. Research to be initiated in FY12 will take a broad view and investigate the role of various decision frameworks and their ability to match climate information to the needs of DoD infrastructure managers.

Adaptation Science—Adaptation to climate change involves reconfiguring DoD's natural and built infrastructure or increasing its resilience. Research is focused on improving the understanding of how to manage species and ecosystems that will be affected by climate change. Certain types of natural infrastructure provide physical protection from extreme weather events for training and testing areas and built infrastructure. Research involves studying how to enhance the resistance, resilience, or recovery capacity to enable such natural infrastructure to continue to provide benefits in the face of climate change.

Land Use and Carbon Management—Land-use practices affect the rates of carbon cycling and storage within the soil and vegetation. Research initiated in FY 2011 will improve the understanding of carbon cycle dynamics across the various landforms and vegetation types that DoD manages. This knowledge can be used to ensure land and carbon management is compatible with maintaining military mission support, desired ecosystem services, and biological diversity.

Department of Defense, Legacy Resource Management Program

The DoD Legacy Resource Management Program (Legacy) funds natural and cultural resources projects with national, regional or other wide-scale DoD applications to support overall DoD conservation goals and military readiness. Legacy helps protect and manage these resources to ensure continued access to realistic habitat conditions that support the military's combat readiness mission, while fulfilling its stewardship responsibilities. Legacy has funded several climate change-related projects in the past three years.

Guidelines for Assessing the Vulnerability of Species and Habitats to Climate Change—These guidelines describe ways to assess the vulnerability of plants and animals to anticipated changes in climate. The information is intended to help DoD natural resources managers better manage those species and habitats most likely to need conservation actions as a result of expected changes.

Sea Level Rise Risk Assessment for DoD Coastal Installations—This project assessed the risk of sea level rise to natural, cultural, and operational resources at five DoD installations on the Dare County peninsula in North Carolina. The assessments were made using the Intergovernmental Panel on Climate Change moderate sea level rise scenario, and showed that major training interruptions could potentially begin as soon as 2050, when forestland converts to wetter marsh transition vegetation.

Modeling the Impacts of Climate Change on Birds and Vegetation on Military Lands—These models predict and map how climate change may alter vegetation and bird distribution on DoD lands in California. Vegetation and bird losses are projected to be much greater on DoD lands than on other public lands in California, as birds and vegetation are significantly more abundant and diverse on DoD lands. If regional changes in climate result in declines of already at-risk species on military installations, those species could become federally listed. This could lead to potential impacts to testing and training activities.

Climate Change Tools Workshop—The DoD Natural Resources Program sponsored the Climate Change Tools for Adapting Management Strategies workshop at the 2010 National Military Fish and Wildlife Association (NMFWA) annual meeting. This workshop described currently available tools and provided information on how and when to use them appropriately. Specifically, the workshop:

- educated DoD natural resources personnel about tools that are, or will soon be, available to help them adapt management activities in light of anticipated climate change impacts;
- described how and when to use these various tools; and
- guided them through the use of these tools.

DoD Animation on Climate Change Activities—The video introduces the issue of climate change and features projects on sea level rise and threatened and endangered species, as well as an overview of DoD's conservation funding programs. The animation and an accompanying fact sheet are available at www.dodnaturalresources.net.

US Department of the Army

Research and development (R&D) on the topic of climate change within the Army is executed by the U.S. Army Engineer Research and Development Center (ERDC). The relevant R&D activities are focused on developing capability to understand and inform decisions related to the consequences of climate change and variability on Army installations, assets, and infrastructure. Research concerned with the effects of climate change on military installations is primarily supported by the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)). The Office of the Assistant Secretary of the Army for Civil Works (ASA(CW)) and US Army Corps of Engineers (USACE) Headquarters (HQ) support research at ERDC in the areas of coastal and inland water infrastructure and ecosystems.

Research Supporting Military Installations

Within the thrust areas of Sustainable Ranges and Lands and Military Materials in the Environment, research is being conducted in three areas.

Prediction and Adaption of Military Infrastructure in Response to Climate Change—The objective of this R&D is to develop advanced ecological network models for vulnerability assessments of mission critical ecosystem processes impacted by climate change. The ecological components considered are those that constrain military mission including regulatory constraints (e.g., endangered species, invasive species, and erosion) and aspects of community structure and function critical for training missions (e.g., "vegetation encroachment"). Climate drivers for these models will be obtained from previously developed general circulation models (GCM) and regional climate models (RCM), including those used or developed in other ERDC research activities. Ecological network models will incorporate data from previously completed research projects. Developed models are intended for use in existing modeling frameworks and/or emerging systems. The current effort targets model development for installations in the southeastern U.S., specifically the Sandhills region.

Climate Change-Induced Biome Shifts and Contaminant Management Implications for DoD Lands—The objective of this project is to build a toolkit for use in ecological risk assessment, sustainable contaminant management, and remediation activities. This project will utilize existing regional biome-shift models to predict significant changes in conventional knowledge of contaminant fate, transport, and biological impact due to climate change and related stressors for ecological risk assessment at continental US (CONUS) installations. Biome models cover larger geographic regions as compared to typical ecosystem models and are characterized by a focus on specific dominant organisms. Specifically for this effort, vegetative dominant biome-shift models will be utilized as the most influential factor on soil properties and change in contaminant behavior. Although changing climate will affect individual species and populations, the whole will be more than the sum of the parts. Landscape conversion produced by passive biome shift with or without altered disturbance regimes, or a more dynamic synergy between climate change and anthropogenically induced stressors, will cause upheavals in community assemblages, interspecies relationships, and biological processes.

Integrated Modeling and Risk Analysis for the Environmental Consequences of Climate Change: A Framework for Assessing the Environmental Effects of Climate Change for the Military—This project is developing an integrated technology platform for modeling and analyzing the influence of climate change on environmental impacts of interest to military planners and decision-makers. The analytical framework integrates rigorous, large-scale models of the global climate system with analytically tractable model linkages to regional assessments of climatic change, weather, ecological stressors, watershed processes, and landscape evolution. A diverse range of environmental impacts are explored in terms of their potentially deleterious effects on ecosystems associated with military installations and the missions they support. All of these components are integrated within a risk-based decision analytic framework that provides military planners with a robust computational environment for formally evaluating a broad range of possible response, mitigation, and adaptation strategies.

Research Supporting the USACE Civil Works Mission

ERDC conducts a range of research, funded by multiple research programs, in support of USACE Civil Works program missions related to coastal and flood infrastructure, navigation systems and infrastructure, and

ecosystem restoration. The relevant physical research includes the development of hydrologic and hydrodynamic models for characterizing wave processes in coastal environments, flooding and inundation, sediment transport, and a variety of other processes. The environmental research supporting both the navigation and restoration missions includes processes and modeling affecting water and sediment quality as well as ecological processes at a variety of scales.

US Department of the Navy

Research and development (R&D) on the topic of climate change within the Navy is executed by a number of organizations.

Task Force Climate Change

Navy's Task Force Climate Change (TFCC) is the principal Navy organization responsible for developing policy, requirements, and identifying Navy research requirements regarding climate change science, mitigation, and adaptation. All Navy components have representatives on TFCC who identify their organization's needs and questions regarding climate change science and research. These needs exist on spatial scales from sub-regional to global and on operational scales from tactical to strategic. As a result, a wide range of needs exists, including the development and implementation of mission/operational/campaign plans, infrastructure/facilities plans, education and outreach, policy development, development of Naval platforms, weapons and sensors, and the investments associated with these efforts.

Office of Naval Research

Although the Office of Naval Research (ONR) does not fund research for the purpose of understanding or predicting climate change, ONR supports basic research programs that, while directed toward fulfilling the objectives outlined in the Naval Science and Technology Strategic Plan, also project onto the science goals needed for the U.S Navy to understand a changing physical environment and maintain readiness. ONR has developed initiatives that will improve monitoring and prediction of critical environmental changes in the Arctic, including the marginal ice zone in which the Navy and Coast Guard may be required to operate.

Naval Research Laboratory

The Naval Research Laboratory (NRL) Oceanography, Remote Sensing, Marine Geosciences, and Space Science Divisions conduct research and development related to climate in the following areas: (1) basic research related to climate change, (2) applied research in development of prediction systems for changing climate, and (3) multi-agency R&D related to climate change. Each of these areas is described in additional detail below.

Basic Research Related to Climate Change—Includes the following research areas:

- Improving understanding of the changing Arctic environment, including the study of the influence of air-sea interaction on the development and propagation of global tropical instabilities, such as the Madden-Julian Oscillation.
- Determining how future changes in the operational environment could impact Navy and Marine Corps policy, strategy, force structure, and investment. This research uses state-of-the-art earth system prediction models to explore the following areas: (1) modeling feedbacks between Arctic sea ice and vertically deep atmospheric circulations to better understand observed trends; (2) quantifying the impact of increased frequency of extreme weather on installations and operations worldwide; (3) developing better parameterizations of physical processes to improve the skill of numerical climate and weather prediction systems; and (4) performing observations-based statistical modeling to quantify natural sources of climate variability, such as solar cycle influences on surface temperatures and upper atmospheric densities.

- Identifying cycles/trends in solar irradiance and their impact on climate. Multi-year data regression studies are showing resonant responses and positive feedbacks in the ocean-atmosphere system that may amplify response to solar irradiance variations. These cycles and trends are becoming recognized as important components of natural climate variability on decadal to centennial scales. Research in this area examines the linkage between solar irradiance in relation to other natural and man-made phenomena impacting terrestrial climate variability. This research is funded by a non-DoD source.

- Establishing the capability to measure soil moisture. Soil moisture is a key climate variable in the global water, energy, and carbon cycles and in environmental assessment and prediction.

Applied Research in Development of Prediction Systems for Changing Climate—Includes the following research areas:

- Adding an ice predictive capability to the Navy's new global ocean model, the Hybrid Coordinate Model (HYCOM), to predict (7 days) ice conditions for the Arctic and the Antarctic, which is called the Navy's Arctic Nowcast/Forecast System or the Arctic CAP model. The intent is to repeat this demonstration next year and contribute these results to the Search Sea Ice Outlook community-wide published summary for the expected September arctic sea ice minimum in FY12 (<http://www.arcus.org/search/seoiceoutlook/>).

- Developing the next generation atmosphere prediction model, the Non-hydrostatic Unified Model for Atmosphere (NUMA). The design of NUMA is aimed for a seamless, unified numerical prediction suitable for both short-term (< 2 weeks) weather and long-term (to decadal) climate prediction.

- Using data from the NRL WindSat instrument to develop an optional capability to monitor the sea ice extent and concentration from space. The data streams are fed into the National Ice Center (NIC) for distribution to users from scientific and operational communities.

Multi-Agency R&D Related to Climate Change: Includes the following research areas:

- Supporting the multi-agency National Unified Operation Prediction Capability (NUOPC) by building the framework for coupling the global atmosphere model, NAVGEM, with the global ocean circulation model, HYCOM, using the Earth System Modeling Framework (ESMF). This infrastructure paves the road for longer-term prediction as the atmosphere, ocean, ice, land, and space components are seamlessly coupled to form a whole earth system. A follow-on effort is proposed to couple together the Navy's global atmosphere model, global ocean model, and global wave model to create a system for longer-term prediction that will provide consistent forecasts of the atmosphere, ocean, and wave state for operational and tactical planning beyond the current capability.

- Participating in the multi-agency Earth System Prediction Capability-Research, Development, and Operations (ESPC-RDO) initiative. The goal of ESPC-RDO is to develop a new operational global earth system model consisting of high-resolution atmosphere, ocean, ice, land, and space components capable of seamless prediction from zero hour to three decades within the next ten years. Related to this initiative, NRL has proposed to study the seasonal prediction with a focus on the impact of model resolution on multi-scale simulations. This research will set the foundation for the development of the seamless weather-climate ESPC-RDO.

Naval Postgraduate School

The Naval Postgraduate School (NPS) is a graduate level research university located in Monterey, California. NPS operates in many ways like a civilian research university but with a focus on DoD relevant basic and applied research and on corresponding graduate-level education (masters of science and doctoral studies and research). NPS conducts basic and applied research and development projects on a wide range of climate topics, including: studies of the local, regional, and global atmosphere, ocean, and land; studies of specific phenomena (e.g., storms, floods and droughts, ocean circulation, and sea ice process); long term data collection and analysis; climate model development and testing (e.g., statistical, dynamical, statistical-dynamical, multi-model, and multi-decadal hindcasting and verification); climate system prediction (intraseasonal to multi-decadal lead times); performance prediction (e.g., prediction of sensor and weapons performance); operational impacts of climate

change (e.g., impacts on infrastructure, sensors and weapons, personnel, planning—tactical, operational, and strategic, and national and international policy). Climate change is covered in several climate science courses, numerous other meteorology and oceanography courses, and also in operations analysis, national security, and defense analysis courses. NPS graduate students conduct masters and doctoral research studies on these topics and on the application of research and development results to the Fleet. NPS research and development addresses climate issues in the areas of responsibility for all the Combatant Commands.

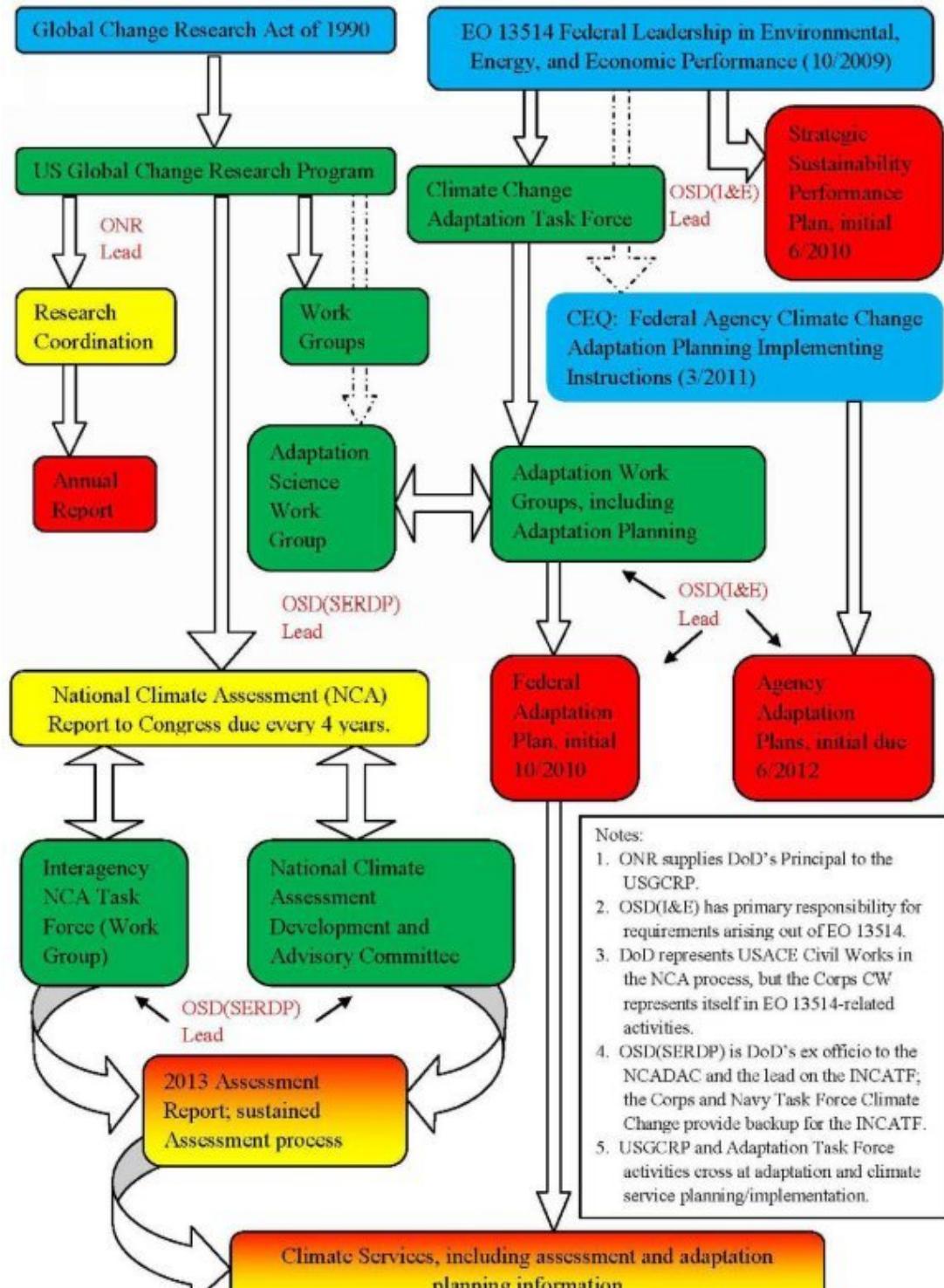
United States Naval Academy

The United States Naval Academy (USNA) conducts research and teaches classes that incorporate global climate change. The Oceanography Department offers two dedicated climate-themed courses, Global Climate Change and Polar Oceanography. The Oceanography Department is taking the lead in the development of a USNA field research-based Polar Science Program (USNA PSP), with contributions from the Ocean Engineering, Systems Engineering, and Computer Science Departments that will greatly enhance midshipman education and research. At the core of this effort is the development and maintenance of a USNA PSP Arctic buoy, which will be built and deployed by midshipmen as a collaborator in the BRomine, Ozone, and Mercury Experiment (BROMEX 2012; <http://seacie.apl.washington.edu/AirChemistry>). This field experiment will take place in Point Barrow, Alaska during March of 2012. Midshipmen and USNA faculty also will conduct field research on seismo-acoustic characterizations of ice lead ruptures and collisions and linked land-sea-air-ice chemistry in support of BROMEX 2012 science objectives. Results and lessons learned from BROMEX 2012 will provide the basis for continued USNA PSP and midshipman involvement in ongoing national and international Polar research projects. As a related effort, the USNA PSP will provide a basis to promote and enhance current and planned USNA Science, Technology, Engineering, and Mathematics (STEM) initiatives specifically in the realm of Polar Science.

USNA professors are conducting research on the flood risk associated with coastal storms in combination with sea level rise. Work has been funded by US Army Corps of Engineers to provide engineering design guidance for sea level change as it relates to the Corps' mission of national flood damage reduction. Emphasis is on regional comparison of 28 cities around US coast to define differences in flood risk and vulnerability to different sea level rise scenarios as outlined in recent Corps design guidance to field offices.

Senior Ocean Engineering Capstone design project to develop feasibility-level design of an Alaska Arctic Deep Water Port. Midshipmen from USNA are pursuing concept-level design for a new port to support joint US Coast Guard and commercial operations in Arctic Alaska. The study will consider site selection, port size and operational capacity, port layout and need for breakwater protection, and dredging requirements.

APPENDIX F FEDERAL CLIMATE CHANGE RESEARCH AND DEVELOPMENT AND RESPONSE DRIVERS AND NETWORK



Appendix G

Breakout Session Summaries

G1 Service Breakout: Army/Air Force

Breakout session 1

Service Breakouts

Army/Air Force Session Chair: Dr. Todd Bridges, USACE ERDC-EL

Organizational Relevance

The Army and Air Force are both engaged in organizational activities with respect to the generation and use of climate change information. Within the Army, the four elements currently engaged include the Army Installation Management Command, IMCOM; the Office of the Assistant Secretary of the Army for Installations, Energy and the Environment, ASA(IE&E); The Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, ASA(ALT); and the Office of the Assistant Secretary of the Army for Civil Works, ASA(CW). Within the Air Force, climate change is currently being addressed within the Office of the Assistant Secretary of the Air Force for Installations, Environment and Logistics (SAF/IE).

The relevance of climate change information for Army IMCOM, the ASA(IE&E), and the SAF/IE relate to their complementary roles in policy development, planning, and management pertaining to military installation infrastructure, both natural and built, within the U.S. and elsewhere. Climate change and variability will pose challenges to the performance and reliability of aging infrastructure delivering energy and water to installation communities; it will also exacerbate stressors affecting natural systems and environmental resources comprising training lands and ranges.

The ASA(CW), through the U.S. Army Corps of Engineers (USACE), oversees the development and management of a large network of water resources infrastructure (including navigation channels, locks and dams), reservoirs, both inland and coastal infrastructure related to flood risk management, as well as a series of large-scale ecosystem restoration projects. Climate change and variability, as these affect the spatial and temporal distribution of precipitation and storm activity within the U.S., will pose significant challenges and risks to the performance of such water resources infrastructure and investments.

Both the Army and USACE are currently investing in research related to assessing the impacts of climate change and their management. The ASA(ALT) supports environmental research related to the management of technology development and Army operations, which includes consideration of climate change impacts relevant to Army missions. The U.S. Army Engineer Research and Development Center (ERDC) holds the lead role for conducting environmental research supporting both the Army's military and civil works missions, including climate change. As such, ERDC is currently conducting research to expand the Army's and USACE's capabilities to assess and manage risks related to climate change and variability. The USACE Institute for Water Resources is supporting the ASA(CW) through the development of policy for using existing science on coastal and inland hydrology, sea level change, flood frequency analysis, reservoir sedimentation, and droughts and other climate related topics.

Engagement on the topic of climate change is also relevant to the DoD's Regional Environmental Coordinators (RECs). In 1994, the DoD established 10 multi-state RECs to improve environmental coordination at the regional, state and local levels. The RECs provide DoD and the installations a centralized voice and act as the bridge between DoD, environmental regulators and the states. DoD split the lead role for individual regions among the Army, Navy and Air Force. RECs act as liaisons among any number of agencies and entities concerned with the environment on and around military installations. They coordinate with federal, state and local environmental regulators; state legislators; non-governmental organizations; the Installation Management Agency, other DoD entities; and Native American tribes. They communicate via conferences, forums and newsletters. The RECs facilitate partnerships and collaboration efforts within and among these groups. An example of the relevance of climate change to the evolving mission of the RECs is the Army's new Strategy for the Environment which sets forth the triple bottom line of sustainability: mission, environment and community. RECs work to reach this bottom

line by opening lines of communication, coordinating efforts, and facilitating solutions to ensure the readiness of the Army and the well-being of people and the environment now and into the future.

Needs, Opportunities, and Relationships to USGCRP and NCA

While progress continues to be made in organizing climate change initiatives and policy within the headquarters of DoD and the Services, plans for distributing these products within and between the Services as well as with organizations external to DoD will need to be developed. Current needs within the Army and Air Force include the development of relevant requirements for climate change indicators that can be used to identify trends, thresholds, or impacts related to climate change for which engineering or management actions should be formulated. In addition, new policies and analytical capabilities will be needed to support coherent adaptation strategies that minimize costs and risks to mission critical functions over time. Engagement between the R&D communities within the Army and Air Force and the USGCRP and the NCA can facilitate both the communication of DoD's needs within the broader technical community while providing the DoD ready access to expertise and technology across the federal government. The USACE Chief Scientist, as Director of ERDC and the Director of USACE R&D, could serve as a point of engagement between the Army's research and development (R&D) activities and the R&D activities of other federal organizations participating within the USGCRP and the NCA.

As a part of this engagement process, the RECs could play an important role in identifying regional input to the development of requirements within the headquarters of DoD and the Services. The RECs may also provide a logical engagement point for regional assessments being conducted as a part of the NCA. Given the importance and challenges associated with stakeholder engagement in relation to climate change, the stakeholder networks developed by the RECs should provide an efficient and effective means for fostering the coordination and communication needed to move forward with the actions comprising a local or regional climate change adaptation plan.

Climate Change Future Needs Driving R&D Requirements

The following provides a list of R&D needs/requirements that were identified as germane to the Army and Air Force during the workshop.

• Processes

* Using long-term physical lines-of-evidence (e.g., tree rings) in combination with process models to characterize trends for regional up-scaling that support global circulation mode (GCM) scenario-based regional downscaling.

* Evidence to support predictions of momentum for how long climate change effects related to greenhouse gas (GHG) production (both duration and magnitude) will occur. Such evidence is needed to develop predictive capabilities for explaining incremental costs and consequences for emission scenarios and other influences.

* Understanding climate change impacts on aircraft dynamics and sensor performance in new and legacy systems.

* Higher resolution digital elevation maps (DEMs) and water level gauging to support climate change R&D.

• Analytics

* Improved approaches for predicting and characterizing climate change effects and impacts to a level of acceptable uncertainty.

* Methods for developing and then testing the efficacy of adaptation strategies and operational practices devised to address the predictions associated with climate change research.

- * Quantification methods for characterizing uncertainty in predictions.
- * Quantification of variability with respect to infrastructure operational/performance thresholds.
- * Downscaling that is sufficient for evaluating hydrologic system response.
- * Improved understanding for determining which variables matter most in decisions.
- * Guidance to support how to use climate change information to best inform decisions.
- * Downscaling to improve understanding of hazards and impacts.
- * Economic and budget analysis for supporting cost-benefit analysis under high levels of uncertainty.
- * Understanding of complex interactions of systems to characterize potential unintended consequences.
- * Ability to downscale GCMs to a reasonable level of uncertainty to inform hazard event modeling simulation regionally.
- * Engineering guidance for infrastructure adaptation.
- * Agreement on which GCMs the scientific community should be using.
- * New definition of return period for hazard events.
- * Better GCM regional downscaling and impact assessment to identify infrastructure related requirements.
- * Improved decision analytics to support rational identification and implementation of adaptive management actions.
- Future Conditions
 - * Prediction of future water demands on a geographical basis.
 - * Identification of common future climate change scenarios for DoD Services and regions to apply in planning.
 - * Identification of environmental tipping points with lead times for effective management.
 - * Non-stationarity lookup tables of conditions anticipated in the future for use in scenario development.
 - * Predictive knowledge for how climate change is currently and will affect DoD Services' missions.

Using Climate Change Information

The Army and Air Force expect to use climate change information in the following ways:

- Increasing the situational awareness of senior leadership on climate change phenomena and potential Service vulnerabilities and global risks at the strategic level.
- Risk assessment and identification of management actions that can be taken to reduce risks to the portfolio of Service assets, infrastructure, and missions at the full range of scales: globally, regionally, and locally.

- Technology transfer of tools to operational end users at installations to support the development of local strategies and plans to address the projected consequences of climate change, including adverse effects caused by extreme events.

G2 Service Breakout: Navy

Breakout session 1

Service Breakouts

Navy

Session Chair: CAPT Tim Gallaudet, USN, OPNAV/TFCC

Assistant Chair: Dr. Tom Murphree, NPS

Navy attendees at the workshop included representatives from the Chief of Naval Operations (OPNAV) staff (Task Force Climate Change/Oceanographer of the Navy), the Naval Postgraduate School (NPS), the Office of Naval Research (ONR), the Naval Research Lab (NRL), Naval Facilities Engineering Command (NAVFAC ESC), and others. The following provides a summary of the breakout session findings by question, followed by additional issues and questions raised by session attendees.

Charge Question 1: Who (person or office) in your Service is interested in and should receive updates on USGCRP or may want to present needs or questions to the DoD USGCRP representative so he can query USGCRP relative to the federal investment in climate change science and its relevance to the DoD/military Services? (The goal is to develop the basis of a communication "wiring" diagram, so names, email, office symbol would be useful in the listing.)

The Navy's Task Force Climate Change (TFCC) is the principal Navy organization responsible for developing policy and requirements and identifying Navy research requirements regarding climate change adaptation, mitigation, and science. Within TFCC, the Navy Climate Change Coordination Office (NCCCO) under the Chief of Naval Operations Staff (OPNAV N2/N6E) acts as the central point of contact and administrative office to coordinate climate change requirements and policy across the Navy.

All Navy components have representatives on TFCC that report to the NCCCO, and their Flag/SES representatives are members of the TFCC Executive Steering Committee (ESC), which is chaired by the TFCC Director (Oceanographer of the Navy - OPNAV N2/N6E) and charged with providing the Chief of Naval Operations with recommendations regarding climate change related policy, requirements, and investments.

Navy components represented on TFCC that have needs and questions regarding climate change science and research include USFF/PACFLT/Fleet Commanders, Commander Naval Installations Command and the Navy Region Commanders, Navy Resource Sponsors and Offices on the Chief of Naval Operations Staff (e.g., Information Dominance, Surface/Aviation/Submarine/Expeditionary Warfare, Naval Medicine, Naval Reserves), Office of Naval Research (DoD's USGCRP representative), Naval Research Lab, Naval Postgraduate School, Naval War College, and U.S. Naval Academy.

Despite the institutional representation by TFCC for climate change issues across the Navy, several challenges exist for effectively communicating climate change science needs to the TFCC NCCCO, ONR, and USGCRP, including challenges concerning climate education within the Navy component staffs, sufficiency of resources and staffs, prioritizations, and perceptions of relevancy.

Areas of climate change science and research of interest within the Navy are diverse and can be divided into: (1) basic physical science relevant to strategic, operational, and tactical planning and (2) applied science and engineering related to installation and platform and system adaptation. Examples of the former include

understanding and predicting the physical mechanisms of oceanic, atmospheric, and terrestrial climate change on regional to global scales, including complex feedback mechanisms associated with, for example, abrupt climate change and tipping point phenomena.

Charge Question 2: The next National Climate Assessment is now underway with a target date of a 2013 report to Congress. Included may be updates to or new assessments at the regional scale. Who (person or office) in your Service is interested in and should receive updates on opportunities to participate in regional assessment activities? (The goal is to provide a list of interested offices/participants by region through the DoD Interagency National Climate Assessment Task Force representatives.)

As indicated above, the Navy's Task Force Climate (TFCC) Navy Climate Change Coordination Office (NCCCO) is the lead Navy office that would participate in regional assessments, coordinate with TFCC representatives from the Navy Regional Commands and Fleet Commander staffs, and interact with other Navy organizations that might need to be aware of and/or participate in regional assessments (e.g., Office of Naval Research (ONR), Naval Research Lab (NRL), Naval Postgraduate School (NPS), Naval War College (NWC), U.S. Naval Academy (USNA), and Naval Facilities Engineering Service Center (NAVFAC ESC)). TFCC will prepare a contact information list for these organizations.

Charge Question 3: What research or activities is your Service, either internally or though extramural funding, actively conducting or planning to conduct that are related to climate change vulnerability and impact assessment, adaptation science, mitigation, or climate modeling? (The goal would be a list of what is underway or planned, where/who, and the requirement being addressed.)

The Navy has several ongoing and planned activities related to climate change vulnerability and impact assessment, adaptation science, mitigation, and climate modeling. Organizations sponsoring or contributing to this work include the Office of Naval Research (ONR), Naval Research Lab (NRL), Naval Postgraduate School (NPS), Naval War College (NWC), U.S. Naval Academy (USNA), Naval Facilities Engineering Service Center (NAVFAC ESC), Task Force Climate Change (TFCC)/Oceanographer of the Navy, and Office of the Secretary of Defense (OSD) Strategic Environmental Research and Development Program (SERDP). The following briefly summarizes these activities:

- Task Force Climate Change (TFCC)/Oceanographer of the Navy: Assessment of Naval coastal installation vulnerability to sea level rise.
- The Office of the Secretary of Defense (OSD) Strategic Environmental Research and Development Program (SERDP): Multi-disciplinary studies of climate change impacts to military installations in the continental United States (CONUS).
- Office of Naval Research (ONR): Participation in an interagency, advanced Arctic and global numerical environmental prediction program, including development of observation and prediction capabilities, and studies of physical processes. In addition, ONR is supporting OPNAV N86 in studying the impact and design requirements for surface ship operations in cold region environments.
- Naval Research Lab (NRL): NRL-DC, Monterey, and Stennis are conducting and have proposed several environmental prediction efforts, including: (1) development of a coupled ocean-atmosphere model to assess variability with a focus on extreme events; (2) development of a seasonal prediction capability; and (3) development of a 0hr-30yr prediction capability for planning downscaled to regional/local scale. Elements of these climate related projects include exploration of physical, chemical, and dynamical processes; tropical-polar teleconnections/interactions; ocean and atmospheric (stratospheric and tropospheric) heat exchange and flux; air-sea-land-ice coupled modeling; space and upper atmospheric modeling and reanalysis; and fully coupled sun-Earth models.
- Naval Postgraduate School (NPS): NPS conducts basic and applied research and development projects on a wide range of climate topics, including: studies of the local, regional, and global atmosphere, ocean, and land; studies of specific phenomena (e.g., storms, floods and droughts, ocean circulation, sea ice process); long term data

collection and analysis; climate model development and testing (e.g., statistical, dynamical, statistical-dynamical, multi-model, multi-decadal hindcasting and verification); climate system prediction (intraseasonal to multi-decadal lead times); performance prediction (e.g., prediction of sensor and weapons performance); operational impacts of climate change (e.g., impacts on infrastructure, sensors and weapons, personnel, planning—tactical, operational, and strategic, and national and international policy). Climate change is covered in several climate science courses, numerous other meteorology and oceanography courses, and also in operations analysis, national security, and defense analysis courses. NPS graduate students conduct masters and doctoral research studies on these topics and on the application of research and development results to the Fleet. NPS R&D addresses climate issues in the areas of responsibility for all the Combatant Commands.

- Naval War College (NWC): Individual student projects assessing the impact of climate change on National Security policy and planning, as well as scenario-based gaming with emphasis on Arctic operations and security over the next three decades.
- U.S. Naval Academy (USNA): Climate change science is covered in several courses within the Oceanography Department, and students conduct senior projects that involve climate-related factors.
- Naval Sea Systems Command (NAVSEA): NAVSEA is conducting assessments of cold region ship design in collaboration with Russia and Finland.
- Naval Facilities Engineering Service Center (NAVFAC ESC): Supported an initial assessment of Naval installation vulnerability in support of the 2010 Quadrennial Defense Review (QDR), supported a Central Command water study for the Horn of Africa region, participated in the TFCC-led Naval coastal installation vulnerability assessment, supports elements of SERDP's four coastal military installation assessments, and have proposed a study addressing the impact of climate change on coastal ecosystems.
- All of these organizations and efforts have included numerous publications and conferences, workshops, and working group meetings.

Charge Question 4: What do you see as the current requirements or demands for climate information from your Service that will drive the need for future research? (The goal is a list of future needs, research required, by whom.)

Current Navy requirements for climate information exist on spatial scales from local to global, and on planning scales from tactical to strategic, to support development and implementation of mission/operational/campaign plans, infrastructure/facilities plans, education and outreach, policy development, development of Naval platforms, weapons, and sensors, and the investments associated with these efforts.

Improvements are needed in the climate science and climate information necessary for addressing these Navy requirements, including: (1) developing models with higher temporal and spatial resolution; (2) developing a range of model types (e.g., statistical, dynamical, statistical-dynamical, multi-model); (3) improving the physics in physical models of sea ice, ice sheets, the atmosphere, the ocean, permafrost, and coastal zones; (4) reducing and quantifying the uncertainties of these physical models; (5) providing probabilistic output from climate models and in climate assessments; (6) improving understanding of abrupt climate change scenarios and likelihood; (7) improving modeling of geoengineering deployment and associated global system response; and (8) addressing the wide variety of adaptation science interest areas for the Navy, such as improving surface ship/system operational performance in cold regions, and adapting coastal installations to sea level rise.

Charge Question 5: How do you envision your Service using climate information: are their new needs for research or information translation to support these efforts?

The Navy is using and will continue to use climate information to support: (1) development of tactical/operational/strategic plans and policy development; (2) the design, construction, and/or retrofitting of Naval platforms, weapons systems, installations, and facilities; (3) the sustainment of natural and cultural resources; and (4) the associated investment decisions required for each of these. Each of these require information

regarding different physical processes (e.g. oceanic, atmospheric, and cryospheric), different spatial and temporal scales and resolutions, and with differing levels of confidence/uncertainty.

Although current Navy research efforts address these needs to varying degrees, new research is needed in: data access, management, and fusion; decision support; risk and uncertainty quantification; adaptation science; applications of operations analysis to climate change impacts/scenarios; and effective visual representation of climate data and predictions.

The greatest impediments to progress in supporting Navy climate change needs are the lack of availability of resources, educated personnel, and perception of the importance of climate change impacts on national security. Additionally, it is important to define the scope of climate change and climate variability for Navy research and applications. Some important elements to consider when defining this scope are temporal and spatial scales of variability, valid periods of prediction, rate of change (e.g., abrupt climate change), high priority regions, spatial and temporal interactions within the climate system (e.g., teleconnections), and geoengineering.

Several challenges impair effectively communicating climate-related information within the Navy, including challenges concerning climate education within the Navy component staffs, sufficiency of resources and staffs to process and manage climate information, prioritizations concerning climate issues, and perceptions of the relevance of climate change challenges.

G3 Coastal Environments

Breakout session 2

Cross-Cutting Theme 1: Regional Research and Development Needs

Group A — Coastal Environments

Session Chair: Mr. William Curtis, USACE ERDC-CHL

Assistant Chair: Dr. Edmond Russo, USACE ERDC-CHL

Charge: Coastal environments will be one of the most sensitive to climate change as they are exposed to the effects of sea level rise, potentially enhanced storm activity, ecosystem shifts, and salt water intrusion into groundwater supplies. Many DoD installations are located in coastal environs that provide valuable operational, training, testing, and ecosystem services in strategic locations.

Charge Question 1: What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure from local sea level rise, storm surge, and inland flooding during large precipitation events?

Physical processes that represent natural systems and hazards (i.e., forcing functions) at regional and local scales should be considered in the context of climate change. Beyond local sea level rise, storm surge, and inland flooding during large precipitation events, consideration should be given to physical process-based hazards including wind, sediment movement (erosion/ sedimentation), and constituent releases, movements, fate, and effects. The systems involved include:

- Coastal geomorphologic features (e.g., sandy shoreline/barrier island dynamics under wave/current forcings; vegetated wetland morphology under sea level rise and extreme event storm activity);
- Island systems;
- Coastal geohydrologic features (e.g., aquifer functions); and

- Ecosystem functions.

Increased knowledge is required of how climate change effects will transform coastal hazards (i.e., changes in probability distributions over time for such phenomena as coastal storm frequency/intensity; wave climates) and system drivers (i.e., increased constraints of uncertainties such as sea level change rates). In addition, understanding vulnerabilities and risks (i.e., what can go wrong) is needed for installation management and for natural systems and training under climate change drivers and hazards. Finally, knowledge also is needed on civil works infrastructure conditions and associated performance that installations depend on that also may be impacted by climate change.

Local data at installations that are required to support assessments include:

- Digital elevation models of sufficient resolution;
- Land cover / land use and attendant changes over time;
- Coastal water level data (e.g., waves, river flood stages, coastal storm surges, and tides);
- Water quality data;
- Temperature and precipitation patterns; and
- Ground surface movement information.

Charge Question 2: What technical needs are relevant to evaluating and distinguishing among alternative adaptation strategies for increased storm frequency and/or intensity for both built and natural infrastructure?

Improvements are needed in model coupling for computational efficiency and representation of non-linear/dynamic feedback of climate change, scenario-driver influences on quantification of solutions. Techniques for characterization of uncertainties that propagate through the assessment process are required for further development. The importance of using iterative approaches at different scales for alternative solution development and refinement must be emphasized and enhanced. Inventory of new climate change knowledge development (e.g., seasonal-scale variations in forcing) is required, beyond linking existing knowledge for executing vulnerability and risk assessments to support the ability to examine adaptations. The capability to work at multiple scales with existing methods/models and evolving them and the underpinning science are enablers that should be pursued. Significant improvements are needed in ecological modeling with guidance on how to sustainably assist natural processes in coastal marshes that can enable such marshes to keep up with sea level change. Coastal engineering guidance is needed on how to adapt designs of sea walls, revetments, etc., considering climate change effects. Identification is required on the tipping points in installation mission impairment that result in going from minor to catastrophic impacts, as well as for natural asset functionality.

Charge Question 3: What scientific and technology advances are needed to develop reliable predictions concerning future changes in coastal ecosystems under the combined effects of climate and land use change and how those ecosystem changes will affect military infrastructure, readiness, and operations?

Improved capabilities of earth systems instrumentation/remote sensing platforms and greater span of deployments for data collection are critical to enabling quantitative assessments. Increases in the amount of computing power available to DoD scientists would be very supportive for achieving enhanced model resolution and run cycle times. Methodological approaches to explore the effects of non-linear feedbacks of systems and process models on risk assessment are required. Environmental risks associated with abandoned and current military facilities are needed relative to liberation of contaminants.

Charge Question 4: What policy and technical guidance is needed for determining which climate and sea level rise scenarios should be used and at what spatial scales to drive risk assessment and response in coastal environments?

Definition of key decisions the military is contemplating that will enable scoping of technical assessments is required at the policy level. Technical guidance is required for quantitative risk assessment at installations globally, characterized as highly vulnerable to climate change effects, for identification of mission impairment tipping points and associated networked mission assets/capabilities. This guidance should be for systematic climate change risk reduction that is commonly occurring globally and uniquely occurring regionally/locally. Update of the Services' Unified Facilities Criteria (UFC) to address climate change scenarios for planning and implementation should be informed in updates via such technical investigations that demonstrate these needs. Guidance on effective communication and technical transfer of information to installation management personnel will improve opportunities that new knowledge is employed in identifying adaptations.

G4 Cold Region Environments

Breakout Session 2

Cross-Cutting Theme 1: Regional Research and Development Needs

Group B — Cold Region Environments

Session Chair: CAPT Tim Gallaudet, USN, OPNAV/TFCC

Assistant Chair: Dr. Tom Murphree, NPS

Charge: Changes in cold region environments may affect DoD readiness and operations. The Navy in particular identified the Arctic as its near-term climate change concern, including possible changes in mission and required capabilities. Continued access to and use of training lands by the Army is contingent on permafrost conditions, which are subject to degradation under a warming climate. A relatively broad understanding of research needs has been developed for this region, but there are gaps in translating needed information into requirements.

Charge Question 1: How can science and technology developments from the research community be best transitioned to the operational level and into programs of record?

To best transition science and technology developments from the R&D community to the operational level and into programs of record, the existing programs designed for this purpose should be used. Examples of general DoD/Navy processes include OSD's Joint Capability Technological Demonstration (JCTD) process, the Navy Trident Warrior (TW) events for Fleet experimentation, and use of Joint Urgent Operational Needs Statements (JUONS) by the Combatant Commanders. Examples specific to environmental observation and prediction include the Naval Oceanography Enterprise's Future Meteorology and Oceanography Capabilities Program, Rapid Transition Program (RTP), the Administrative Modeling and Oversight Panel (AMOP), the Naval Oceanographic Partnership Program (NOPP), and the Oceanographic and Atmospheric Master Library (OAML).

Despite the advantages provided by these examples, improvements to the DoD acquisition process are required to speed science and technology to operational capability. Suggestions include: (1) leveling the playing field for all research performer organizations competing for R&D funds; (2) improving communication between the R&D and operational communities; (3) updating climate/environmental guidance for engineers; and (4) improving or developing new partnerships between the military Services and NSF, NOAA, other US Government agencies, and the scientific/academic communities.

Charge Question 2: What is the best mechanism to ensure operational planning documents and programs of record are informed on a regular basis by science and technology developments?

Research and development sponsors and R&D scientists and engineers need to routinely and frequently reach out to DoD planners (e.g., planners at the Combatant Commands, Navy Fleet Commanders, Air Force Major Commands, etc.) to: (1) inform them of science and technology advances and (2) determine if and how these advances can be applied to meet present and future operational needs. In addition, DoD educational organizations (e.g., service academies, war colleges, NPS) need to educate future DoD leaders on climate change and its ongoing and potential operational impacts. DoD R&D sponsors and researchers need to closely interact with each other to ensure that their efforts are well-coordinated and collaborative (e.g., coordinate and collaborate between Navy, Air Force, Army sponsors and researchers) to best meet joint and service specific operational needs. Finally, DoD sponsors and researchers need to intensively interact with their non-DoD counterparts to ensure that funding and research resources are effectively leveraged (e.g., so that DoD can quickly apply non-DoD results to DoD operational needs and avoid unnecessary replication of non-DoD efforts).

Existing examples of the methods exist that need to be applied. OSD's SERDP, USACE's Engineer Research and Development Center (ERDC), and the Navy's ONR, NRL, and NPS develop research guidelines and funding programs, conduct regular research, and/or coordinate with program managers and resource sponsors on a routine basis. The conferences and workshops that occur on a regular basis throughout the DoD, academia, and industry contribute to needed information exchanges (e.g., NDIA, SAME, ESTCP/SERDP). Several organizations and processes associated with DoD facilitate such information exchange, including the National Ocean Council (NOC), Defense Science Board (DSB), Naval Studies Board (NSB), State Department's Arctic Policy Group (APG), Center for Naval Analyses (CNA), U.S. Global Change Research Program (USGCRP), and National Research Council (NRC). All of these existing organizations have informed DoD programs on climate science and technology requirements.

Charge Question 3: What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure in cold region environments, in particular as a result of thawing permafrost, poorly understood coastal erosion processes, and altered fire and hydrologic regimes?

Several critical gaps exist regarding assessing and responding to risks to natural and built infrastructure in cold region environments, including: (1) sparse and incomplete environmental data sets (e.g. atmospheric soundings, digital elevation model, and hydrographic charts); (2) incomplete understanding of physical processes; (3) lack of skillful predictive systems for the physical environment; and (4) a lack of skillful downscaling methods. The physical phenomena that are most important but least understood include currents, sea ice, storm frequency and intensity, bathymetry, shoreline and geoid characterization, and permafrost.

Charge Question 4: What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive risk assessment and response in cold region environments?

Policy and technical guidance that is required for identifying climate scenarios and appropriate spatial scales for risk assessment and response in cold region environments include guidelines concerning the following topics: (1) anticipated DoD operating capabilities requirements for cold regions; (2) DoD operating thresholds or limits on operations; (3) climate vulnerabilities and sensitivities (e.g., of platforms, sensors, weapons, and personnel); (4) temporal and spatial scales for planning of DoD operations (e.g., operating periods, planning lead times, and planning regions); and (5) types, nature, and format for climate information to be used in DoD planning (e.g., deterministic and probabilistic predictions, prediction target spatial and temporal scales, and confidence and uncertainty supplements to predictions).

G5 Inland and Arid Region Environments

Breakout Session 2

Cross-Cutting Theme 1: Regional Research and Development Needs

Group C — Inland Regions, with a Focus on Arid Regions

Session Chair: Ms. Kelly A. Burks-Copes, USACE ERDC-EL

Charge: Climate change is expected to produce increased warming and altered precipitation patterns in inland regions, especially in the arid Southwest US. Even if mean precipitation increases, rainfall variability and cycles of drought and extreme precipitation events will likely increase. The preceding changes will affect the nature of flooding events, the quantity and quality of water, energy usage patterns, fire regimes, and ecosystem shifts.

Charge Question 1: What are the critical science gaps concerning climate change and land use impacts occurring within inland environments that are most relevant to military installations and their activities?

A round-robin exercise was undertaken to identify critical scientific gaps and the responses were aggregated in 3 main categories:

1. Policy and Guidance
2. Natural Systems and Resources
3. Infrastructure and Weapons

1. Policy and Guidance: Planning, Operations, Risk-based Decision Making all with regard to Climate Change Scenario Options

- a. Understanding of the very broad range of conditions in this rather large region is needed.
- b. How (particularly in the West) are the water rights & accessibility issues affected (assuming that the laws do not change)?
 - c. The dilemma of having agencies with multiple missions is that decisions regarding operations are based on the assumption that the water to support these choices is available. Do the agencies have the necessary tools to explore the vulnerability of the decisions given that water may be a particularly calamitous limiting factor?
 - d. What do you use in (scenario- or projection-wise) in place of stationarity assumptions—what methodologies or strategies do you use that capture both spatial and temporal variations, with enough lead time to be effective and efficiently used in large-scale infrastructure planning and management activities?
 - e. Planning for or simulating the probability of "events"—that is, storms (a variety of types: tornadoes, floods, blizzards, etc.) and their frequencies.
 - i. How disruptive will they be on inland installations?
 - ii. How do you prepare for events of a variety of "types" and frequencies/durations?
 - iii. There are different types of problems to consider and the science and methods used to address trends in means with clusters or increased frequency of events.
 - iv. The USACE doesn't "live" in the means of an event, but rather, focuses on the outliers—an increase in the frequency of these outlying events is of concern. And addressing the increased variability of these extremes is the priority. As a general rule, the area of numerical modeling/simulations do not work well in these "tail" areas—these are the events that really "bite you." The current models leave us particularly vulnerable because of these limitations.

f. How exactly do you "do" adaptive management; what steps do you take? Who's responsible? What is the analytical architecture needed to implement it?

g. There is a high degree of variability when you consider the breadth of this "region."

i. Can we even consider developing tools that (even at the regional level) that can adequately capture/characterize the degree of variability of climate change response?

ii. What is different about the regional precipitation patterns throughout the "inland" regions?

iii. This is likely a problem with the way we (the Workshop Facilitators) framed the questions with respect to "inland" installations; however, as we get more arid, the climate and weather becomes more variable.

h. Risk-based strategy or structured decision making activities. Because of the magnitude and scope of uncertainty decision analytics need to be able to characterize or bound uncertainties in a meaningful and relevant manner.

i. The farther you go up in the decision making chain, the problem becomes simplified.

ii. How could you better preserve information in a useful form as the issue is elevated in the decision-making chain?

iii. RAND robust-decision making is attempting to tackle this issue that could be incorporated—possibly tackling standardization (even maybe across all branches of the military).

iv. Do we want to make decisions with a common toolset or BMPs?

2. Natural Systems and Resources

a. River geomorphological processes and how it would be affected by climate change responses.

b. The inter-relationship between the water available and the demands of wildlife is unknown or definitely a gap. Do we have tools or methods to make these connections and project forward the "sustainability" of the current or planned activities/operations of wildlife habitat?

c. There are larger ramifications to the above. As human populations move nearby or encroach upon installations, how does this impact how we (the military) plan for and address the multiple demands for the same water, and how do we incorporate this into planning/management and how does this affect mission capabilities?

d. Migratory patterns: will these be affected? Will they shift in response to temp/precipitation changes due to climate change? Ultimately this could affect BASH; it could affect operations and management.

e. From the Navy's perspective one of the gaps for long-term predictions is a provision or insertion of aerosols so that when looking at the inland installations, can we begin to account for and predict when activities (increased dust or increased fires and the increased particulates released into the atmosphere). We need to develop methodologies to characterize and capture these potential inputs into the overall climate change scenarios.

f. If we can assume or predict species population trajectories, and how these might be affected by climate change (ecosystem response to), we need to begin discussion where the "hot spots" are, where there might be regulatory issues, and how these potential changes could be addressed in planning and managed over the long term.

g. Dispersal, establishment, extirpation. How will communities reorganize under future climate conditions? Animals have the potential to move or adapt to a point, but floral communities are likely to be significantly altered.

Fire, drought, and invasive species will all become concerns.

i. Do we have some climate change "canary" that we could use as an indicator? What happens when they get restricted to these "islands"?

ii. If we want an indicator that is truly telling us about climate change, we need to be careful that we select species that are not necessarily sensitive to climate variability.

iii. Because of the complexity, we are really talking about a series of hypotheses. "With this climate change scenario, we would expect to see x, y, z and by a Weight of Evidence approach we should be able to draw conclusions regarding planning and operational response."

h. Wetland status and implications for DoD in regards to wetlands: regulatory issues will arise; there will be a causation issue.

i. Contaminant releases: problems with assumptions of climate stationarity.

i. What happens when soil moisture regimes change? Will contaminants be released?

ii. Some sources of contaminants are known, but they currently lack receptors or pathways. Will this change under climate change and reduce the effectiveness of relying on natural attenuation as a remediation strategy?

iii. Is there any way to forecast these problems in advance and proactively address these issues in advance?

j. Invasive species management: will these better adapted species be more tolerated? Some examples: Spanish broom, salt cedar. And will they be an impediment to training (e.g., yellow star thistle will increase and impede training).

3. Infrastructure and Weapons

a. Heat is a concern—training and infrastructure—are they built to accommodate these anticipated changes?

b. Need new projected floodplain mapping that incorporates climate change scenarios. This may not be possible given the current political ramifications. There is an opportunity here for DoD to assist the Federal Emergency Management Agency (FEMA) in their efforts and collaborate on stakeholder engagement and consensus building.

c. When do we modify legacy weapons systems?

d. How do we build in "climate change" into the decisions during the acquisition/ development process?

Charge Question 2: What science, engineering, or technology gaps should be addressed to advance our ability to inform decisions about the risks climate change poses to military infrastructure and training and testing capacity in inland regions?

See responses to Charge Question 1 above.

Charge Question 3: What technology developments are needed to support military adaptation to climate change in inland regions?

Two more specific questions were devised in this session:

1. Do we need a new technology or engineering design to help the military adapt to climate change?

2. Are there new technologies to proactively address droughts/floods?

A second round-robin exercise was undertaken to identify needed technology developments. The following list was developed:

1. "Flexible" designs that have capacity built into them to address concerns of rain water storage, classic gray water usage, non-porous structures that can channel and pool water for reuse, and permeable asphalt to allow for infiltration. These technologies may already be available, but policy and guidance is lagging behind.

2. Natural infrastructure.

3. Weapon system improvements.

4. Dust.

5. Surface coatings.

6. Radar absorbing materials.

7. Pest management (vector-borne diseases).

8. Technologies that harden structures against forcings (i.e., strong-winds).

9. Soil conservation and erosion: are there some cheap, readily deployable additives that would stabilize soils, particularly in areas of heavy equipment and paratrooper drop zones?

10. Soil compaction in maneuver areas—maybe not?

11. Flood management: permanent structures are the status quo, but what about more temporary structures?

12. Biome shift models: prediction of rate/extent of biome shifts to facilitate habitat planning and T&E management or novel introductions or extirpations.

Charge Question 4: What critical gaps exist in scientific understanding, data, models, and tools in regard to assessing and responding to risks to both natural and built infrastructure in inland region environments, in particular as a result of extended drought, more extreme precipitation and wind events, and altered fire and hydrologic regimes?

See responses to Charge Question 1 above.

Charge Question 5: What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive risk assessment and response in arid region environments?

A final round-robin exercise was undertaken to identify policy and guidance needs - the points were made:

1. We need it; we need scientifically-driven and defensible guidance & policy, tailored specifically to "where you're at in the 'decision-space' and how to incorporate climate change and environmental response into decision making." It should be tailored to the multiple decision-making levels.

2. Whatever the policy and guidance it is, it needs to be very flexible/pliable so that the design criteria and specifications can be adaptive as more information becomes available.

3. Our breakout group's challenge to upper management: "Just begin!" The installation-levels simply need to begin to incorporate a non-stationarity assumption of climate into their planning and management activities. This could then be refined through experience and progressive iterations.

4. New guidance should incorporate:

a. Accepted levels of confidence & degrees of acceptable uncertainty.

b. Planning horizons.

c. Identification of credible emission scenarios to use and their sources (IPCC?) to generate anticipated x, y, and z environmental responses.

d. What should "we" the end-user or installation manager incorporate? Temperature? Precipitation?

e. Contractual qualifications/capabilities.

f. Incorporate monitoring and iteration (adaptive management).

g. Tied to the Master Plan or the EMS as a follow-on action.

Note to upper management: researchers and technical program directors need proponents. OSD support is needed for x, y, and z research to provide science input to policy development.

Researchers and technical program directors need broadly framed questions or concerns from OSD to prioritize research initiatives and programs given constrained budgets and resources. Investments are being made with limited policy input. Input is needed to optimize investments.

G6 Vulnerability and Impact Assessment

Breakout Session 3

Cross-Cutting Theme 2: Vulnerability and Impact Assessment/Adaptation/Climatology Research and Development Needs

Group A — Vulnerability and Impact Assessment

Session Chair: Dr. Edmond Russo, USACE ERDC-CHL

Charge: Vulnerability of a military mission or of an installation's built and natural infrastructure to climate change is based on exposure (the location of concern is projected to experience some change in climate or an associated change such as sea level rise), sensitivity (the mission or infrastructure functionality would be sensitive to such a change), and adaptive capacity (degree to which the mission or infrastructure can or cannot accommodate to the change without significant functional impairment). Impact assessment considers a specific pathway of analysis that includes assumptions about climate drivers, whether probabilistic or scenario-based, environmental models, and impact assessment models, the last of which can be specific to military infrastructure, readiness, and operations. Having a clear understanding of potential impacts can provide a foundation for identifying necessary adaptation strategies.

Charge Question 1: What scientific understanding, models, and tools are needed to conduct vulnerability assessments of DoD installations, especially if such assessments are conducted as a high level screen across installations or regions versus within installations or regions?

Well documented and qualified scientific understandings about the climate changes that potentially impact DoD installations provide the foundation of performing skillful vulnerability assessments. The science must be able to clearly explain how and in what scenarios DoD installations could be adversely impacted by climate changes. Knowledge gaps about what is not well known must also be described for the purpose of understanding limitations in information applicability. Models that synthesize existing relevant data and input from subject matter experts about this science are often practical and expedient for use in characterizing the types, variability, and trends of climate changes in regions and at individual installations at the appropriate tempo-spatial scales. Tools that elicit value-laden responses of decision makers, based on this information are needed to distinguish on a relative basis and rank negative and positive impacts to mission functions and supporting assets/capabilities for individual installations. These tools should employ indicators for describing the following at successively higher levels in a framework that is able to cut across installation and command missions by type and by region geographically.

1. Ways an individual installation system state and its forcings could evolve with respect to potential climate changes.
2. Installation system performance limitations with potential climate changes and certain rates thereof, considering evolution in the system state and its forcings.
3. Current state of installation system stress in the prevailing climate conditions, considering any management activities already planned.
4. Synergistic effects of systems of installation systems, either by organizational structure/hierarchy, or by region, with regard to mission performance in these conditions.

Outputs should elevate the most certain and urgent potential losses and opportunities to sustaining performance of mission-critical infrastructure/training settings that are most effectively, efficiently, and expediently addressed via risk reduction and adaptation. Understanding is also needed on where to strategically focus investigative resources in successive tiers/iterations of vulnerability assessment, following the general approach described above, to scope where impact assessment is required within installation systems to sustain missions. Finally, identification of critical gaps in knowledge and understanding is an output requirement on climate science relevant to supporting future, continued vulnerability assessment.

Charge Question 2: What scientific understanding, models, and tools are needed to conduct comprehensive impact assessments for vulnerable missions and installations?

Comprehensive impact assessment, as it relates to climate change variability and extremes, requires the ability to describe systems scale performance in a probabilistic manner for objectives of interest from the present time into the long term, considering plausible future scenarios about key drivers with remaining uncertainties in scientific understanding. Thus, there must be sufficient scientific understanding to model the following in support of quantitative impact assessment at installations.

1. Projected changes in climate variability and extremes for the timeframes of concern at sites considered.
2. Characterized climate changes to the system considering current/planned practices.
3. Predicted changes in system forcings attributable to projected changes in climate.
4. Definition of boundary conditions under a changing climate regarding interaction with external systems in which the installation is dependent.

An inventory of science, models, and tools that are available with explanation of their strengths and weakness is needed by the impact assessment community to support this work. These include the following:

1. Science

a. Focused on the rates of relevant climate change effects (e.g., saltwater intrusion, temperature/precipitation patterns/durations/frequencies) and system response, including non-linear feedback loops that change the system over time.

b. Long-term (longitudinal) studies of natural phenomena of interest.

2. Models

a. Climate/weather (accurately downscaled to a useful level).

b. Hydrologic and hydraulic models.

c. Sediment and constituent transport/water quality.

d. Carbon sequestration.

e. Fire.

f. Ecological response models (e.g., species, communities, landscape-level).

g. Infrastructure (e.g., networks & fragility).

h. Economics/budget.

i. Ecosystem services quantification. j. Energy/water consumption & usage. k. Integrated models.

3. Impact assessment framework tools

a. Decision frameworks and strategies (e.g., drivers, stressors, pathways, response, endpoints, decision points, and turning points).

b. Hardware/software/methodologies that take models outputs/observations and present/communicate them in a useful format.

4. Datasets with both sufficient temporal and spatial resolution as the environment changes to support modeling is also necessary, to include detailed:

a. Topographical/bathymetric data.

b. Geomorphology/soil properties.

c. Land cover/land use.

d. Water-levels and vertical land movements.

e. Surface and groundwater hydrology.

f. Weather, ocean, and ice formation.

g. Ecological (e.g., species ranges, community functionality, landscape/patch dynamics & patterns).

- h. Infrastructure and anthropogenic activities information.
- i. Socioeconomics.
- j. Retrospective analyses.
- k. Metadata and data digests.

Charge Question 3: What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive vulnerability and impact assessments?

Policy and technical guidance should include those factors that will aide decision makers in advancing studies for identifying and acting upon potential for large-scale, frequent, and/or long-duration likelihoods of loss to installation mission performance, as well as strategic opportunities for exploitation in further advancing missions. These include:

1. Addressing treaties, laws, and agreements that must be informed for modification regarding long-term sustainability in the face of climate changes and their potential impacts.
2. Identification of decision making goals and objectives at the policy level and how those network to goals and objectives of installations and their missions.
3. A hierarchy of routine and long-term types of decisions required at various spatial scales.
4. Given prescribed time horizons and geospatial scales, specification on requirements needed to plan, operate, and maintain mission capabilities.
5. Update of Unified Facilities Criteria to address climate change issues.
6. Authority, methodology, and budgeting on how to evolve installation management and technical guidance, considering forcings that can be expected under given climate scenarios for current and future installation infrastructure designs.

Charge Question 4: How can science and technology developments from the research community relative to vulnerability and impact assessment be best transitioned to the implementation level and into operational practice?

For research activities to be highly relevant and richly successful in addressing climate change for installation sustainability, these activities would best be systematically integrated into the installation operations for deep, continuous engagement of their community of practice. This would sufficiently engage end-users for practically developing and implementing vulnerability and impact assessments that work to achieve aims. This should involve:

1. Developing a process for climate change-based installations operations research studies, pilot projects, documentation of lessons learned/best practices, and technical assessment product transition to the field (communication, training, support, guidance, resources & program).
2. Specifying in the Program Objective Memorandum the integration of climate change studies into current (established) policies & practices (e.g., Master Plans, Integrated Natural Resources Management Plans, Environmental Management Systems, etc.).
3. Incorporation of the science on addressing climate change issues into recognized accreditations (National Institute of Standards and Technology, etc.).

G7 Adaptation and Mitigation Science

Breakout Session 3

Cross-Cutting Theme 2: Vulnerability and Impact Assessment/Adaptation/Climatology Research and Development Needs

Group B — Adaptation and Mitigation Science Session

Chair: Mr. William Goran, USACE ERDC-CERL

Charge: The science of adaptation in the context of climate change is nascent, though it can build on a rich understanding from the engineering, ecological, and physical science disciplines as to how human and natural systems respond to environmental disturbances and stressors. When faced with uncertainty about the potential impacts of climate change, improving the resilience to stress of DOD natural and built infrastructure can be a no-regrets adaptation strategy. Because the future may present novel climates, built and natural systems may be exposed to climate extremes and variability never experienced. For natural systems we need a deeper understanding of how they respond to dynamic environments and for built infrastructure we may need to consider new design tolerances. Adaptation and mitigation are linked and strategies to reduce emissions may have unintended consequences that affect adaptive capacity.

Charge Question 1: What scientific understanding, models, and tools are needed to advance the development of adaptation strategies?

Key discussion points:

- Decisions to manage built and natural infrastructure are being made regularly, so how can climate risk data be well integrated into these decisions? One needs a better understanding of the risks of not incorporating changes in the climate into our management decision processes—in terms of economic and mission costs.
- Adaptation implies adjustments in the face of new data, monitoring of vulnerabilities, and a nimble management capability to respond to data. How do we make our management framework more nimble? What management adjustments allow for more "adaptive" approaches in managing lands, facilities and operations?
- Strategies for adaptation need to work at multiple temporal scales—management usually focuses on short-term risks, whereas many risks from a changing climate are long-term.
- Methods and tools are needed to provide analysis of changing phenomena at various temporal resolutions. In addition, a framework is needed that works "backwards" from the projected timeframes when climatic changes are projected to impact operations and assets and determines the sequence of decisions and actions necessary to avoid or adapt to these impacts.
- Decisions should be robust in light of uncertainties. With infrastructure, some decisions (e.g., increased passive protection in light of anticipated increase in cooling degree days) will have no regrets regardless of the path of uncertainty, as extra insulation, triple pane windows, improved building envelope, etc. will only reduce cooling (and heating) demand. But other questions—should a building be moved or protected from storm surge and sea level rise—could be costly if anticipated conditions are greatly at variance from actual changes. So, tools that help decision makers understand "decision risk" would be helpful when reviewing investment or management adjustment plans.

Charge Question 2: What are the critical natural systems—whether they serve as protective barriers for other infrastructure or are needed for stewardship purposes—for which we need improved understanding of their dynamics under climate change to enhance their adaptive capacity and resilience?

Essentially all natural systems are impacted to some degree (must consider all of these holistically). Some systems are especially vulnerable to changing conditions, or at least they impacted sooner by changing conditions, to include: shorelines, coastal fringe systems, groundwater, hydrology, sea ice, coastal erosion, ice sheets, and arctic land surfaces (tundra, permafrost, and methane release issues).

As conditions change, dialogue is needed with regulatory agencies responsible for various natural systems, such as wetlands, endangered species, and protected marine ecosystems and species. In addition, the rapid implementation of renewable energy technologies, especially in these sensitive areas, is having and will have impacts on these systems that need to be better understood. Currently, these trade-offs are occurring without sufficient understanding of the system consequences. Finally, mitigation strategies are needed that provide feedback on the status of natural systems, which can inform adaptive decisions.

Charge Question 3: What design features of DOD's built infrastructure should be assessed and modified for improving their adaptive capacity to a changing climate?

Key Discussion Points:

- Facilities: Both new and upgraded facilities need to be designed for the climate that they will experience during their useful life, rather than the climate during the timeframe in which they are built. Engineering design parameters, however, have not been changed and a natural reluctance is present in the engineering community to change design parameters based upon "projections" rather than observations. To address this issue, investigations are needed to examine what approaches can be used to provide engineering data-based design specifications (e.g., such as cooling degree days) that meet engineering standards and also are responsive to both observed and anticipated condition trends. For the most part, facilities designed for changing conditions will be using less energy and providing more occupant comfort under any future scenario; as a result, the investments anticipating such changing conditions would be viewed as "no regrets" under most any future climatic scenario.
- Utility systems: Several circumstances need to be considered for utility systems: physical conditions such as temporary submersion, permanent submersion, increased water flows due to increases in storm frequency and intensity, and increases in duration and extent of high temperatures causing material stress. All of these stress conditions will be experienced widely by municipalities and other utility providers. Few will be unique to Defense organizations. In addition, there are load stresses that should be anticipated. These can occur with the electrical grid with extended high heat conditions over large areas with high cooling demands that may cause extensive overload conditions on the national and regional grids. In addition, flooding and intense storm events will overload many storm water systems. In addition to understanding where, when, and to what extent Defense utility infrastructures (whether managed by Defense organizations or others) could be vulnerable to changing climatic conditions, Defense may also need to contribute towards helping to define the critical features of "climate resilient utilities."
- Smart Planning at the Campus Level: The new Uniformed Facilities Criteria (UFC) Master Planning guidelines call for smart planning, and they also may include language that calls for planners to anticipate and adapt to changing conditions, such as changing climate, using reliable and defensible sources of information. These guidelines include guiding principles for mixed use, smaller footprints, walkable campuses, and waterway protection, as well as many other planning approaches critical to military community resilience to changing climatic conditions. Smart planning needs to reach beyond the fence line in several contexts by engaging local communities in transportation options and waterway protection, water reuse strategies and storm water strategies, and engaging the code and regulatory community in planning design features that are flexible and adaptive.
- Designer Material Features: In terms of "designer" material features (e.g., features that would be designed into future materials but are not yet on the market) several characteristics could help build climate resilience into infrastructure: such as energy conserving features, environmentally responsive features (e.g., reacts and changes properties in light or dark, wet or dry, and cold or hot conditions), materials that combine strength, durability, and permeability (e.g., improve storm water flow while providing surface protections), and self-reporting and self-healing materials that have durability and resilience in changing conditions.

Charge Question 4: How can science and technology developments from the research community relative to adaptation be best transitioned to the implementation level and into operational practice?

Some of the approaches discussed include:

- Integrating adaptation into operational decision processing: One of the reasons for the "gap" between the R&D community and operations is that often no programmatic context is provided that moves science and technology beyond demonstration in environmental and facility infrastructure. One approach to help achieve this is to engage operational managers in demonstration review and then have them design the necessary steps to move beyond demonstrations (if deemed appropriate).

- Consciously integrate "data, tools, science, and technology reachback" into operations:

Can new science and technologies be fully integrated into operations? Currently, most science and technology development occurs in a removed context, with some marginal input and engagement from operators, and is primarily accomplished by external parties. In addition, it usually occurs over a relatively short (2 to 4 year) timeline. Climate data need a longer timeline, and given the need to develop a resilient, adaptive framework to respond to climate (and other) stressors, it might be more effective to actually integrate a monitoring and decision framework that responds to data signals and provides tools (and expert reachback) to better examine alternatives related to these signals. This approach would start to "bridge" the science and technology-operational gap.

- Tailor science and technology outcomes to better match operational needs: Provide improved "packaging" guidance for science and technology outcomes, so that these outcomes fit directly into operational decision processes.

- Interdisciplinary teams: Understanding the "system" issues with changing climatic condition and complex system responses and interactions requires interdisciplinary teams. We often build interdisciplinary science and technology teams; however, transition success also will require interdisciplinary management team capable of understanding data signals and adaptation options.

- Embed "bridging" persons into research and development (R&D) and operational organizations: One of the more effective ways to "bridge" science and technology to operations is to embed R&D staff into operational environments to help with the transition of science and technology outcomes into management operations. The reverse situation—embedding operational experts into the science and technology development process, also should be considered.

- Emphasize integrating new knowledge outcomes in operational training and in job solicitations and assessments: Because of the challenges of adaptation, requiring effective multi-year collection and interpretation of changing climatic conditions and system response data, another approach to bridge science and technology outcomes into operations is to shape operational positions to have a stronger science and technology component.

- Forums and partnerships: Enhancing the dialogue between R&D staff and operational staff can happen in numerous venues, through social media, meetings, webinars, reachback, and informal discussions. Various mechanisms are needed to ensure effective communication and information flow between R&D performers and operational decision makers.

Charge Question 5: What is the best mechanism to ensure planning documents and programs of record are informed on a regular basis by science and technology developments related to adaptation?

- Plan Updates: Installation- and service-level plans are regularly updated. Opportunity exists, with each iteration of a plan, to capture new information; however, effective guidance and/or protocols to identify relevant new information and bring it into the new plans is not necessarily available. Because climatic conditions are changing, trends in weather events and new projections, relevant to the planning period, would be appropriate for numerous installation- and service-level plans, such as Integrated Natural (and Cultural) Resource Management Plans (INRMPs), Master Plans, Strategic Plans (to include Sustainability Plans), Critical Infrastructure

Assessments, Training Plans at the installation level and Stationing and Readiness plans at the service level, etc. To ensure that new science and technology information is considered in plans, the R&D committees could "certify" specific types of relevant new information and present them in easy to use "packets" that are "plan ready."

- Integrating planning criteria into planning and financial request systems: One problem with financial requests is verifying that appropriate steps have been taken to follow planning criteria. Conceptually, planning and financial submission systems already seek to provide such verifications; however, more could be done to facilitate this process by integrating planning criteria into planning systems that provide users feedback on how well these plans conform to guidelines and planning criteria and by suggesting approaches to resolve or evaluate these issues. For example, the new Defense-level Unified Criteria for Master Planning has a chapter providing "Master Planning Philosophy and Strategies." These philosophies and strategies could be captured in a planning environment as a set of "criteria." Any plan could be evaluated against these criteria.

- Links between multiple plans: Plans interact, and military installations have structured plan team development and review processes to capture the linkages across plans. These steps are important, but plans could be "linked" in a more consistent and structured process, using such mechanisms as hyperlinks and "dependency measures" that trigger reviews across plans in a dynamic fashion that makes each plan more of a living document. This has been tested in some installation contexts; however, more work is needed to design, evaluate, and exercise such linkages and to change management operations to take advantage of these dynamic linkages. Although it is more complex, these same types of links could exist between installation- and service-level plans and also between deployment plans of units.

- Dynamic planning environments: One of the key capabilities to facilitate the integration of new data into plans is the development of more dynamic planning systems that provide for the feedback to users, linkages across plans, and stakeholder alignment evaluations to facilitate interactions between stakeholders. Such an environment can enable improved cross-factor sustainability planning and help illuminate the complex pathways and interactions across "systems" impacted by different engineering options, resource management approaches, and changing environmental circumstances.

Charge Question 6: What policy and technical guidance is needed for determining which climate scenarios should be used and at what spatial scales to drive the development of adaptation strategies, models, and tools?

This topic was not covered in group discussion because of the lack of time and a perceived overlap with other topics. This is an important topic, however, that does need to be addressed (perhaps in an ongoing fashion) by the report recommendations. Although some specific recommendations about where to find appropriate climate data and how to use these data for installation planning might be useful, a Defense science and technology resource (technical committee?) is needed to provide updates to this guidance and assistance in following the guidance. This committee would not be creating climatic data, but rather helping Defense organizations locate and apply climatic data from appropriate regional, national, and international sources.

FOOTNOTES

1 EO 13514 also included elements related to greenhouse gas reduction targets and energy efficiency and renewable energy goals that in combination constitute mitigation actions related to climate change. Policy aspects related to climate change mitigation were not the focus of the workshop except when adaptation and mitigation strategies are linked and strategies to reduce emissions may have unintended consequences that affect adaptive capacity, such as when considering forest restoration strategies to sequester more carbon that may reduce ecosystem resilience.

2 One participant noted that the Bureau of Reclamation has ongoing research on the 7 western regions (survey of regional climate data) & are beginning to look at climate change risk.

* * * * *

Climate Change Implications to the Global Security Environment, U.S. Interests, and Future Naval Operations

* * * * *

PREFACE AND ACKNOWLEDGEMENTS

EXECUTIVE SUMMARY

INTRODUCTION

SECTION 1: PHYSICAL EFFECTS OF CLIMATE CHANGE

SECTION 2: SOCIOECONOMIC EFFECTS OF CLIMATE CHANGE

SECTION 3: SECURITY EFFECTS OF CLIMATE CHANGE

SECTION 4: CONCLUSION

ENDNOTES

APPENDIX A: GLOBAL WARMING TREND

APPENDIX B: PREDICTED GLOBAL IMPACTS OF TEMPERATURE INCREASES

APPENDIX C: ALTERNATE SHIPPING ROUTE THROUGH THE NORTHERN SEA

BIBLIOGRAPHY

* * * * *

PREFACE AND ACKNOWLEDGEMENTS

I chose this topic for both personal and professional reasons. As an oceanography major at the United States Naval Academy, I particularly enjoyed studying polar oceanography. In 1996, I researched and wrote a paper on climate change effects on the development of polar sea ice. During this time I had the opportunity to work with many professionals at the National Ice Center who were on the cutting edge of what was then the relatively new topic of global climate change.

During my fourteen years as a Surface Warfare Officer, I have maintained an interest in oceanography and climate change, and have observed firsthand humanitarian and disaster relief operations, which the Navy increasingly is called upon to respond. In my research, I found that the U.S. Government, the Department of Defense, and the Navy in particular have recognized the issue of climate change and are working to identify the effects climate change will have on the full spectrum of operations. The Navy must maintain the ability to conduct its enduring core capabilities, but it must also prepare to adapt to changes in the operating environment as a result of climate change.

Many thanks to the numerous individuals who provided me with their guidance and knowledge, as well as, a most important resource, their time, significantly enhancing my personal advancement on this subject.

To my parents, for raising me steps from the Gulf of Mexico and instilling in me a love and deep appreciation for the water.

EXECUTIVE SUMMARY

Title: Climate Change Implications to the Global Security Environment, U.S. Interests, and Future Naval Operations

Thesis: This paper aims to identify the physical and socioeconomic changes occurring across the globe as a result of climate change and relate them to evolving security challenges. Security challenges exist on several levels, first on a global scale, then specific impacts to the U.S. and its interests, and finally to the Navy and its future operations.

Discussion: The effects of climate change are intertwined with existing political, social, cultural, and economic issues, which have significant implications for U.S. interests around the world. These effects are reshaping the national security environment, which pose great changes for DOD priorities. Climate change is a factor that interacts with other issues such as weak governments, poor economies, and population growth, which drive vulnerable states toward instability. As climate change progresses, the United States will be drawn more frequently into unstable situations where weakened and failing states cannot support the basic needs of their populations or maintain security. From the National Security Strategy to the Quadrennial Defense Review to the Naval Operations Concept of the sea services, these documents address the need to develop further a plan to mitigate the effects of climate change. The Navy must prepare for expanded operations, more frequent engagements around the globe, and a higher demand signal. Both the Navy's operating and strategic environment are affected by climate change. In the operating environment, the Navy must look to reduce its dependency on fossil fuels, adapt to changing ocean environments and weather patterns, and assess critical infrastructure susceptible to rising sea levels. Strategically, the Navy must prepare for increased humanitarian operations and determine the best solution to meet the demand signal. Additionally, national emphasis on the Arctic region increasingly requires Navy involvement. The Navy, along with other Arctic stakeholders must work together to ensure a safe and secure Arctic region.

Conclusion: The impacts of climate change will have significant implications to national security on a strategic, operational, and tactical level, and will cross domestic and international boundaries. Extreme weather events around the globe followed by their second and third order affects will endanger populations, damage critical infrastructure, and require employment of military assets. Countries with weak governments and poor economies are particularly vulnerable to climate change, which could lead to refugee and humanitarian crises. The Defense Department's recognition of climate change in the Quadrennial Defense Review marked a step forward in reevaluating long-term strategies, identifying potential issues, and planning enhanced military operations due to climate change effects. Continuing partnerships between the White House, Department of State, Department of Defense, and numerous other stakeholder agencies are imperative as the United States seeks to mitigate climate change effects to U.S. strategic interests at home and abroad. The Department of the Navy is leading the DOD in recognizing the potential impact of climate change and has positioned itself to make wide-ranging adaptive changes to its operations and force structure

INTRODUCTION

"All across the world, in every kind of environment and region known to man, increasingly dangerous weather patterns and devastating storms are abruptly putting an end to the long-running debate over whether or not climate change is real. Not only is it real, it's here."

- President Barack Obama 1

The debate over climate change has been gaining momentum for well over a decade. On any given day, climate change and its increasingly visible effects are making the news around the world. The effects of climate change are inextricably intertwined with existing political, social, cultural, and economic issues, which have significant implications for U.S. interests around the globe.² These effects are reshaping the national security environment which poses great changes for Department of Defense (DOD) priorities.

The 2010 Quadrennial Defense Review (QDR) uses the term "instability accelerant" when referring to climate change. Climate change is a factor that interacts with other issues such as weak governments, poor economies, and population growth which drive vulnerable states toward instability.³ Although the United Nations plays a large role in managing emergencies which result from climate change, the U.S. continues to be called upon as a first responder immediately following natural disasters or anywhere humanitarian assistance is deemed necessary by the U.S. or the international community.⁴

Within the United States Government, climate change and its global security impact must be addressed comprehensively between many agencies to include the White House, Department of State, and Department of Defense (DOD). Partnerships are key in developing a comprehensive strategy to anticipate and mitigate climate change effects. As merely one stakeholder among many, it is unlikely that the DOD will be the lead agency in addressing climate change issues. As a result, it is imperative that the DOD adequately defines its priorities and challenges in response to issues attributed to climate change and ensures its voice is heard.⁵ This is a difficult task given the lack of fidelity in climate change projections. Planning, budgeting, and acquisition decisions must be made with the information currently available, although the scientific community continues to refine predictions of climate change and its effects.

The sea services - the Navy, Marine Corps, and Coast Guard, more than the other armed services, are witnessing the effects of climate change on a daily basis in places like the Arctic where ice is melting at an alarming rate, opening new sea lines of communications and bringing to light new security issues. In response, the Navy has been proactive and is leading the DOD in addressing these new challenges. This paper aims to identify the physical and socioeconomic changes occurring across the globe as a result of climate change and relate them to evolving security challenges. These security challenges exist on several levels, first on a global scale, then specific impacts to the U.S. and its interests, and finally to the Navy and its future operations.

SECTION 1: PHYSICAL EFFECTS OF CLIMATE CHANGE

"Even the minimum predicted shifts in climate for the 21st century are likely to be significant and disruptive."

- United Nations Framework Convention on Climate Change 6

The predicted physical effects of climate change must first be identified before an accurate analysis of security implications can be completed. As the climate change debate continues, one fact has unequivocally been established - the earth is warming. In 2007, the Intergovernmental Panel on Climate Change (IPCC) reported that the earth's climate is warming based on scientific data which indicates increases in atmospheric and ocean temperatures around the world, extensive snow and ice melting, and a steady increase in sea levels.⁷ However, the rate at which the earth is warming, the causes for warming, and the mitigation measures to reverse warming remains a point of contention in the scientific community. Over the past century, average global temperatures rose by more than 1° F and in some regions by as much as 4° F. The oceans have also warmed, especially in the Arctic and Antarctic.⁸ (Appendix A) The scientific community predicts that surface and ocean temperatures could rise as much as 11° F by the end of the century, causing dramatic and adverse changes to the climate with profound consequences for the earth and its inhabitants. For every degree of temperature increase, profound and often irreversible damage occurs in the environment from desertification of land to increased intensity of storms to decline in crop yields. (Appendix B)

Many impacts of climate change are already occurring and are under observation by scientists. One of these is the melting of land-based ice around the globe. Mountain glaciers are in retreat around the globe and immeasurable amounts of ice are lost each year due to the melting and slipping of glacier ice into the ocean, adding billions of tons of water to the oceans annually. Both the Greenland ice sheet and the Antarctic ice sheet are losing mass twice as fast as predicted. It is estimated that these ice sheets will reach an unknown threshold at some point where they will become unstable and cause rapid, uncontrollable sea level rise.⁹ Scientific sea level rise scenarios estimate that by the end of the century a global sea level increase of 1 meter is not only plausible but likely a low estimate. In addition, if one of the polar ice sheets becomes unstable, sea levels could potentially rise by more than 5 meters.¹⁰

Sea ice in the Arctic has also seen drastic declines in recent years. Climate change effects have been amplified in the region, so much so, that sea ice has declined three times faster than computer models initially predicted. In 2007, Arctic sea ice shrank more than had ever been observed since scientists began recording data in 1979. The consequence of sea ice decline is threefold. First, sea ice reflects sunlight very effectively while open water absorbs sunlight. As sea ice melts, more sunlight will be absorbed by open water, adding to the overall warming trend and intensifying climate change. Second, sea ice is home to many marine mammals and provides their food sources. The delicate ecosystem residing in the Arctic will become extinct as sea ice continues to retreat.¹¹ Finally, retreating sea ice has opened the Northern Sea Route and the Northwest Passage for longer periods during the summer, allowing transit between Northern Europe and the Far East, a 35-60 percent savings in distance as compared to transit via the Panama or Suez canals.¹² (Appendix C)

Another effect of climate change is extreme weather events, which have become a more common occurrence in recent years. This trend is expected to continue due to changes in local weather patterns caused by climate change. More intense hurricanes and typhoons, such as Hurricane Katrina, are predicted due to increased ocean surface temperatures which fuel the unstable low pressure weather systems. Not only is the average atmospheric temperature rising, the incidence of extreme atmospheric temperatures is increasing as well, leading to more frequent heat waves and high temperature extremes. Significant rainfall events are also occurring more frequently which causes an increase in flash flooding. As a whole, these extreme weather events are expected to increase over the next several years causing adverse effects to "coastal communities, human health, water quality and availability, and agriculture".¹³

Lastly, climate change is affecting ecosystems around the world. Plants and animals across the spectrum are affected, those on land, in oceans, and in freshwater lakes and rivers. Ecosystems particularly at risk are those in the polar regions, as discussed above, coral reefs in the tropics, and tropical rainforests. These ecosystems are hypersensitive to changes in temperature, precipitation, and salinity. The risk of extinction for species in these ecosystems increases as temperatures increase.¹⁴ Additionally, mosquitoes and other disease carrying insects are expected to extend their ranges as a result of temperature increases and changing weather patterns.

Drawing from the physical effects of climate change discussed above, the most drastic effect will be to the quality and quantity of water around the globe. Although, different regions will be affected in different ways, it is expected that regions of the world which are already dry will get drier and likewise regions prone to a large amount of precipitation will receive increasingly more precipitation. The repercussions of this change will have a dramatic impact on the human population around the globe.

SECTION 2: SOCIOECONOMIC EFFECTS OF CLIMATE CHANGE

"Climate change will have wide-ranging implications for the United States over the next 20 years. This is because it will aggravate existing problems such as poverty tensions, environmental degradation, ineffectual leadership and weakened political institutions that threaten state stability."

- Major General Richard Engel, director of the Climate Change and State Stability Program, Office of the Director of National Intelligence ¹⁵

The physical effects of climate change will trigger adverse socioeconomic changes. There will be a shortfall of water for drinking and irrigation, which adds the risk of thirst and famine. The world's population largely depends on water from the seasonal melting of alpine snow and ice. The quality of drinking water will be impacted as sea levels rise and saltwater infiltrates freshwater resources. Increased rainfall and flooding in areas could overwhelm local water infrastructure causing an increase in contaminants and sediment to the water supply. Additionally, more agricultural fertilizer and municipal sewage could be washed into coastal waters by flooding and increased rainfall causing "dead zones".¹⁶

As climate change progresses and intensifies, shifts in human migration patterns are inevitable. According to the United Nations, by 2050, the world's population is estimated to be 9 billion and over 90 percent of this growth will take place in developing nations. Today there are estimated to be 214 million migrants globally, by 2050 that number is expected to nearly double, due in large part to climate migration.¹⁷ Refugees affected by

natural disasters can usually return home, but future climate migrants could be permanently forced from their homes due to scarcity of resources, food, and water exacerbated by natural disasters. Additionally, in many cases, climate migration occurs in regions which are already unstable and volatile making the potential for border conflicts and security concerns even greater.

Climate change will have a wide spectrum of adverse effects on global health, particularly in developing nations. Increased rates and extended ranges of malaria, dengue fever, and other insect-borne diseases are predicted in countries experiencing significant rainfall. Conversely, airborne diseases will thrive in areas more susceptible to drought. Additionally, shortages of food and water will leave populations more susceptible to illness.¹⁸

The risk of a pandemic also increases with large numbers of climate migrants. Repercussions of a pandemic will be felt both economically and politically due to loss of life, diverting resources to immediate medical crises, and restrictions placed on the movement of goods across borders of countries. Countries dependent upon tourism will be affected disproportionately economically. A country's political climate can quickly and drastically change in a health crisis depending on the government's capability to respond. Perceived preference of medical treatment to a particular ethnic, religious, or political group could spark unrest. Regardless of the scenario, the UN, other international organizations, and developing countries look to the U.S. for help in responding to health crises and will continue to do so. Climate change will only increase the likelihood of such occurrences.¹⁹

Changes and declines in agricultural prosperity will also occur as a result of increased temperature, changes in rainfall, and insect patterns. "Crop ecologists estimate that for every 1.8°F rise in temperature above norms, grain production will decrease by 10 percent." An excellent example of how climate related factors could push a marginal situation beyond the tipping point is in Darfur. A conflict arose between herders and farmers when herders lost their land to the desert after a long drought. The herders were forced to migrate in search of water and fertile land, coming into conflict with farmers occupying the land. When "coupled with population growth, tribal, ethnic, and religious differences, the competition for land turned violent."²¹

SECTION 3: SECURITY IMPLICATIONS OF CLIMATE CHANGE

"The stresses that climate change will put on our national security will be different than any we've dealt with in the past . . . this is why we need to study this issue now, so that we will be prepared and not overwhelmed by the required scope of our response when the time comes."

- Vice Admiral Richard Truly, Director, Department of Energy National Renewable Energy Lab²²

Climate Change Implications on the Global Security Environment

As discussed above, the physical effects of climate change - rising sea levels, rising temperatures, drought, and extreme weather lead to the socioeconomic effects of climate change - famine, migration, and disease. These are all stressors that many developing countries are not prepared to cope with. The effects are "interwoven and self-perpetuating": water shortages lead to a shortage of food, which can then lead to a pandemic, which can force mass migration of populations, which ultimately can lead to food shortages in new regions.²³

From this stems a myriad of security implications. But first, the question of 'what is security' needs to be addressed. In broad terms, security refers to freedom from the risk of loss or damage to a thing that is important to survival and well-being. The concept of human security which continues to evolve can be defined as a "concern with human life and dignity", which when broken down into components includes "economic, food, health, environmental, personal, community, and political factors."²⁴ Stable societies require access to these fundamental resources, most importantly food and water. When a government cannot provide these resources, deliver services to its people, ensure domestic order, and protect its borders and citizens, a vacuum is created leaving conditions ripe for conflict, extremism, and acts of terrorism.²⁵

The threats of climate change effects are significant and not equally distributed globally. Some governments will be more affected than others. By looking at history and through predictions, those most affected by climate change will be states that are under-developed, fragile, and undemocratic. Developing nations do not have the

government, infrastructure, or technical capabilities to adapt to climate change. Their ability to prevent or even adequately react to humanitarian disasters is inadequate. Weak or failing states experience some of the same issues as developing states. Often these states suffer from the absence of a strong government, repressed populations, weak economies or lack of border control, which leave the governments unable to respond adequately to humanitarian crises. Finally, populations of undemocratic states are vulnerable to climate change effects because their governments have no incentive or often no desire to protect the population at large. Democracies, where leaders must be responsive to the people or they will be voted out of office, generally are not susceptible to severe humanitarian crises.²⁶

Although climate change effects will most likely not be the primary cause for breakdowns in security, they will certainly be a factor. In reviewing the three major threats to security, most significant is violence and armed conflict. With the change in quality and quantity of vital natural resources such as fresh water, fertile farmland, and marine resources due to climate change, competition for these resources will increase. The incidence of violence and armed conflict could be more likely and be prolonged as populations struggle to secure resources.²⁷ There are numerous examples where this is already being seen today in places such as Somalia and Darfur. As global temperatures rise and resources become scarcer, the frequency and duration of violence is expected to increase.

Natural disasters are already a significant security threat as observed in the wake of events such as the Haiti earthquake in 2010 and the Southeast Asia tsunami in 2005. "Between 1990 and 1999, an estimated 188 million people per year were affected by natural disasters, six times more than the 31 million affected by armed conflict."²⁸ As global temperatures increase, the incidence and severity of natural disasters will also increase, leaving behind refugees. Those affected will suffer from disease, malnutrition, loss of income and a lack of security. In weak and developing states where the capacity or willingness to help the affected populations is lacking, these issues will be exacerbated.

The physical effects of climate change such as drought, disease, and economic stagnation are destabilizing forces and have the potential to act as tipping points causing state failures to become more likely. The spread of disease such as malaria due to climate change has the potential to destabilize vulnerable nations. A recent World Health Organization study estimates that as many as 160,000 deaths occur annual from the secondary effects of climate change such as disease and malnutrition. Predictions indicate that numbers could double by 2020.²⁹

Climate Change Implications on U.S. Security Interests

Given the information above which indicates that climate change is occurring and it will increasingly have adverse impacts around the globe, the question to be answered is what impact will this have on the United States and its security environment? At a minimum as climate change progresses, the United States will be drawn more often into unstable situations where weakened and failing states cannot support the basic needs of their populations or maintain security. The United States, as the world's "911 force" will be called upon more frequently in times of need. Additionally, as Arctic sea ice melts an entirely new geographic region, once virtually inaccessible, will be open for commercial and military activity. As this change occurs, the United States must increase its Arctic presence to protect its interests and ensure security, safety, and stability in the region.

For many years there were questions at the highest levels of government on whether the scientific evidence of climate change was enough to warrant the United States' attention and whether climate change would pose a threat to the nation's security. In the past two years, enough actionable scientific data has proven that climate change is occurring and that it is an issue that must be addressed. Although there is still much to be learned from scientific data about climate change, the administration now considers climate change to be a justifiable national security concern.

From the President's National Security Strategy to the Department of Defense's Quadrennial Defense Review to the Naval Operating Concept of the sea services, these documents over the past few years have addressed the need to develop further a plan to address the effects of climate change. Starting with the National Security Strategy of 2010, climate change is identified as a key challenge facing our nation. It states that "the change wrought by a warming planet will lead to new conflicts over refugees and resources; new suffering from drought and famine; catastrophic natural disasters; and the degradation of land across the globe."³⁰ The U.S. is

charged with confronting this challenge based upon scientific information and in cooperation with nations around the globe.

Within the Department of Defense, the National Defense Strategy references current and future environmental and climate issues as security challenges which must be addressed.³¹ Additionally, the QDR presented to congress in early 2010 took a huge step forward in addressing climate change by laying out the DOD's "vision for its missions and force structure in the face of anticipated threats." The document identified climate change as a destabilizing agent and discussed how military operations will be affected and how the military should respond to climate-related disasters. It further stated that climate change will have a "significant geopolitical impact" around the world and will contribute to "poverty, environmental degradation, and the further weakening of fragile governments."³²

The QDR goes on to state, "while climate change alone does not cause conflict, it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world." Additionally, "extreme weather events may lead to increased demands for support to civil authorities for humanitarian assistance and disaster relief. Proactive engagement in these countries can help build their capability to respond to such events."³³

In a similar vein, the QDR also for the first time addressed the effect of climate change on the DOD's operating environment, specifically the Arctic. The opening of Arctic waters which now permits commerce and transit presents new opportunities and security challenges for the United States and all Arctic countries.

Narrowing in scope, the 2010 Naval Operations Concept (NOC 10), a joint Navy-Marine Corps-Coast Guard document states that social instability in over-populated cities, especially those that exist in already unstable parts of the world, has the potential to create dire situations and armed conflict. The effects of climate change may "amplify human suffering through catastrophic storms, loss of arable lands, and coastal flooding and could lead to loss of life, population migration, social instability, and regional crises". The NOC 10 references the specific mission of humanitarian assistance/disaster relief (HA/DR) as a core capability of the sea services which is expected to increase as a result of climate change effects.³⁴ Given its forward presence, inherent mobility, and flexible capabilities, naval assets are often the force of choice for such missions. From 1970 through 2000, U.S. forces were involved in 366 humanitarian missions as compared to 22 combat-related missions for that same period.³⁵

The core capability of HA/DR is broken down into two categories. First, proactive HA/DR is defined as the enduring, rotational missions focused on building critical partner capacity and improving disaster response readiness in targeted countries through training and relationship building. The Navy is currently participating in missions such as PACIFIC PARTNERSHIP in Southeast Asia and CONTINUING PROMISE in Central and South America. Reactive HA/DR, on the other hand is a crisis response operation which employs naval expeditionary capabilities to meet the urgent needs of a partner nation. Given its unique organization, global presence, and self-sufficiency, the naval service is uniquely postured to respond to disasters, both natural and man-made around the globe.³⁶

Climate Change Implications for Naval Operations

Drawing on the scientific evidence of climate change, its effects on human populations, and the current guidance promulgated by the President, Secretary of Defense, and Chief of Naval Operations (CNO), the Navy must prepare for expanded operations, more frequent engagements around the globe, and a higher demand signal. As the global highway for more than 90 percent of worldwide trade and a source of sustenance for billions of people, the world's oceans are the lifeblood of the planet and the global population.³⁷

The 2007 Maritime Strategy identifies the Navy's enduring core capabilities as forward presence, deterrence, sea control, power projection, maritime security, and humanitarian assistance/disaster response.³⁸ Each of these capabilities and the Navy's ability to conduct them will be affected by climate change as both the Navy's operating and strategic environment is affected.

The operating environment ranges from the political to the physical. The political environment in which the Navy as an organization operates increasingly has been putting more pressure on the DOD to curb spending and trim energy consumption. As more and more legislation is passed by Congress for federal agencies to trim their energy usage, the Navy will be required explore the use of alternative fuels and monitor and control greenhouse gas emissions. Higher energy prices have been putting a strain on the Navy's budget for many years, requiring difficult choices to be made between funding for procurement, maintenance, and operations. As one of the largest consumers of fossil fuels, which are the number one source of man-made greenhouse gases, the Navy must look to alternative fuel sources.³⁹ Showing the Navy's level of commitment to making positive changes for the environment, the CNO established Task Force Energy in 2010, which is charged with formulating a strategy and plan for reducing the Navy's reliance on fossil fuels.

The physical environment is changing as well, although the Navy is very adept at operating in dynamic ocean environments. The difficulty is the tremendous uncertainty regarding the when and where and the extent of changes that will occur. Some considerations that the Navy must prepare for include change in water densities, salinity, and acidity due to the infusion on more freshwater into the oceans from ice melt. Water density affects mobility of submarines making it more difficult to maintain neutral buoyancy at depth and it also affects sonar capabilities for both submarines and surface ships. Acidity changes the underwater acoustic properties which could have adverse effects on long-established predictions of propagation paths which are critical to anti-submarine warfare. Additionally, accurate sonar detection is critical in detecting underwater ridges.⁴⁰

Climate change induced modifications to surface conditions also have the ability to affect surface operations. Changes in ocean currents due to Arctic ice melt have the potential to drastically impact the climate in the North Atlantic region and navigation routes used by the Navy. Severe weather events have huge impacts on the Navy from operations and maintenance to mobility. Today, the Navy's answer to extreme weather is avoidance. The Naval Meteorological and Oceanography Command provides weather forecasting to the Navy's operational forces to avoid extreme weather. In the future, if the incidence of extreme weather increases as is predicted, it could be more difficult for ships to avoid these events. High sea states have many adverse effects on surface ships from curtailing flight operations, re-charting courses causing longer transits, the possible damage to super-structures and sonar domes, and the increased risk to personnel. Increased temperatures can also impact operational readiness. In places like the Arabian Gulf where temperatures can reach well over 120°F, equipment and personnel are put under great strain. High operational tempo in these conditions increases the risk of mishaps, and takes a toll on the physical and mental well-being of personnel.⁴¹

Another critical vulnerability facing the Navy is its infrastructure, specifically port facilities which are vulnerable to rising sea levels and extreme weather. In the United States and around the world, the Navy relies on port facilities, both military and commercial. Disruption of port facilities has the potential to affect the Navy on several levels. First, a key mission of the Navy is to keep sea line of communications and access routes open for trade. In the event of port disruptions, the Navy could be called upon to intervene. Second, the Navy relies on port facilities around the world during deployments for maintenance, fuel, and supplies. Port disruptions could have adverse impacts on the Navy's sustainability at sea during extended deployments. Finally, military shipbuilding facilities which support the defense industrial base are located in at-risk areas along the coasts. An example of the impact of extreme weather on shipbuilding facilities has already been realized on the Gulf Coast during Hurricane Katrina in 2005. Several ships under construction in New Orleans and Pascagoula experienced schedule delays due to damage sustained during the hurricane.⁴² Vulnerability assessments of naval facilities will be critical in preparing for the consequences of climate change. Evaluations will help determine at-risk facilities and response plans can then be developed to mitigate risks.⁴³

To address climate change issues, the Navy must anticipate the changes in the future operating environment, although it may be difficult to accurately define today. Preparing for multiple scenarios will require the Navy to expand its cooperation with other agencies, both governmental and civilian, and other nations. Over the past several years, the Navy has embraced a formal lessons learned database which spans across all warfare areas and missions. Expanding this database to address relevant climate change information including best practices in response to climate change and making it available to relevant agencies such as the Coast Guard is needed. Climate change cannot be addressed by the Navy in a vacuum. Information sharing will be imperative to meeting the forthcoming challenges posed by climate change.⁴⁴

Just as important as the changes in the Navy's operating environment due to climate change, the strategic environment will undergo many changes as well. As discussed earlier, the Navy must anticipate an increase in humanitarian assistance operations. Natural disasters and armed conflict resulting from climate-induced migration, resource scarcity, and state failure speak directly to the Navy's strategic priorities and core capabilities.

The Navy has proven time and again that it is the force of choice when responding to humanitarian crises. There are, however, improvements and efficiencies to be gained in preparing for and executing these operations. Although in times of crises, the Navy has successfully responded around the globe, in an environment of increased humanitarian need, the Navy is at risk of not being capable to meet the demand signal. A solution is an expanded, routine presence through the Global Fleet Station concept. The Navy has the capability to bolster the capacity of local governments through routine engagement in the form of exercises and training.⁴⁵ The ongoing Africa Partnership Station mission is an example. Through the employment of one amphibious ship and carefully selected embarked detachments of aviation assets, Naval Mobile Construction Battalion assets, and medical assets, the Africa Partnership Station has become a model for security cooperation.

Another asset which requires review to ensure its full integration and utilization is the Military Sealift Command (MSC). MSC operates several types of ships from oilers to combat stores ships to Maritime Prepositioning Ships, which are deployed around the globe in support of naval combatants and are capable of embarking large quantities of humanitarian assistance supplies. The range of MSC ships can carry fuel, ammunition, and food, and many have enhanced dry stores capacity. These vessels have not participated in humanitarian assistance missions in the past, but due to their stores capacity and forward-deployed capability could be a critical asset during a crisis.

Given that climate change is expected to affect coastal nations at a higher rate than landlocked nations, the Navy should look to expand its capability to operate in the littorals. Maritime crises of today no longer look like the large-scale blue water naval battles of the past. The focus on independent operations in the littorals where ships can support freedom of navigation operations and mediate between foreign navies in dispute over fisheries and economic exclusion zones, are operations that the Navy must increasingly be prepared for. The Littoral Combat Ship (LCS) is one answer to this issue. Today, the Navy has two LCS in its inventory with several more under construction to meet a goal of 55 upon completion of the class. The versatility of this platform lies in its speed, shallow draft, and flexible mission modules. The mission modules are a plug-and-play concept where warfare modules ranging from anti-submarine warfare to surface warfare to mine warfare have the capability of being swapped out in one to two days in a designated port anywhere around the world. In addition, these ships are scheduled to be forward deployed as sea bases around the world with rotating crews. When fully implemented, this concept will give the Navy far more flexibility to execute missions and remain on-station indefinitely.

Finally, the Navy is paying particular attention to the unique issues emerging in the Arctic region. In 2009, the Navy approved an Arctic Roadmap which gives specific guidance for the way-ahead in developing policy, strategy, and force structure in the region. The Arctic is strategically important to the United States and particularly the Navy. Scientific evidence has confirmed that the climate in the Arctic is changing much more rapidly than in any other region around the world. In 2009, and for the first time in recorded history, several German cargo vessels transited the Northern Sea route unaided by icebreakers. It is an anticipated and likely that the door has been opened for much more commercial traffic to transit this route in the future.

Rich fossil fuel reserves, the prospect of eco-tourism, and the potential fuel savings for commercial shipping by transiting the Northern Sea during ice-free conditions make the Arctic particularly alluring.

The United States as a whole has virtually no footprint currently in the region, although the Navy has a long history of operating in there. In 2009, President Bush signed the Arctic Region Policy which declared that the "United States is an Arctic nation, with varied and compelling interests in that region."⁴⁶ It went on to "direct the departments of State, Homeland Defense, and Defense to develop greater capabilities and capacity to protect U.S. borders; increase Arctic maritime domain awareness; preserve global mobility; project a sovereign American maritime presence; encourage peaceful resolution of disputes; cooperate with other Arctic nations to address issues attributed to increased shipping and to establish a risk-based capability to address hazards to include search and rescue (SAR), basing and logistical support."⁴⁷ This directive was a clear indication to the Navy that it must be prepared to increase Arctic engagement.

Today the only surface assets in the U.S. inventory capable of operating in the Arctic are three Coast Guard icebreakers. They play a critical role in Arctic operations, particularly SAR missions, which will only increase as the region becomes more navigable. The Navy has not yet invested in icebreaking ships, although it will likely be necessary in the near future as the Northern Sea and Northwest Passage become more accessible. An option for the Navy is to retrofit current ships with an icebreaking capability. Although, likely more expensive due to the extensive strengthening of the hull and alterations required to the propellers, retrofitting would most certainly have a more timely turnaround than would procuring a new class of icebreaking ships.

There is much work required and challenges to overcome to ensure a safe and secure Arctic region. These include an increase in infrastructure and logistics support, improved navigational aids and nautical charts of the region, and improved interagency communications. The Navy's Arctic Roadmap, stresses the importance of cooperative partnerships to meet the objectives as delineated in the Arctic Region Policy. The Navy must continue to strengthen its relationship with the Coast Guard and ensure the two services and all U.S. stakeholders in the Arctic are working together to meet the overall responsibilities of the U.S. as an Arctic nation.

SECTION 4: CONCLUSION

"We have many advantages in the fight against global warming, but time is not one of them. Instead of idly debating the precise extent of global warming, or the precise timeline of global warming, we need to deal with the central facts of rising temperatures, rising waters, and all the endless troubles that global warming will bring. We stand warned by serious and credible scientists across the world that time is short and the dangers are great. The most relevant question now is whether our own government is equal to the challenge."

- Senator John McCain 48

The future implications of climate change are increasingly becoming clear, although the magnitude of the shift remains in question. At a minimum, increasing environmental stressors will have some degree of socioeconomic impact around the globe. As a first responder, the United States must anticipate a wide-spectrum of second and third order effects of climate change and be prepared to meet the challenge.

The impacts of climate change will have significant implications to national security on a strategic, operational, and tactical level, and will cross domestic and international boundaries. Extreme weather events around the globe will endanger populations, damage critical infrastructure, and require employment of military assets. Countries with weak governments and poor economies are particularly vulnerable to climate change, which could lead to refugee and humanitarian crises.

The United States cannot face this issue in alone, nor can it move forward in developing solutions and mitigating strategies in a vacuum. Continuing partnerships between international organizations such as the United Nations are critical as the White House, Department of State, Department of Defense, and numerous other stakeholder agencies seek to mitigate climate change effects to U.S. strategic interests at home and abroad.

The Defense Department's recognition of climate change in the Quadrennial Defense Review in 2010 marked a step forward in reevaluating long-term strategies, identifying potential issues, and planning enhanced military operations due to climate change effects. The Department of the Navy is leading the DOD in recognizing the potential impact of climate change and has positioned itself to make wide-ranging adaptive changes to its operations and force structure. Guided by the National Security Strategy, Naval Operations Concept 2010, and the Maritime Strategy and facilitated by today's leadership, the Navy must continue to steer a smart course in meeting the climate change challenge head-on.

FOOTNOTES

¹ Barack Obama, "Energy Independence and the Safety of Our Planet Speech." (speech, Chicago, Illinois, April 3, 2006).

2 Commander Herbert E. Carmen, Christine Parthemore, and Will Rogers, "Broadening Horizons: Climate Change and the U.S. Armed Forces" (Center for a New American Security, April 2010), 5.

3 Christine Parthemore and Will Rogers, "Promoting the Dialogue: Climate Change and the Quadrennial Defense Review" (Working paper, Center for a New American Security, January 2010), 8.

4 John Podesta and Peter Ogden, 'The Security Implications of Climate Change" The Washington Quarterly (Winter 2007-2008): 132.

5 Carmen, "Broadening Horizons," 13.

6 United Nations Framework Convention on Climate Change. "A Question of Degree," accessed on March 2, 2010, http://unfccc.int/essential-background/feeling_the_heat/items/2905.php.

7 Sharon Burke et al., "Uncharted Waters: The U.S. Navy and Navigating Climate Change" (Working paper, Center for a New American Security), 11.

8 The Pew Center on Global Climate Change, Climate Change 101: Understanding and Responding to Global Climate Change (Jan 2009), 1.

9 The Pew Center, Climate Change 101, 5.

10 Kurt M. Campbell, Editor, *Climatic Cataclysm: The Foreign Policy and National Security Implications of Climate Change* (Washington D.C.: Brookings Institution Press, 2008), 58-61,

11 The Pew Center, Climate Change 101, 5.

12 David W. Titley and Courtney C. St. John, "Arctic Security Considerations and the U.S. Navy's Roadmap for the Arctic" Naval War College Review (Spring 2010): 39.

13 The Pew Center, Climate Change 101,6.

14 The Pew Center, Climate Change 101, 6.

15 Patricia Kime, "The Climate Challenge," Seapower (May 2010): 56.

16 The Pew Center, Climate Change 101,1.

17 Michael Werz and Kari Manlove, "Climate Change on the Move" (Center for American Progress, December 8, 2006), 1-2.

18 Podesta, "The Security Implications of Climate Change," 123.

19 Podesta, "The Security Implications of Climate Change," 125.

20The CNA Corporation, National Security and the Threat of Climate Change (2007), 15.

21The CNA Corporation, National Security and the Threat of Climate Change (2007), 15.

22 House Committee on Science and Technology, Subcommittee on Energy and Environment, Statement of Rear Admiral David Titley, Oceanographer of the Navy and Director, Task Force Climate Change, 112th Cong., 1st sess., November, 17, 2010,

http://democrats.science.house.gov/Media/file/Commdocs/hearings/2010/Energy/17nov>Titley_Testimony.pdf
(accessed March 2, 2011),

23 Podesta, "The Security Implications of Climate Change," 116.

24 Jon Barnett, Richard A. Matthew, and Karen L. O'Brien, *Global Environmental Change and Human Security* (Cambridge, Massachusetts: The MIT Press, 2010), 5-8.

25 The CNA Corporation, *National Security and the Threat of Climate Change*, 16.

26 Nigel Purvis and Joshua Busby, "The Security Implications of Climate Change for the UN System." Chap. In *Environmental Change and Security Project Report* (Washington D.C.: Woodrow Wilson International Center for Scholars, 2004), 2.

27 Purvis, "The Security Implications of Climate Change," 2.

28 Purvis, "The Security Implications of Climate Change," 2.

29 Purvis, "The Security Implications of Climate Change," 2.

30 White House, *National Security Strategy* (Washington, DC, May 2010), 47.

31 U.S. Department of Defense, *National Defense Strategy* (Washington, DC: U.S. Department of Defense, June 2008), 5.

32 Michael Werz and Kari Manlove, "Quadrennial Defense Review Should Spark Interagency Climate Conversation" (Center for American Progress, February 11, 2010), 1-4.

33 U.S. Department of Defense, *Quadrennial Defense Review Report* (Washington, DC; U.S. Department of Defense, February 2010), 85.

34 U.S. Department of the Navy, *Naval Operations Concept 2010*, (Washington DC: U.S. Department of the Navy, 2010), 46-48.

35 US, Department of the Navy, *Naval Operations Concept 2010*, 46.

36 US. Department of the Navy, *Naval Operations Concept 2010*, 47-48.

37 U.S. Department of the Navy, *A Cooperative Strategy for 21st Century Seapower*, (Washington, DC: U.S. Department of the Navy, October 2007), 2.

38 U.S. Department of the Navy, *A Cooperative Strategy for 21st Century Seapower*, 12-14.

39 Burke, "Uncharted Waters," 17.

40 Burke, "Uncharted Waters," 19.

41 Burke, "Uncharted Waters," 20-21.

42 Burke, "Uncharted Waters," 24.

43 Burke, "Uncharted Waters," 25.

44 Burke, "Uncharted Waters," 21.

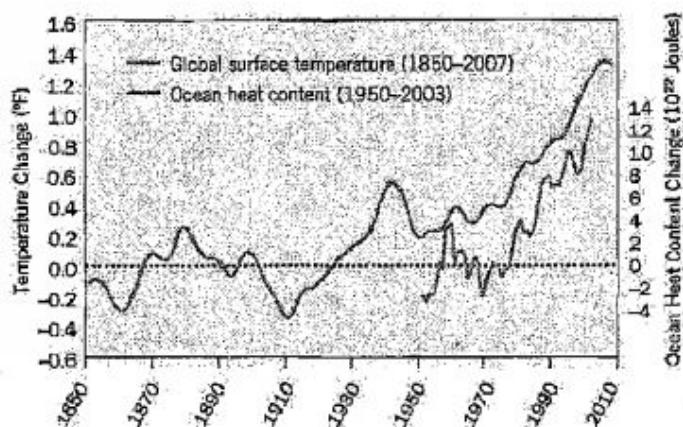
45 U.S. Department of the Navy, Naval Operations Concept 2010, 31.

46 Titley, "Arctic Security Considerations," 43.

47 Titley, "Arctic Security Considerations," 43.

48 John McCain, "Energy Independence and the Safety of Our Planet Speech." (speech, Chicago, Illinois, May 12, 2008).

APPENDIX A: GLOBAL WARMING TREND – AVERAGE SURFACE WARMING AND OCEAN HEAT CONTENT



Global average surface temperature change (left axis) and ocean heat content change in upper 2300 feet (right axis).

SOURCES

Surface temperature: Brohan, P., J.J. Kennedy, S.F.B. Tett, and P.D. Jones. "Uncertainty estimates in regional and global observed temperature changes: A new dataset from 1850." *Journal of Geophysical Research* 111, no. D12106 (2006). doi: 20.2029/2005JD006548.

Ocean heat: Domingues, C.M., J.A. Church, N.J. White, P.J. Gleckler, S.E. Wijffels, P.M. Barker and J.R. Dunn. 2008. "Improved estimates of upper-ocean warming and multi-decadal sea-level rise." *Nature* 453:1090-1093.

APPENDIX B: PREDICTED GLOBAL IMPACTS OF TEMPERATURE INCREASES

	0°C	1°C	2°C	3°C	4°C	5°C	6°C
Food							
	Severe impacts in marginal agricultural regions	Rising number of people at risk from hunger (20–60% increase in the 2050s in one study with weak carbon fertilization), with half of the increase in Africa and West Asia	Falling crop yields in many developing regions	Entire regions experience major declines in crop yields (e.g. up to one-third in Africa)			
	Rising crop yields in high-latitude developed countries if strong carbon fertilization			Yields in many developed regions decline even if strong carbon fertilization			
Water							
	Small mountain glaciers disappear worldwide – potential threat to water supplies in several areas	Significant changes in water availability (one study projects more than a billion people suffer water shortages in the 2030s, many in Africa, while a similar number gain water)			Sea level rise threatens major world cities, including London, Shanghai, New York, Tokyo and Hong Kong		
	Coral reefs die over time extensively and eventually irreversibly damaged	Possible onset of collapse of part or all of Amazonian rainforest					
Ecosystems							
					Large fraction of ecosystems unable to maintain current form		
					Many species face extinction (20–50% in one study)		
Extreme Weather Events					Rising intensity of storms, forest fires, droughts, flooding and heat waves		
					Small increases in hurricane intensity lead to a doubling of damage costs in the US		
					Risk of weakening of natural carbon absorption and possible increasing natural methane releases and weakening of the Atlantic THC		
					Onset of irreversible melting of the Greenland ice sheet		
						Increasing risk of abrupt, large-scale shifts in the climate system (e.g. collapse of the Atlantic THC and the West Antarctic ice sheet)	

Source: <http://www.ice.org.uk/patoolkit/Planning/Climate-change>

APPENDIX C: ALTERNATE SHIPPING ROUTE THROUGH THE NORTHERN SEA

A Shortcut Across The Top of the World

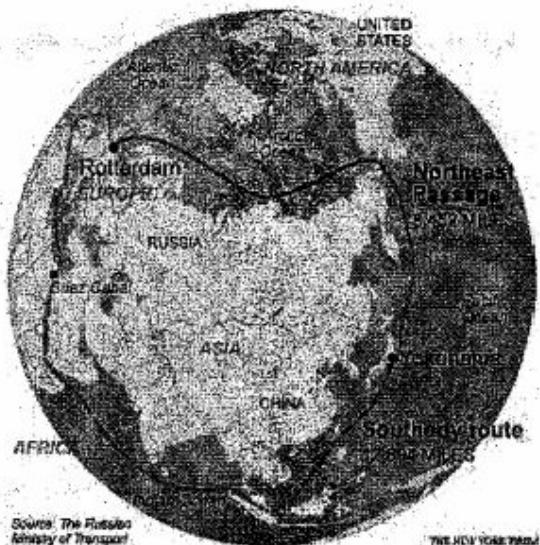
The Northeast Passage, across the Arctic Ocean, provides a shorter alternative for cargo vessels travelling between Europe and Asia than using the Suez Canal. It is shorter than the Panama Canal route for some voyages between the North American west coast and Europe.

LENGTH OF A VOYAGE TO ROTTERDAM FROM:

YOKOHAMA, JAPAN
12,894 miles via Suez Canal,
8,452 miles via Northeast Passage

SHANGHAI, CHINA
12,107 miles via Suez Canal,
9,297 miles via Northeast Passage

VANCOUVER, CANADA
10,262 miles via Panama Canal
8,038 miles via Northeast Passage



Source: <http://daniellemelitiv.com/2009/09/11/arctic-shortcut-a-reality-and-likely-to-speed-arcticwarming-and-melting/>

BIBLIOGRAPHY

Barnett, Jon, Richard A. Matthew, and Karen L. O'Brien. Global Environmental Change and Human Security. Cambridge, Massachusetts: The MIT Press, 2010.

Burke, Sharon, Dr. Jay Gulledge, Dr. Michael Horowitz, Christine Parthemore, and Nirav Patel. "Uncharted Waters: The U.S. Navy and Navigating Climate Change." Working paper, Center for a New American Security, December 2008.

Campbell, Kurt M., Editor. Climatic Cataclysm: The Foreign Policy and National Security Implications of Climate Change. Washington D.C.: Brookings Institution Press, 2008.

Carmen, Commander Herbert E., Christine Parthemore, and Will Rogers. "Broadening Horizons: Climate Change and the U.S Armed Forces," Center for a New American Security, April 2010.

Climate and Energy Symposium 2010, Proceedings on Climate and Energy: Imperatives for Future Naval Forces, 23-24 March 2010.

Kime, Patricia. "The Climate Challenge." Seapower, May 2010.

Obama, Barack. "Energy Independence and the Safety of Our Planet Speech." Chicago, Illinois. April 6, 2006.

Parthemore, Christine and Will Rogers. "Promoting the Dialogue: Climate Change and the Quadrennial Defense Review." Working paper, Center for a New American Security, January 2010.

Podesta, John and Peter Ogden. "The Security Implications of Climate Change." The Washington Quarterly, Winter 2007-2008: 115-138.

Purvis, Nigel and Joshua Busby. "The Security Implications of Climate Change for the UN System." Chap, in Environmental Change and Security Project Report. Washington, D.C.: Woodrow Wilson International Center for Scholars, 2004.

The CNA Corporation, National Security and the Threat of Climate Change, 2007.

The Pew Center on Global Climate Change, Climate Change 101: Understanding and Responding to Global Climate Change, January 2009.

Titley, David W. and Courtney C. St. John. "Arctic Security Considerations and the U.S. Navy's Roadmap for the Arctic." Naval War College Review[^] Spring 2010, Vol. 63, No. 2.

U.S. Congress. House. Committee on Science and Technology, Subcommittee on Energy and Environment. Statement of Rear Admiral David Titley, Oceanographer of the Navy and Director, Task Force Climate Change. 112th Cong., 1st sess., November 17, 2010. http://democrats.science.Titley_Testimony.pdf (accessed March 2, 2011).

U.S. Department of Defense. National Defense Strategy. Washington, DC: U.S. Department of Defense, June 2008.

U.S. Department of Defense, Quadrennial Defense Review Report. Washington, DC: U.S. Department of Defense, February 2010.

U.S. Department of the Navy. A Cooperative Strategy for 21st Century Seapower. Washington, DC: U.S. Department of the Navy, October 2007.

U.S. Department of the Navy, Naval Operations Concept 2010. Washington DC: U.S. Department of the Navy, 2010.

United Nations Framework Convention on Climate Change. "A Question of Degree." Accessed March 2, 2010. http://unfccc.int/essential_background/feeling_the_heat/items/2905.php.

Werz, Michael and Kari Manlove. "Climate Change on the Move," Center for American Progress, December 8, 2009.

Werz, Michael and Kari Manlove. "Quadrennial Defense Review Should Spark Interagency Climate Conversation," Center for American Progress, February 11, 2010.

White House. National Security Strategy, May 2010.

**SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES**

Lieutenant Commander Jessica J. O'Brien, USN

United States Marine Corps Command and Staff College

Marine Corps University

2076 South Street

Marine Corps Combat Development Command

Quantico, Virginia 22134-5068

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE MARINE CORPS COMMAND AND STAFF COLLEGE OR ANY OTHER GOVERNMENT AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

QUOTATION FROM, ABSTRACTION FROM, OR REPRODUCTION OF ALL OR ANY PART OF THIS DOCUMENT IS PERMITTED PROVIDED PROPER ACKNOWLEDGEMENT IS MADE

* * * * *



[Department of Defense 2014 Climate Change Adaptation Roadmap](#)

* * * * *

FOREWORD

The responsibility of the Department of Defense is the security of our country. That requires thinking ahead and planning for a wide range of contingencies.

Among the future trends that will impact our national security is climate change. Rising global temperatures, changing precipitation patterns, climbing sea levels, and more extreme weather events will intensify the challenges of global instability, hunger, poverty, and conflict. They will likely lead to food and water shortages, pandemic disease, disputes over refugees and resources, and destruction by natural disasters in regions across the globe.

In our defense strategy, we refer to climate change as a "threat multiplier" because it has the potential to exacerbate many of the challenges we are dealing with today - from infectious disease to terrorism. We are already beginning to see some of these impacts.

A changing climate will have real impacts on our military and the way it executes its missions. The military could be called upon more often to support civil authorities, and provide humanitarian assistance and disaster relief in the face of more frequent and more intense natural disasters. Our coastal installations are vulnerable to rising sea levels and increased flooding, while droughts, wildfires, and more extreme temperatures could threaten many of our training activities. Our supply chains could be impacted, and we will need to ensure our critical equipment works under more extreme weather conditions. Weather has always affected military operations, and as the climate changes, the way we execute operations may be altered or constrained.

While scientists are converging toward consensus on future climate projections, uncertainty remains. But this cannot be an excuse for delaying action. Every day, our military deals with global uncertainty. Our planners know that, as military strategist Carl von Clausewitz wrote, "all action must, to a certain extent, be planned in a mere twilight."

It is in this context that DoD is releasing a Climate Change Adaptation Roadmap. Climate change is a long-term trend, but with wise planning and risk mitigation now, we can reduce adverse impacts downrange.

Our first step in planning for these challenges is to identify the effects of climate change on the Department with tangible and specific metrics, using the best available science. We are almost done with a baseline survey to assess the vulnerability of our military's more than 7,000 bases, installations, and other facilities. In places like the Hampton Roads region in Virginia, which houses the largest concentration of US military sites in the world, we see recurrent flooding today, and we are beginning work to address a projected sea-level rise of 1.5 feet over the next 20 to 50 years.

Drawing on these assessments, we are integrating climate change considerations into our plans, operations, and training across the Department so that we can manage associated risks. We are considering the impacts of climate change in our war games and defense planning scenarios, and are working with our Combatant Commands to address impacts in their areas of responsibility.

At home, we are studying the implications of increased demand for our National Guard in the aftermath of extreme weather events. We are also assessing impacts on our global operations - for instance, how climate change may factor into our rebalance to the Asia-Pacific. Last year, I released the Department of Defense's Arctic Strategy, which addresses the potential security implications of increased human activity in the Arctic - a consequence of rapidly melting sea ice.

We are also collaborating with relevant partners on climate change challenges. Domestically, this means working across our federal and local agencies and institutions to develop a comprehensive, whole-of-government approach to a challenge that reaches across traditional portfolios and jurisdictions. Within the U.S. Government,

DoD stands ready to support other agencies that will take the lead in preparing for these challenges - such as the State Department, US Agency for International Development, and the Federal Emergency Management Agency.

We must also work with other nations to share tools for assessing and managing climate change impacts, and help build their capacity to respond. Climate change is a global problem. Its impacts do not respect national borders. No nation can deal with it alone. We must work together, building joint capabilities to deal with these emerging threats.

Politics or ideology must not get in the way of sound planning. Our armed forces must prepare for a future with a wide spectrum of possible threats, weighing risks and probabilities to ensure that we will continue to keep our country secure. By taking a proactive, flexible approach to assessment, analysis, and adaptation, the Defense Department will keep pace with a changing climate, minimize its impacts on our missions, and continue to protect our national security.

Chuck Hagel

Department of Defense

FY 2014 Climate Change Adaptation Roadmap

Climate change will affect the Department of Defense's ability to defend the Nation and poses immediate risks to U.S. national security. The Department is responding to climate change in two ways: adaptation, or efforts to plan for the changes that are occurring or expected to occur; and mitigation, or efforts that reduce greenhouse gas emissions. This Climate Change Adaptation Roadmap (Roadmap) focuses on the Department's climate change adaptation activities¹.

The Strategic Sustainability Performance Plan (SSPP) articulates the Department's sustainability vision to maintain our ability to operate into the future without decline in the mission or the supporting natural and man-made systems. The actions set forth in this Roadmap will increase the Department's resilience to the impacts of climate change, which is a key part of fulfilling this vision.

The Department has established three broad adaptation goals:

Goal 1: Identify and assess the effects of climate change on the Department.

Goal 2: Integrate climate change considerations across the Department and manage associated risks.

Goal 3: Collaborate with internal and external stakeholders on climate change challenges. These goals are supported by four lines of effort:

■ **Plans and Operations** include the activities dedicated to preparing for and carrying out the full range of military operations. Also included are the operating environments in the air, on land, and at sea, at home and abroad, that shape the development of plans and execution of operations.

■ **Training and Testing** are critical to maintaining a capable and ready Force in the face of a rapidly changing strategic setting. Access to land, air, and sea space that replicate the operational environment for training and testing is essential to readiness.

■ **Built and Natural Infrastructure** are both necessary for successful mission preparedness and readiness. While built infrastructure serves as the staging platform for the Department's national defense and humanitarian missions, natural infrastructure also supports military combat readiness by providing realistic combat conditions and vital resources to personnel.

■ **Acquisition and Supply Chain** include the full range of developing, acquiring, fielding, and sustaining equipment and services and leveraging technologies and capabilities to meet the Department's current and future needs, including requirements analysis.

The Roadmap is divided into four sections: the policy framework for climate change adaptation planning and three goal sections. For each goal, the Roadmap provides an overview, and specific details on how the Department's adaptation will occur across the four lines of effort, as well as a description of ongoing efforts (where applicable).

1 The Department's progress and strategies towards climate change mitigation, mainly through changes in our energy use, can be found in the main body of Strategic Sustainability Performance Plan (SSPP), Goals 1, 2, 3, 5 and 6.

"But the challenge of global climate change, while not new to history, is new to the modern world. Climate change does not directly cause conflict, but it can significantly add to the challenges of global instability, hunger, poverty, and conflict. Food and water shortages, pandemic disease, disputes over refugees and resources, more severe natural disasters - all place additional burdens on economies, societies, and institutions around the world."

- Secretary Hagel

Halifax International Security Forum

(DoD Arctic Strategy) Nov 2013

POLICY FRAMEWORK FOR CLIMATE CHANGE ADAPTATION PLANNING

The foundation for the Department's strategic policy on climate change adaptation began with the publication of the Quadrennial Defense Review (QDR) in 2010 by the Secretary of Defense. The QDR articulates the United States' national defense strategy and seeks to adapt, shape and rebalance our military to prepare for the strategic challenges and opportunities we face in the years ahead.

The 2010 QDR recognized that climate change was a threat to national security and the 2014 QDR reaffirms the Department's position: "The impacts of climate change may increase the frequency, scale, and complexity of future missions, including Defense Support to Civil Authorities (DSCA), while at the same time undermining the capacity of our domestic installations to support training activities."

The third National Climate Assessment notes that certain types of weather events have become more frequent and/or intense, including heat waves, heavy downpours, and, in some regions, floods and droughts. Sea levels are rising, oceans are becoming more acidic, and glaciers and arctic sea ice are melting. Scientists predict that these changes will continue and even increase in frequency or duration over the next 100 years.

These climate-related effects are already being observed at installations throughout the U.S. and overseas and affect many of the Department's activities and decisions related to future operating environments, military readiness, stationing, environmental compliance and stewardship, and infrastructure planning and maintenance.

Climate change also will interact with other stressors in ways that may affect the deployment of U.S. Forces overseas and here at home. As climate change affects the availability of food and water, human migration, and competition for natural resources, the Department's unique capability to provide logistical, material, and security assistance on a massive scale or in rapid fashion may be called upon with increasing frequency. As the incidence and severity of extreme weather events change, the Department will adapt to meet these dynamic operational realities.



Army National Guard rescues flooding victims after Hurricane Isaac
August 30, 2012. Credit: US ARNG SGT Rashawn D. Price

RESPONSIBLE SENIOR AGENCY OFFICIAL

The Deputy Under Secretary of Defense (Installations and Environment) is the Department's Climate Change Adaptation Planning Officer and is responsible for overseeing the implementation of the Department's climate change adaptation efforts.

COORDINATING BODY

The Department's Senior Sustainability Council (SSC), established in 2010, comprises Department senior leaders, the military departments and components and is charged with developing strategy, recommending policy, and ensuring coordination on sustainability initiatives across the Department. The SSC is co-chaired by the Deputy Under Secretary of Defense (Installations and Environment) and the Assistant Secretary of Defense for Operational Energy Plans and Programs. The SSC directs, oversees, and supports development of the Department's annual integrated SSPP and has purview over mitigation - through greenhouse gas emissions reduction efforts - and climate change adaptation.

The SSC established a Climate Change Adaptation Working Group (CCAWG) in December 2012, to facilitate implementation of the climate change requirements found in EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance, and EO 13653, Preparing the United States for the Impacts of Climate Change. The CCAWG takes direction from and provides advice to the SSC regarding the state of climate science, vulnerability and impact assessment, and adaptation practices, and they lead the development of the Department's Roadmap. The CCAWG has membership from all Services and multiple offices, including Policy, Operational Energy Plans & Programs, Personnel and Readiness, and the Joint Staff. The SSC and CCAWG fulfill the Department's original Goal 1, set forth in the 2012 Roadmap - "Define a coordinating body to address climate change." The SSC and CCAWG will continue to analyze climate change-related policy, guidance, and practice; ensure that the Department has access to the climate-related information necessary to make informed decisions; and engage with internal and external stakeholders.

EXECUTIVE ORDER REQUIREMENTS

This 2014 update to the Roadmap fulfills the requirements of a Climate Change Adaptation Plan found in Executive Orders 13514 and 13653. Executive Order 13514 requires that all Federal Departments and Agencies evaluate climate change risks and vulnerabilities to manage both the short- and long-term effects of climate change on the agency's mission and operations, and include an adaptation planning document as an appendix to its annual SSPP. Executive Order 13653 notes that "building on these efforts, each agency shall develop or continue to develop, implement, and update comprehensive plans that integrate consideration of climate change into agency operations and overall mission objectives and submit those plans to CEQ and OMB for review." A table which cross references this Roadmap to the specific implementation requirements of EO 13653 is provided in Annex 1.

GOAL 1 - IDENTIFY AND ASSESS THE EFFECTS OF CLIMATE CHANGE ON THE DEPARTMENT

Overview. Utilize an iterative assessment process to identify how climate change might shape the Department's plans and operations and what current and projected climate-related impacts might occur to its training and testing, built and natural infrastructure, and acquisition and supply chain.

The effects of the changing climate will be felt across the full range of Department activities, including plans, operations, training, infrastructure, and acquisition. The direction, degree, and rates of the physical changes will differ by region, as will the effects to the Department's mission and operations. By taking a proactive, flexible approach to assessment and analysis, the Department can keep pace with changing climate patterns and minimize effects on the Department.

Initial analysis indicates that four primary climate change phenomena are likely to affect the Department's activities:

- Rising global temperatures
- Changing precipitation patterns
- Increasing frequency or intensity of extreme weather events
- Rising sea levels and associated storm surge

A high-level summary of potential impacts to the four lines of efforts - plans and operations, training and testing, built and natural infrastructure, and acquisition and supply chain - is provided in Annex 2. For convenience to the reader, excerpts from Annex 2 are provided in relevant sections of the Roadmap.

PLANS AND OPERATIONS

The changing climate will affect operating environments and may aggravate existing or trigger new risks to U.S. interests. For example, sea level rise may impact the execution of amphibious landings; changing temperatures and lengthened seasons could impact operation timing windows; and increased frequency of extreme weather could impact overflight possibility as well as intelligence, surveillance and reconnaissance capability. The opening of formerly-frozen Arctic sea lanes will increase the need for the Department to monitor events, safeguard freedom of navigation, and ensure stability in this resource-rich area. Maintaining stability within and among other nations is an important means of avoiding full-scale military conflicts. The impacts of climate change may cause instability in other countries by impairing access to food and water, damaging infrastructure, spreading disease, uprooting and displacing large numbers of people, compelling mass migration, interrupting commercial activity, or restricting electricity availability. These developments could undermine already-fragile governments that are unable to respond effectively or challenge currently-stable governments, as well as increasing competition and tension between countries vying for limited resources. These gaps in governance can create an avenue for extremist ideologies and conditions that foster terrorism. Here in the U.S., state and local governments responding to the effects of extreme weather may seek increased DSCA. These potential effects are summarized in Table 1.

Table 1: Potential Effects of Climate Change on Department Plans & Operations

- Increased demand for DSCA.
- Increased demand for disaster relief and humanitarian assistance overseas.
- Increased need for air, sea, and land capabilities and capacity in the Arctic region.
- Altered, limited or constrained environment for military operations.
- Instability within and among other nations.

"And because we know that climate change is taking place, we are assessing our coastal and desert installations to help ensure they will be resilient to its effects. Planning for climate change and smarter energy investments not only make us a stronger military, they have many additional benefits - saving us money, reducing demand, and helping protect the environment. These initiatives all support President Obama's Climate Action Plan..."

- Secretary Hagel

Halifax International Security Forum

(DoD Arctic Strategy) Nov 2013

As a Department, we need to better understand how the changing climate will affect plans and operations in the U.S. and abroad. The Department will need to monitor these developments and decide which situations will require intervention based on U.S. security interests - either preemptively through security cooperation and capacity building, or with stability measures once conditions escalate.

Specifically, the **Department must assess how the projected effects of climate change may:**

- Alter operating environments. As these operating environments change, so may the need for adjustments to Department capabilities and capacity.
- Impact Department planning assumptions.
- Interact with other stressors—poverty, environmental degradation, political instability and social tensions—to accelerate conflict and instability detrimental to U.S. interests.
- Impact capacity building projects, stability operations, and construction of military and civilian infrastructure.
- Affect the demand for Department capabilities and prioritization of engagement across the range of military operations, with special attention to overseas humanitarian assistance and disaster response missions.
- Influence demands on the Department, including the Reserve Component, to support DSCA and other emergency operations in the U.S.

TRAINING AND TESTING

Maintaining a capable and ready Force in the face of a rapidly changing strategic setting requires agility and preparedness. The Department must be able to train our Forces to meet the evolving nature of the operational environment. The Department executes training in the field environment to achieve and sustain proficiency in

mission requirements. Similarly, the Department conducts testing in the field environment in anticipation of the military's use of weapons, equipment, munitions, systems, or their components. As such, access to the land, air, and sea space that replicate the operational environment for training and testing is critical to the readiness of the Force. Potential effects to the Department's training and testing are summarized in Table 2.



Hospital ship USNS Comfort and fleet replenishment oiler USNS Leroy Gunner provide support in Haiti, February, 2010. Credit: US Navy, Petty Officer 3rd Class Matthew Jackson

Table 2. Potential Effects of Climate Change on Department Training & Testing

- Increased number of 'black flag' (suspended outdoor training) or fire hazard days.
- Decreased training/testing land carrying capacity to support current testing and training rotation types or levels. Some training/testing lands may lose their carrying capacity altogether.
- Increased dust generation during training activities, which may interfere with sensitive equipment, resulting in greater repairs, or may require more extensive dust control measures to meet environmental compliance requirements.
- Stressed threatened and endangered species and related ecosystems, on and adjacent to DoD installations, resulting in increased endangered species and land management requirements.
- Increased operational health surveillance and health and safety risks to the Department's personnel.
- Increased maintenance/repair requirements for training/testing lands and associated infrastructure and equipment (e.g., training roads, targets)

The Department **must assess the effects of projected climate change on its:**

- Ability to carry out training and testing activities in the field environment.
- Access to existing training lands. Diminished access may increase the demand for acquisition/development of new training lands or alternative training to maintain unit readiness.
- Readiness of an individual unit or an individual weapons system's testing regime from 'lost days' at an individual training/testing location. The Department must assess these impacts at local training/testing assets and quantify the cumulative effects across all the Department's training and testing.
- Health and safety risks to the Department's personnel, and the extent to which demand for operational health surveillance programs and health services might increase.

BUILT AND NATURAL INFRASTRUCTURE

The Department manages a diverse mixture of built and natural infrastructure to support testing, training and other mission and readiness requirements. For example an installation may need a forest or desert landscape for maneuvers, coastal waters for amphibious assault training, or wetlands to prevent flooding and erosion. Climate change will have serious implications for the Department's ability to maintain both its built and natural infrastructure, and to ensure military readiness in the future. Potential effects to the Department's built and natural infrastructure are summarized in Table 3.

Table 3. Potential Effects of Climate Change on Department Built & Natural Infrastructure

- Increased inundation, erosion, and flooding damage.
- Changing building heating and cooling demand, impacting installation energy intensity and operating costs.
- Disruption to and competition for reliable energy and fresh water supplies.
- Damage from thawing permafrost and sea ice in Alaska and the Arctic region.
- Increased ecosystem, wetland, sensitive species, and non-native invasive species management challenges.
- Increased maintenance requirements for runways or roads to remain operable during extreme hot days.
- Changed disease vector distribution, increasing the complexity and cost of on-going disease management efforts.



Amphibious assault training. Credit: Petty Officer 3rd Class Amanda S. Kitchner

The Department must assess the effects of projected climate change on the:

- Design, operation, maintenance and repair of buildings and transportation assets.
- Management of natural infrastructure assets, including unique landscapes, ecosystems and habitats, particularly those supporting sensitive species.
- Energy, fuel, water supply, and utility services, including electrical grid, drinking water, wastewater, and steam systems.
- Adequacy of existing stormwater management systems to accommodate more frequent and intense precipitation events.
- Emergency preparedness and response.
- Distribution of disease vectors, including exposure to diseases in regions not routinely encountered, that may have acute and long-term impacts on personnel health and safety.

ACQUISITION AND SUPPLY CHAIN

The Department's acquisition and supply chain include the full range of developing, acquiring, fielding, and sustaining equipment and services and leveraging technologies and capabilities to meet the Department's current and future needs, including requirements analysis. Climate change impacts may affect the supplies, equipment, vehicles, and weapons systems the Department buys, where and from whom we buy them, how they are

transported and distributed, and how and where they are stockpiled and stored. Potential effects to the Department's acquisition and supply chain services are summarized in Table 4.

Table 4. Potential Effects of Climate Change on Department Acquisition & Supply Chain

- Changed operational parameters for current and planned weapons and equipment, resulting in increased associated maintenance requirements or requirements for new equipment.
- Reduced availability of or access to the materials, resources, and industrial infrastructure needed to manufacture the Department's weapon systems and supplies.
- Interrupted shipment, delivery or storage/stockpile of materials or manufactured equipment and supplies.
- Alterations in storage and stockpile activities.
- Reduced or changed availability and access to food and water sources to support personnel.



Flooding at Keesler Air Force Base. Credit: SSgt Kimberly Rae

The Department must assess the effects of projected climate change on its:

- Wide array of weapons systems, both in terms of operating range and associated maintenance requirements, and determine if new equipment is required to operate in new environments.
- Individual critical supplier, as well as the cumulative effects across all Department acquisition and supply activities, to identify critical component acquisition and supply chain vulnerabilities and associated cost increases.
- Key transportation modes and routes.
- Storage and stockpile activities, both at the individual site and cumulatively across the Department.

ONGOING EFFORTS

The Department has initiated several research and survey efforts to more fully identify and characterize vulnerabilities, impacts, and risks posed by climate change. The Department is implementing a phased installation-level vulnerability assessment approach to: develop methodologies for conducting consistent screening-level vulnerability assessments of military installations world-wide (starting with coastal and tidal installations); leverage recent scientific advancements regarding coastal assessment; and provide a platform to build upon prior to conducting more comprehensive and detailed assessments, whether coastal installations or otherwise.

A screening level survey assessment tool was piloted in the Fall of 2013 and was deployed in 2014 to assess current installation-specific vulnerability to climate impacts. Data from these screening-level assessments will be used to identify areas and installations where more detailed vulnerability assessments may be needed. The Department is using a whole-of-government approach to develop recommendations on regional sea level rise for use in more detailed coastal vulnerability and impact assessments of military installations worldwide, to ensure consistency in conducting these assessments.

As climate science advances, the Department will regularly reevaluate climate change risks and opportunities in order to develop policies and plans to manage its effects on the Department's operating environment, missions, and facilities. Research organizations within the Department, including the Strategic Environmental Research and Development Program (SERDP), are planning and completing studies to characterize climate change impacts in specific regions of the world and develop and pilot vulnerability assessment and adaptation methodologies and strategies.

Research involving coastal assessment method development is scheduled for completion during 2014. As a synthesis of this work, SERDP prepared a report in 2013 - Assessing Impacts of Climate Change on Coastal Military Installations: Policy Implications - that drew on the lessons learned from the SERDP-funded research efforts in the context of coastal installations and on the expertise of individuals within the DoD community and other Federal agencies. Work in other regions is still underway, including research designed to understand how: increased temperature trends and changes in the fire regime in the interior of Alaska will impact the dynamics of thawing permafrost and the subsequent effects on hydrology, access to training lands, and infrastructure; and changes in storm patterns and sea levels will impact the Department's Pacific Island installations, including their water supplies.

GOAL 2 - INTEGRATE CLIMATE CHANGE CONSIDERATIONS ACROSS THE DEPARTMENT AND MANAGE ASSOCIATED RISKS

Overview. Continue efforts to integrate climate considerations into programs, operations, plans and processes. Develop and implement adaptation strategies to address risks identified through the iterative assessment process in Goal 1.

Adaptation to climate change cannot be a separate decisionmaking process, but rather integrated into the Department's existing management processes. Therefore, the Department will review and, as needed, make changes to existing plans, policies, programs, and operations to incorporate climate change considerations. Some additional policy and guidance may be needed to support specific activities and adaptation implementation; however, by and large, the Department will use existing mechanisms to implement policy and guidance that ensure mission resilience.

PLANS AND OPERATIONS

Dynamic environmental conditions, climate-aggravated flashpoints, and increasingly severe natural disasters may require adaptations to how the Department plans and executes operations around the globe. As appropriate, the Department will seek refinements to existing processes and develop new climate-specific plans and guidance.

Specifically, the **Department will review and, as needed, modify:**

- Plans and guidance unique to climate change related challenges, such as the Department's Arctic Strategy and the Navy's Arctic Roadmap.
- Overarching Department-wide plans and guidance to Combatant Commanders.
- Combatant Command deliberate planning, including Theater Campaign Plans, Operation Plans, Contingency Plans, and Theater Security Cooperation Plans.
- Country-specific cooperation and engagement.
- Department-wide Force planning analyses and processes, including Defense Planning Scenarios and war games.
- Internal policy guidance provided to the Components for the preparation and review of program and budget submissions.
- Total Force capacity and capabilities for DSCA, disaster relief, and humanitarian assistance, to include specific focus on the Reserve Component.

"Climate change shapes the operating environment and the missions that DoD must undertake."

- John Conger, Acting Deputy Undersecretary of Defense for Installations and Environment

March/April 2014, Environmental Law Institute Forum

TRAINING AND TESTING

The Department's long-standing stewardship of its training and testing lands is articulated through its sustainable range program, installation-level Range Complex Master Plans (RCMPs), and the Readiness and Environmental Protection Initiative (REPI). As appropriate, the Department will seek refinements to existing processes and develop new climate-specific plans and guidance.

Specifically, the **Department will review and, as needed, modify**:

- The sustainable range program, RCMPs, and the REPI program.
- Training and testing plans, including the location, frequency, and duration of training and testing rotations.
- Future Base Realignment and Closure (BRAC) and stationing decisions.
- Health surveillance programs, including increased frequency of health monitoring, and adequacy of personnel protective equipment.

BUILT AND NATURAL INFRASTRUCTURE

DoD installations are in essence "power projection platforms" from which the Department employs Forces across the full spectrum of military operations. As such, adapting to changing climate conditions is critical to the ability of the Department to address current and future threats, and sustain its mission. Effective adaptation planning will ensure the continued availability of the land, air, and water resources at our installations and ranges so the Department can train and operate today and into the future. As appropriate, the Department will seek refinements to existing processes and develop new climate-specific plans and guidance. Specifically, the **Department will review and, as needed, modify**:

- Installation Master Plans to guide development activities.
 - Integrated Natural Resource Management Plans (INRMPs), Integrated Cultural Resource Management Plans (ICRMPs), and Integrated Pest Management Plans (INMPs).
- Design and construction standards.
- Encroachment management plans and programs.
- Stormwater management and other utility systems.
- Facility maintenance and repair cost models.
- Installation-level water resource management plans.
- Emergency preparedness and response planning.

ACQUISITION AND SUPPLY CHAIN

The Department depends upon the private sector for the manufacture of its weapons systems and replacement parts. Many major corporations have recognized the potential effects of climate change on their operations and are aggressively pursuing manufacturing/supply resiliency efforts. As appropriate, the Department will seek refinements to existing processes and develop new climate-specific plans and guidance.

Specifically, the **Department will review and, as needed, modify:**

- Requirements analysis and acquisition strategies, including strategic reserves and stockpiles for critical components.



U.S. Marines and Navy sailors range training in the Middle East in 2009 under dry conditions. Credit: USMC Cpl Robert C. Medina

- New and existing weapons systems and their associated maintenance plans.
- Storage, distribution, and transportation activities, including transportation modes and routes.

ONGOING EFFORTS

In 2013, the Department initiated a review of existing directives, policies, manuals, and associated guidance documents and criteria to identify which ones should incorporate considerations of a changing climate. The initial screen identified 58 documents for review, primarily associated with mission assurance, plus those having the potential to adversely impact the Department's mission if climate change risks were not addressed. During 2014, the Department will work within the existing review and update cycle to establish a plan for incorporating consideration of climate change into the appropriate documents.

Many infrastructure managers are already adapting to changing climate factors. Reported rebuilding efforts after extreme storms include upgrading to more wind-resistant structures, burying utility lines underground, changing storage locations for chemicals used in low-lying wastewater treatment plants, protecting water supply wells, and removing vulnerable trees. In preparation for the possibility of more wildfires, installations reported preparing better firebreaks and making timber stand improvements to reduce fire fuel loads.

The 2012 Unified Facilities Criteria for Installation Master Planning (UFC 2-100-01) requires the consideration of climatic conditions along with other variables already being assessed (e.g., changes in mission requirements, surrounding land use and population density, and infrastructure assets and configurations beyond and linking to the installation). The 2013 UFC for High Performance and Sustainable Building Requirements (UFC 1-200-02), mandates the consideration of changing climate conditions when designing buildings, including potential increased heating or cooling requirements. The Department issued a Floodplain Management Policy in February 2014 that establishes requirements to minimize risks when military assets must be located within flood plains.

The Department is exploring the expansion of applications of risk management schemes already in use, primarily within the Defense Critical Infrastructure Program. Decisions on where and how to locate future infrastructure will become increasingly reliant on robust risk management processes that account for dynamic factors associated with climate change. While the initial modifications to risk management methodologies are focused on critical infrastructure, it is anticipated that the Department will utilize them across all decision making in the future.

Similarly, the Department already takes many actions addressing its natural infrastructure. The Natural Resources Conservation Program policy (DoDI 4715.03) was updated in 2011 to incorporate consideration of potential climate change impacts in the management of installation natural resources.

These considerations are documented in the INRMPs which are coordinated with the appropriate fish and wildlife management agencies. The INRMP Implementation Guide (DoDM 4715.03) was issued in November 2013 and provides specific direction for how INRMPs should incorporate climate change. Adaptive management approaches are the foundation for sustainable use of natural resources to support mission needs, meet stewardship requirements, and contribute to ecosystem resilience in the face of climate change. Maintaining ecosystem resilience is a key adaptation strategy given the uncertainty of potential impacts.

The Department is actively conducting research that will support further integration of climate change. This includes projects that: assess potential changes in the intensity, duration, and frequency of extreme precipitation events, including changes in the timing and intensity of snowmelt and subsequent run-off events; include development of adaptive decision frameworks; and address understanding the characteristics of species that are either conservation (management) reliant or adaptable to potential changes in climate and human activities.

"[DoD] needs to consider all aspects of the global security environment and plan appropriately for potential contingencies and the possibility of unexpected developments both in the near and the longer terms. It is in this context that the Department of Defense must consider the effects of climate change... and how these effects could impact our national security."

- Dr. Daniel Chiu

Deputy Assistant Secretary of Defense for Strategy and Force Development, Testimony to the Senate Defense Appropriations Subcommittee, May 21, 2014

GOAL 3: COLLABORATE WITH INTERNAL AND EXTERNAL STAKEHOLDERS ON CLIMATE CHANGE CHALLENGES

Overview. Promote deliberate collaboration with stakeholders - across the Department and with other Federal, State, local, tribal and international agencies and organizations - in addressing climate change considerations. This collaboration may include expanded operations, adaptation strategies and research.

Partnerships are needed to fully ensure the Department's mission is sustainable under climate change. The Department cannot effectively assess its vulnerabilities and implement adaptive responses at its installations if neighbors and stakeholders are not part of the process. The Department's decisions and those of neighboring communities are intrinsically interconnected. Aspects of our mission, such as Force deployment, may be affected by assets outside our control, such as transportation infrastructure.

The complexities and uncertainties of climate change require a whole-of-government approach. The Department already participates in nationwide efforts such as the U.S. Global Change Research Program and the National Climate Assessment sustained assessment process. It also partners with individual agencies such as the National Oceanic and Atmospheric Administration on, for example, the development and operational implementation of a national Earth System Prediction Capability.

The Department is also represented on all of the councils and working groups established under EO 13653 and will continue to participate in federal climate partnerships and other interagency processes. The Department,

through the Air Force Weather Agency, contributes earth-space environmental data, receiving nearly 500,000 weather observations and satellite-derived wind profiles each day and sharing these data with the National Climatic Data Center and the Navy's Fleet Numerical Meteorological and Oceanographic Center.

"Climate change also creates both a need and an opportunity for nations to work together, which the Department will seize through a range of initiatives. We are developing new policies, strategies, and plans, including the Department's Arctic Strategy and our work in building humanitarian assistance and disaster response capabilities, both within the Department and with our allies and partners."

- 2014 Quadrennial Defense Review

PLANS AND OPERATIONS

Collaboration is essential to effectively adapting Department plans and operations, and the Department will enhance collaboration within the Department itself, across the Federal Government, and with external entities that include partner nations, non-government organizations, and the private sector. Focus areas include:

- Cooperation with the Coast Guard, other agencies, and other Arctic nations to ensure that the increasingly accessible Arctic region remains peaceful and open to all nations.
- Continued collaboration with the State Department and foreign militaries to improve vulnerability assessments and adaptation efforts.
- Collaboration with interagency, state, and local officials to streamline and integrate responses to extreme weather events in the U.S.
- Cooperation with partner nations to enhance planning, responses, and resilience to the effects of climate change.

TRAINING AND TESTING

The anticipated effects of climate change on the Department's ability to train and test will drive the need for creative collaboration at multiple levels. Focus areas include:

- Shared use of training and testing assets within the Department and with our Allies.
- Collaboration with maritime and land management agencies.
- Collaboration with the medical and research communities to address health surveillance and disease treatment programs.

BUILT AND NATURAL INFRASTRUCTURE

Effective collaboration with internal and external stakeholders will be required to address myriad built and natural infrastructure challenges. Focus areas include:

- Collaboration on design, construction, and operation of high-performance sustainable buildings and construction standards.
- Collaboration with surrounding communities for planning climate change adaptation and emergency preparedness and response.
- Collaboration with other land/resource management agencies with regard to encroachment challenges.

- Expansion of partnerships with external, nonfederal government land and resource stewardship organizations.
- For overseas installations, coordination with host nation military and other appropriate organizations.



Secretary Hagel hosted 10 defense ministers of the Association of Southeast Asian Nations on April 2, 2014. One topic was collaboration on non-traditional security challenges, such as climate change and natural disasters.

Credit: DoD Photo by Erin A. Kirk-Cuomo

ACQUISITION AND SUPPLY CHAIN

Collaboration with the private sector, including major manufacturing, supply, and transportation corporations, may enable the Department to leverage best practices and adaptation strategies to increase resiliency in the Department's acquisition and supply enterprises. Focus areas include:

- Collaboration with external producers and suppliers, transportation networks, and inventory management entities.
- Collaboration with industry as part of the acquisition and procurement process.
- Collaboration within the Department to increase shared use of supply/resupply networks and maintenance facilities.
- Collaboration with other Federal Agencies to leverage best practices and adaptation strategies.

Annex 1. Cross Reference: EO 13653 Implementation Requirements vs. Roadmap

Preparing Federal Agency Climate Change Adaptation Plans in Accordance with Executive Order 13653 (12/19/13)	Department of Defense FY 2014 Climate Change Adaptation Roadmap
Planning Requirements	NA
Affirming Agency Commitment – Policy Framework for Climate Change Adaptation	Policy Framework for Climate Change Adaptation
Planning for Climate Change Related Risk: Section 5(a) of E.O. 13653 states that, "each agency shall develop or continue to develop, implement, and update comprehensive plans that integrate consideration of climate change into agency operations and overall mission objectives..."	NA
i. identification and assessment of climate change related impacts on and risks to the agency's ability to accomplish its missions, operations, and programs	Goal 1: Identify and assess the effects of climate change on the Department
ii. description of programs, policies, and plans the agency has already put in place, as well as additional actions the agency will take, to manage climate risks in the near term and build resilience in the short and long term	Goal 2: Integrate climate change considerations across the Department and manage associated risks
iii. a description of how any climate change related risk identified pursuant to paragraph (i) of this subsection that is deemed so significant that it impairs an agency's statutory mission or operation will be addressed, including through the agency's existing reporting requirements	Goal 1: Identify and assess the effects of climate change on the Department
iv. a description of how the agency will consider the need to improve climate adaptation and resilience, including the costs and benefits of such improvement, with respect to agency suppliers, supply chain, real property investments, and capital equipment purchases such as updating agency policies for leasing, building upgrades, relocation of existing facilities and equipment, and construction of new facilities	Goal 2: Integrate climate change considerations across the Department and manage associated risks
v. a description of how the agency will contribute to coordinated interagency efforts to support climate preparedness and resilience at all levels of government, including collaborative work across agencies' regional offices and hubs, and through coordinated development of information, data, and tools, consistent with section 4 of this order. [Note: section 4 is 'providing information, data, and tools....']	Goal 3: Collaborate with internal and external stakeholders on climate change challenges
Modernizing Federal Programs and Policies to Support Climate Resilient Investment: Section 2(a) of E.O. 13653 states that Federal agencies shall address efforts to modernize Federal programs and policies "(To) support the efforts of regions, States, local communities, and tribes, ... consistent with their missions and in coordination with the Council on Climate Preparedness and Resilience (Council) established in section 6 of this order..." That section also states that agencies shall "report on their progress in achieving the requirements identified above, including accomplished and planned milestones, in the Agency Adaptation Plans developed pursuant to section 5 of this order."	NA
IV.i. identify and seek to remove or reform barriers that discourage investments or other actions to increase the Nation's resilience to climate change while ensuring continued protection of public health and the environment	Goal 1: Identify and assess the effects of climate change on the Department
IV.ii. reform policies and Federal funding programs that may, perhaps unintentionally, increase the vulnerability of natural or built systems, economic sectors, natural resources, or communities to climate change related risks	Goal 2: Integrate climate change considerations across the Department and manage associated risks
IV.iii. identify opportunities to support and encourage smarter, more climate-resilient investments by States, local communities, and tribes, including by providing incentives through agency guidance, grants, technical assistance, performance measures, safety considerations, and other programs.	Goal 3: Collaborate with internal and external stakeholders on climate change challenges
Senior Level Commitment... updated Plans must be reviewed and signed by the agency representative to the Council.	Policy Framework for Climate Change Adaptation

Annex 2. High-Level Summary of Potential Impacts

Potential Effects of Climate Change on the Department	
Plans and Operations	
<ul style="list-style-type: none">• Increased demand for DSCA.• Increased demand for disaster relief and humanitarian assistance overseas.• Increased need for air, sea, and land capabilities and capacity in the Arctic region.• Altered, limited or constrained environment for military operations.• Instability within and among other nations.	
Training & Testing	
<ul style="list-style-type: none">• Increased number of 'black flag' (suspended outdoor training) or fire hazard days.• Decreased training/testing land carrying capacity to support current testing and training rotation types or levels. Some training/testing lands may lose their carrying capacity altogether.• Increased dust generation during training activities, which may interfere with sensitive equipment, resulting in greater repairs, or may require more extensive dust control measures to meet environmental compliance requirements.• Stressed threatened and endangered species and related ecosystems, on and adjacent to DoD installations, resulting in increased endangered species and land management requirements.• Increased operational health surveillance and health and safety risks to the Department's personnel.• Increased maintenance/repair requirements for training/testing lands and associated infrastructure and equipment (e.g., training roads, targets)	
Built & Natural Infrastructure	
<ul style="list-style-type: none">• Increased inundation, erosion, and flooding damage.• Changing building heating and cooling demand, impacting installation energy intensity and operating costs.• Disruption to and competition for reliable energy and fresh water supplies.• Damage from thawing permafrost and sea ice in Alaska and the Arctic region.• Increased ecosystem, wetland, sensitive species, and non-native invasive species management challenges.• Increased maintenance requirements for runways or roads to remain operable during extreme hot days.• Changed disease vector distribution, increasing the complexity and cost of on-going disease management efforts.	
Acquisition & Supply Chain	
<ul style="list-style-type: none">• Changed operational parameters for current and planned weapons and equipment, resulting in increased associated maintenance requirements or requirements for new equipment.• Reduced availability of or access to the materials, resources, and industrial infrastructure needed to manufacture the Department's weapon systems and supplies.• Interrupted shipment, delivery or storage/stockpile of materials or manufactured equipment and supplies.• Alterations in storage and stockpile activities.• Reduced or changed availability and access to food and water sources to support personnel.	

ON THE FRONT COVER

A C130 FROM THE 146TH AIRLIFT WING IN FORT HUENEMER, CALIF., DROPS A LINE OF RETARDANT OVER THE TREES IN THE MOUNTAINS ABOVE PALM SPRINGS JULY 19, 2013.
CREDIT: AIR NATIONAL GUARD, SPC NICHOLAS CARBIS



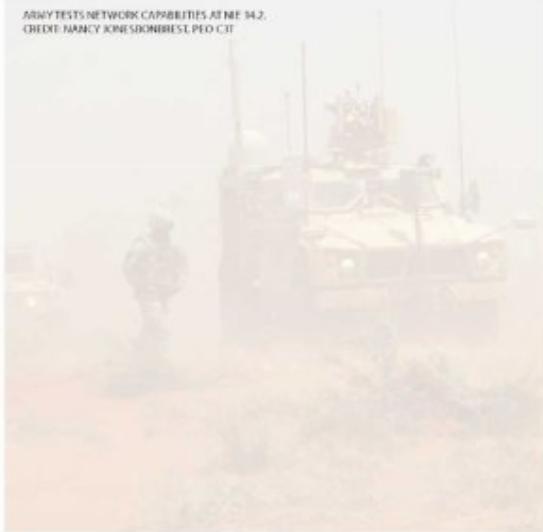
DAMAGE FROM SEVERE PRECIPITATION AND FLASH FLOODING AT L.E. IRVING, CALIFORNIA, AUGUST 2013.
CREDIT: U.S. ARMY

SEAMAN RECRUTS JAMAAL POWELL (LEFT) AND STEPHEN HARISON STAND THE FORWARD LOOKOUT WATCH ABOARD THE GUIDED-MISSILE CRUISER USS NORMANDY (CG 60) AS THE SHIP NAVIGATES THROUGH AN ICE FIELD IN THE ARCTIC CIRCLE NORTH OF ICELAND ON JUNE 12, 2007.
CREDIT: U.S. NAVY LTG RYAN BIRKELBACH

THEY SETTLEMENT RELATED TO PERMAFROST DEGRADATION IS PRESENTLY RESPONSIBLE FOR DAMAGE TO HOUSES, ROADS, AIRPORTS, MILITARY INSTALLATIONS, PIPELINES, AND OTHER FACILITIES FOUNDED ON ICE-RICH PERMAFROST.
CREDIT: VLADIMIR E. ROWANOVSKY



ARMY TESTS NETWORK CAPABILITIES AT NM 342.
CREDIT: NANCY JONES/DOE/NMIST, PEO C3T



HATCHINGS FROM ENDANGERED SEA TURTLES ARE RELEASED INTO THE ATLANTIC OCEAN NEAR KENNEDY SPACE CENTER/CAPE CANAVERAL.
CREDIT: NASA, KIM SHIFFLET



NORTH DAKOTA NATIONAL GUARD VEHICLES PATROL ONE OF THE MANY DRY EVACUATION ZONES IN FARGO, ND, JUNE 12, 2011. FLOODED BY THE RISING WATER OF THE SOURIS RIVER, THE PATROLS ENSURE THAT ALL CITIZENS HAVE EVACUATED THEIR HOMES AND RENDER ANY REQUIRED ASSISTANCE.
CREDIT: USAF, SMSGT DAVID LIPP



ON THE BACK COVER



THE 17- AND 15-STORY OFFICE TOWERS AT THE DIA-MARK CENTER COMPLEX IN ALEXANDRIA, VA., COMPLETED IN 2011, CONSOLIDATED ABOUT 6,000 EMPLOYEES FROM VARIOUS GOVERNMENT AND RELATED AGENCIES THROUGHOUT THE NATIONAL CAPITAL REGION. THE PROJECT WAS PART OF THE 2005 BASE REALIGNMENT AND CLOSURE (BRAC) AMENDMENT AND INCLUDES THE TALLEST STRUCTURES EVER BUILT BY THE U.S. ARMY CORPS OF ENGINEERS. THE ARMY CORPS NEW YORK DISTRICT MANAGED THE DESIGN AND CONSTRUCTION OF THE \$1.0 BILLION PROJECT. THE DIA-MARK CENTER COMPLEX IS CERTIFIED BY THE U.S. GREEN BUILDING COUNCIL FOR LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN, OR LEED GOLD.
PHOTO CREDIT: MARC BARNES, ARMY MEDICINE



Office of the Deputy Under Secretary of Defense
for Installations and Environment
(Science & Technology Directorate)
4800 Mark Center Drive, Suite 17D08
Alexandria, VA 22350-3605

June 2014

* * * * *

Taking Up The Security Challenge of Climate Change

ABSTRACT

Climate change, in which man-made global warming is a major factor, will likely have dramatic and long lasting consequences with profound security implications, making it a challenge the United States must urgently take up. The security implications will be most pronounced in places where the effects of climate change are greatest, particularly affecting weak states already especially vulnerable to environmental destabilization. Two things are vitally important: stemming the tide of climate change and adapting to its far-reaching consequences. This project examines the destabilizing effects of climate change and how the military could be used to mitigate global warming and to assist at-risk peoples and states to adapt to climate change, thereby promoting stability and sustainable security. Recommendations are made on the importance of U.S. leadership on the critical issue of global warming, on defining and dealing with the strategic dimensions of climate change, and as a case in point, on

how Sino-American cooperation in Africa would not only benefit areas where climate change effects are already pronounced, but also strengthen a crucial bi-lateral relationship.

TAKING UP THE SECURITY CHALLENGE OF CLIMATE CHANGE

Climate change is real, serious, and inescapable, and its looming effects, certain and uncertain, may prove to be destabilizing on a massive scale. Stemming the tide of climate change and adapting to its far-reaching security implications must therefore rank among the United States' most vital strategic priorities this century.¹ The military instrument of national power should be used innovatively to mitigate man-made contributions to global warming, to assist especially vulnerable peoples and states to adapt to climate change, and to promote stability and sustainable security in places where climate change effects are most likely to occur.

The time is ripe, perhaps overdue, for the United States to take up the security challenge of climate change. Ways and means for mitigating and adapting to climate change and its security implications must be incorporated artfully into the National Security Strategy, National Defense Strategy, Quadrennial Defense Review, and Guidance for the Employment of the Force. The nature and number of destabilizing effects demand that the right moves be made now and beyond 2050, when the impacts of climate change intensify and multiply.

Sustainable security, an expanded concept of national security in which diplomacy and development play prominent roles, is the policy that should underlie these new strategies. The challenges of climate change in all facets of life will be long-lived and its burdens heavy, in some regions much more so than others. Sub-Saharan Africa dramatically illustrates these challenges, but also poses a unique opportunity for the United States and China.

The United States, which has already begun to vigorously engage China on climate change, should explore regional climate change-related military cooperation in Africa. Sino-American military-to-military cooperation in Sub-Saharan Africa would benefit a region in which climate change effects are already pronounced and will almost certainly worsen, while strengthening a crucial bi-lateral relationship between two mostly peaceful but still uneasy competitors. China, the world's fastest rising power, is the largest emitter of greenhouse gases overall. The United States, the world's leading power, is the largest emitter of greenhouse gases per capita.

Global Warming and Climate Change

Adverse climate change is happening, will continue to happen, and may worsen. Man-made global warming,² produced by accumulation and persistence of "greenhouse gases" in the atmosphere, is a major, if not the major, cause or contributor. Greenhouse gases, carbon dioxide (CO₂) principally, are byproducts of the combustion of fossil fuels (e.g., petroleum, coal, and natural gas) for purposes such as transportation, industry, heat, and electric power generation.³ Reducing the level of greenhouse gases in the atmosphere is imperative,⁴ as is adapting to climate change, particularly in places where climate change is or likely will be destabilizing.⁵

The Science of Global Warming. Even as recently as 2006, the year in which the Academy Award winning film *An Inconvenient Truth*, narrated by former Vice President, unsuccessful 2000 presidential candidate, and 2007 Nobel laureate Al Gore,⁶ was released, climate change, as a consequence of man-made global warming, was hotly debated and deeply politicized in the United States and elsewhere.⁷ The following year, 2007, the United Nations' Intergovernmental Panel on Climate Change (IPCC) released its long-awaited Fourth Assessment. The IPCC report is of signal importance because it is well-balanced and moderate. It did not quell all controversy surrounding the subject, but because of it, climate change is generally accepted, scientifically speaking, to be a product of man-made global warming, even though uncertainties remain as to where, when, and how much.⁸

The IPCC report concludes that man-made global warming is "unequivocal," and that all continents are being affected by the resulting climate change.⁹ The air, the oceans, and the land are all warming with "likely" to "virtually certain" impacts on ecosystems, water resources, human health, industry, settlement, and society.¹⁰ These effects will vary from region-to-region and will prove to be difficult to predict, but in general, climate change will be greater by far in this and subsequent centuries.¹¹ In sum, climate change will continue, will likely

accelerate, and its effects will last for centuries, perhaps millennia, even if precipitous and dramatic action on global warming is taken.¹²

Present and Predicted Climate Change Effects

Climate change is already causing significant impacts in the United States and around the world.¹³ Among the present and predicted effects are more frequent and more severe weather-related natural disasters, intensifying heat waves, wider and more rapid desertification, longer-lasting and more intense drought and other water shortages, more unpredictable and more damaging floods, wider ranging and more destructive wildfires, irreversible sea level rise, and accelerating biodiversity loss.¹⁴ Sea level rise threatens hundreds of millions of coastal residents and billions of dollars in property in the U.S. alone; elsewhere, entire island nations are possibly imperiled by inundation; and the number of persons affected by weather-related natural disaster has tripled in the last decade.¹⁵ These phenomena, set against a back-drop of accelerating population growth, may lead to large-scale displacement of peoples, particularly unsustainable rural-to-urban migration. Competition may ensue over scarce resources. Some states will fail; others will aggressively exploit dwindling resources. Both routes may eventually spawn conflict.¹⁶

As Thomas Friedman put it, the world has entered an "Energy-Climate Era," an era in which "global warming, global flattening, and global crowding" are converging.¹⁷ Observed and predicted climate change effects have sparked grave concern in many quarters; human death toll estimates are in the millions.¹⁸

Security Implications of Climate Change

The idea that the environment has security implications is not new.¹⁹ Environmental security, including the issue of greenhouse gas emissions, was, to varying degrees, part of the national security strategies of Presidents Bill Clinton and George W. Bush.²⁰ Also not new is the idea that the military instrument of power should be used by combatant commanders to address environmental threats at the theater level.²¹ What is new is that climate change poses security threats unmatched among environmental phenomena.²²

Climate change is a multi-faceted threat to America's well-being, and the world's.²³ The life-sustaining capacity of our planet may be in jeopardy.²⁴ Fears are growing that climate change, that which is already occurring and the even more dire consequences that may lie ahead, will generate instability and lead to conflict. The most violent conflict is foreseen in and near areas that become uninhabitable, for example, due to desertification or sea-level rise.²⁵ The nature, uncertainty underlying, growing prevalence, and possible intractability of climate change exacerbate its tensions, risks, and threats.²⁶

In 2007, the Center for Naval Analyses, under the leadership of former Deputy Undersecretary of Defense for Environmental Security Sherri W. Goodman, issued a report entitled "National Security and the Threat of Climate Change." Authored by a Military Advisory Board consisting of former Army, Navy, Air Force, and Marine general and flag officers, the report, which cites IPCC, National Oceanic and Atmospheric Administration (NOAA), and National Aeronautical and Space Administration (NASA) peer-reviewed scientific data and analyses, makes four findings: (1) projected climate change is a serious threat to America's national security; (2) climate change will make some of the most volatile regions of the world even more unstable; (3) projected climate change will increase tensions even in stable regions of the world; and (4) climate change, national security, and energy dependence are related, global challenges.²⁷

Based on these findings, the panel recommended five things: (1) the security implications of climate change should be fully incorporated into national security and national defense strategies; (2) the U.S. should play a stronger role, nationally and internationally, in the mitigation of climate change; (3) the U.S. should build partnerships that help less developed nations adapt to climate change; (4) the Department of Defense (DOD) should enhance its operational capability through more energy efficient combat power; and (5) DOD should assess the impact on U.S. military installations worldwide of rising sea levels, extreme weather events, and other projected climate change impacts over the next 30 to 40 years.²⁸ The panel's findings and recommendations are compelling.

Destabilizing Effects on Failed and Failing States

Food and water shortages, health crises, population displacement (rural-to-urban and across borders), resource and territorial conflict, damage to infrastructure, and greater poverty (real and comparative) are likely to erode confidence in governments too weak or too poor to ameliorate these conditions.²⁹ The infertile, inhospitable climes created by climate change may prove fertile and hospitable to extremist ideology, inviting to transnational crime, and insuperable to their impoverished, weakened, and disenfranchised inhabitants.³⁰

Climate change and other environmental phenomena have not yet caused major war,³¹ but low-level regional conflict is an increasing possibility.³² The new Army Field Manual 3-0, in describing the operational environment, foresees that climate change will exacerbate already difficult conditions in many developing countries, setting off massive humanitarian crises.³³ The U.S. Joint Forces Command's "Joint Operating Environment 2008" also identifies ponderous climate change-related threats.³⁴ By one prediction, there will be as many as 50 million environmental refugees in 2010, 200 million or more by 2050.³⁵

Pandemic disease, mass starvation, and loss of habitable land brought on, in short order, by drought, desertification, loss of biodiversity, sea level rise, and other climate change-related effects, will create conditions of fear, resentment, panic, and mistrust. Governments, weak and strong, alone and in combination, will be hard pressed to maintain order, deliver humanitarian relief, and create economic opportunity on the scale that may be required. The effect on individual states, regions, and even the entire international system may be profoundly negative.

Climate change, to which even highly developed states are vulnerable,³⁶ will overwhelm weaker, less developed states that lack capability and capacity to adapt.³⁷ Already such groups as the Center for a New American Security, which in July 2008 conducted a war game entitled "Clout and Climate Change: A New Global Agenda for the 21st Century," are striving to find solutions to mitigate and adapt to climate change.³⁸ Within the U.S. Government, Congress, DOD, and the State Department, among others, are also very concerned by climate change's destabilizing effects.³⁹ The State Department, for example, now has an Environmental Security Working Group within its Bureau of Oceans, International Environmental and Scientific Affairs.⁴⁰ Like State, the U.S. Agency for International Development (USAID) is increasingly attuned to climate change issues, seeking opportunities with DOD to bring hard power and soft power solutions to bear on the intricate interdependencies of security, stability, and sustainable development.⁴¹

Grand Strategy and Military Strategy for Climate Change

The United States needs to quickly and broadly confront the full strategic implications of climate change - political, economic, and military - and not merely react to its humanitarian and other consequences. Climate change must therefore be a subject of grand strategy and military strategy.⁴² At present, the National Defense Strategy (June 2008) conceives of climate change merely as cause for uncertainty in the strategic environment.⁴³

The Obama Administration has not yet produced a National Security Strategy,⁴⁴ but several signs suggest that President Obama embraces the view that the security dimensions of climate change must be addressed.⁴⁵ In his inaugural address and in defense and environment agenda items posted on the White House website, the President speaks of a global climate crisis and 21st Century security threats that require new military capabilities, whole-of-government approaches, and mutual security alliances.⁴⁶ For their parts, Secretary of State Clinton made climate change a "centerpiece of a broader, more vigorous engagement with China;"⁴⁷ Environmental Protection Agency Head Lisa Jackson has aggressively embraced anti-global warming initiatives;⁴⁸ and, Director of National Intelligence Dennis Blair in his first Annual Threat Assessment, revived the term "environmental security," saying:

Climate change, energy, global health, and environmental security . . . [are] critical issues ... in a future where global warming and resource shortages will have destabilizing effects on many regions, threatening the vital interests of the United States. ⁴⁹

Defense Secretary Robert Gates has not made any detailed pronouncements on the subject.⁵⁰ Undersecretary of Defense for Policy Michele Flournoy, however, speaking on April 29, 2009 at the Center for

Strategic and International Studies about the upcoming Quadrennial Defense Review (QDR), listed climate change as one of five key trends affecting the strategic environment. Climate change, she suggests, is an "accelerant" of state failure, humanitarian crises, and other tensions that could lead to conflict.⁵¹

On the same day Undersecretary Flournoy addressed the Center for Strategic and International Studies, Dr. Geoff Dabelko, of the Woodrow Wilson Center for Scholars, spoke to the Johns Hopkins University Applied Physics Laboratory, as part of the "Rethinking the Foundations of the National Security Strategy and QDR" series.⁵² Using Darfur as an example, Dabelko outlined how climate change can be an underlying cause of conflict.⁵³ Among the impacts on military roles and missions he sees are opportunities for Phase 0 shaping operations, especially in Africa, to pursue environment-related development goals, and to use environment-related activities around the world as military-to-military confidence-building opportunities.⁵⁴

Another high-powered group, the American Security Project, which includes current and former political leaders, former military leaders, and major think tank representatives, issued a report in 2008 entitled "A New American Arsenal."⁵⁵ This work, building on the 2007 Center for Naval Analyses report, cites climate change as one of four "grave challenges" for the United States.⁵⁶ Among its recommendations are entreaties to advance sustainable development and environmental stewardship, to develop capabilities to deal with the consequences of climate change, especially "climate refugees," and to formulate environmental conflict resolution mechanisms.⁵⁷ The report advocates a collective, collaborative view of security and strategies that combine all instruments of national power, placing the economic and diplomatic instruments above the military.⁵⁸

A keener recognition is growing and a deeper consensus is emerging within the U.S. Government⁵⁹ and more broadly around the world that climate change has security implications, challenges that must be addressed with dispatch.⁶⁰ The level of effort required is commensurately great, and although it necessarily includes a significant military dimension, the economic and diplomatic instruments of power must play the greater role. Equally important, the effort must be international, the meaning of which may be very different in 2050 than 2009.

The Future Security Environment

A time is coming, measured in decades, not centuries, in which American military superpower status may remain, but its relative economic power may be less and its resulting political prerogatives may be fewer; that is, a "post-American" world of increasing multi-polarity.⁶¹ For nearly 300 years, world order has been shaped by the hegemony of Western liberalism, first in the form of Pax Britannica, and then Pax Americana,⁶² but a post-American world, though globalized, may also be more non-Western.⁶³ It will be a world to whose evolving modernity the U.S. must adapt, not a world the U.S. will dictate.⁶⁴ It will be a world in which China, already the second-most-important country in nearly every respect, will take a decidedly American tack, though not by employing American methods, to expand its influence in hopes of molding the international system to suit its interests.⁶⁵ Further, it will be a world in which a healthy international community will still be a vital U.S. interest.⁶⁶

The most important bi-lateral relationships China and the U.S. have today are with each other. Strenuous efforts must be made to keep the U.S.-China relationship non-confrontational, and to encourage China to broaden its responsibility for promoting and maintaining peace and stability.⁶⁷ American grand strategy and military strategy must devise ways and means to achieve these ends.⁶⁸ And because the effects of global warming related climate change are of as great, if not greater concern to China than the U.S., the two countries will find much common ground in this arena.⁶⁹ China, like America, will perceive the security implications of climate change, but it remains to be seen whether it will play a constructive or discomfiting role. The U.S. must focus intently on this issue.⁷⁰

Mitigation of Global Warming by DOD and the Importance of U.S. Leadership

On the issue of climate change, U.S. leadership is widely seen as critical to achieving an effective global solution.⁷¹ Other key players, the European Union, Japan, Brazil, Russia, India, and China among them - who together with the U.S. account for 75% of all greenhouse gas emissions - must be included.⁷²

Adapting to and mitigating climate change and the security implications of climate change is a mammoth undertaking. The challenges associated with cutting greenhouse gas emissions are themselves immense, with intricate political and economic considerations. The U.S. should demonstrate its readiness and willingness to assume the mantle of leadership in climate change and environmental security, to stabilize and strengthen the international system, and relieve anxiety over American intentions.⁷³ Progress achieved on climate change will redound to America's advantage in other arenas.⁷⁴

An International Problem Requires an International Solution

In a globalized world almost all problems cross borders, and environmental issues have long been recognized as among the most international, the most transnational of all.⁷⁵ Climate change is affecting Polar Regions, sea coasts, and vast interior spaces; it extends to all points of the compass. It can be found in the developed world and in the developing world.

Mitigating global warming is perhaps the most efficacious way to slow or lessen (but not likely stop or reverse) climate change.⁷⁶ The international community, including the U.S., should therefore expeditiously set and implement meaningful long term emission reductions for greenhouse gases.⁷⁷ To accomplish this, the developed world must assist the developing world, both in technology and money.⁷⁸

The U.S. military, a very large emitter of greenhouse gases in its own right, can play two very significant roles. First, the U.S. should demonstrate resolve and leadership by taking action to reduce greenhouse gas emissions, and prepare itself, doctrinally and in technology and infrastructure, to adapt to climate change-related constraints on how it will operate and where it will be based. Second, the U.S. should conduct military-to-military operations with foreign militaries to help them reduce greenhouse gas emissions and, even more importantly, to promote stability and security directly, through military operations, and indirectly, through climate change-related development assistance.

Reducing DOD's Carbon Footprint

The military, America's single largest consumer of petroleum, should lead the way, for America and the world, in reducing its carbon footprint, that is, consumption (combustion) of fossil fuels.⁷⁹ No better, more impactful example of America's commitment to ameliorating climate change could be set. Many initiatives are now underway toward that end, under the leadership, for example, of the DOD Director of Operational Energy Plans and Programs, the Strategic Environmental Research and Development Program.⁸⁰

A second, even more important, direct, and concrete consequence of reducing DOD's carbon footprint is that a cut in America's dependence on foreign oil resulting from greater energy efficiency and development of alternative fuels and energy sources, will lessen the human, financial, political, and other costs of oil-related conflict.⁸¹ The more money spent on mitigating and adapting to climate change the less must be spent, in dollars and lives, on oil and arms, as fewer energy-driven conflicts will arise.⁸² The resulting reduction in tensions over the scarcity of this resource will contribute greatly to stability and security.

The strategic challenges of climate change come sharply into focus in the global warming context. Competition over access to fossil fuels and the environmental effects of their consumption (combustion) have long been and may long continue to be virulent sources of conflict. A new, more environmentally sound security paradigm is needed.

Sustainable Security and Adaptation to Climate Change

The challenge of climate change in the 21st Century is a four-sided conundrum. Poverty, population growth, ineffective civil government, and environmental crises are the four main elements that combine to produce instability and conflict. It is where this quartet of calamities can be found that the military instrument of national power is needed most.

Many have decried what has been characterized as militarization of U.S. foreign policy.⁸³ Whether or not it is true, and despite recent efforts to encourage whole-of-government approaches to foreign policy and national security, the U.S. military is, and for some time will remain, the most capable instrument of U.S. national power. More than any other component of government, the U.S. military, despite the demands of Iraq and Afghanistan, has the furthest reach and the greatest resources to create and sustain conditions favorable to peace and stability, and thereby promote sustainable development. In short, what is needed for adapting to and mitigating climate change and its destabilizing effects is less kinetic, more peripatetic.⁸⁴

Sustainable security is that paradigm.⁸⁵ It is well suited to this new century of intensifying globalization (good and bad), and the accelerating political, economic, institutional, and environmental changes and challenges that lie ahead. It reflects keenly the reality of the times: the U.S. military must be as adept at making friends as it is at killing enemies.⁸⁶

The U.S. Armed Forces, the Army in particular, have long been involved in development related activity, but largely abandoned such doctrine and capabilities in the aftermath of Vietnam.⁸⁷ Using a whole-of-government approach, the U.S. Armed Forces must again become adept at mixing defense, development, and diplomacy.⁸⁸ This includes, but by no means is limited to, humanitarian disaster relief.⁸⁹ The juxtaposition of sustainable development and national security is sustainable security.

Sustainable Security

Sustainable security is a blend of national security, collective security, and human security. It expands the traditional, inwardly-focused concept of state self-preservation, espousing a global perspective on transnational threats insidious to an ever more globalized international system.⁹⁰ Sustainable security is proactive and preventative, combining diplomacy and development with defense.⁹¹ It elevates moral suasion and American leadership, not at the expense of compulsion and force, when needed, but to champion lasting, development-based solutions to root causes of global violence and instability. Citing the 2007 Center for Naval Analyses report, the Center for American Progress, a chief proponent of sustainable security, labels climate change one such root cause, calling it "a threat multiplier in some of the most volatile regions of the world."⁹²

In practical terms, sustainable security is about sustainable development and the role of U.S. combatant commanders in it.⁹³ In short, the U.S. military must engage more broadly and deeply in development assistance.⁹⁴ Lessons learned in Iraq, Afghanistan, and the Horn of Africa, and lessons that may now be emerging from events unfolding in ungoverned tribal regions of Pakistan, show that meeting basic human needs and facilitating good governance are critical strategic capabilities the U.S. military, in conjunction with the Department of State, USAID, and other U.S. agencies, must have.⁹⁵

Adapting to and mitigating the effects of climate change will require a hybrid of sustainable security and sustainable development, linked by grand strategy and military strategy.⁹⁶ Climate change effects will strike at the heart of political, economic, and military institutions by imposing heavy human, economic, and environmental costs on all societies, especially fragile ones already in crisis for those and other reasons.⁹⁷ Africa may be the best case in point.⁹⁸

Climate change, particularly in Sub-Saharan Africa, provides immediate and compelling context for sustainable security.⁹⁹ The scope of the problem, however, and the many and varied national interests at stake, make this issue one the U.S. cannot and should not address alone.¹⁰⁰ In addition to the individual and regional interests of African states themselves, the U.S. must pay careful attention to China's interests.¹⁰¹ Moreover, as Dr. Kent Butts of the U.S. Army War College Center for Strategic Leadership recently observed, the fact that China has substantial interests in Africa provides a unique and promising opportunity for the U.S. to not only advance its security interests in Africa, but also with China.¹⁰²

Another consideration is that U.S. influence in Africa may be eroding relative to China. China is already seen in several parts of Africa as a global power.¹⁰³ And some Africans perceive that China's presence should be encouraged, not out of love for China, but as a check on unpalatable, overly-aggressive U.S. policies.¹⁰⁴

Sino-American Cooperation in Africa

If the furnace of Chinese economic growth is to continue to roar, it must be fueled, and that fuel is natural resources, especially energy resources like oil that China must import in vast quantities. It is China's growing appetite for resources that undergirds its foreign policy, a policy that has launched China head-long into Africa in a rush to grab timber, oil, natural gas, and other commodities. In fact, China's trade with Africa may be growing by 50 per cent per year.¹⁰⁵

China is feverishly buying billions of dollars' worth of friends and influence in Africa¹⁰⁶ and provides military support to such repressive regimes as Zimbabwe and Sudan in contravention of U.N. proscriptions.¹⁰⁷ "Business is business," a Chinese diplomat is reported to have said,¹⁰⁸ and China seems bent on keeping business booming, no matter the human or environmental cost. In other words, China's exploitative presence in Africa may be good for China, but not for Africa, and it's not good for the U.S.¹⁰⁹ Left unchecked, it will exacerbate the destabilizing effects of climate change, making things even worse for Africa, the U.S. and, eventually, China, too.¹¹⁰ Stability and security in Africa are in everyone's best interests.

Africa has long, but not consistently been a focus of U.S. strategy and policy. Significant evidence of America's renewed interest is the recent establishment of Africa Command (AFRICOM).¹¹¹ One area in which stability and security in Africa could be better served is through bringing - and keeping - more African military forces under civilian control. In other words, it is in the best interests of African states as well as the U.S., and others, that more African military forces be encouraged and provided opportunity to help build greater capability and capacity for good civil governance and stability.¹¹²

The 2007 Center for Naval Analyses report¹¹³ and the 2007 IPCC report¹¹⁴ detail how sea-level rise, water stress, and loss of arable land will affect Africa's peoples and governments, burdens that will push civil society past the breaking point in places already "just short of anarchy."¹¹⁵ Here, too, millions will be displaced; malaria and cholera epidemics will break out.¹¹⁶ Considering the extent to which Africa, especially Sub-Saharan Africa, will be affected by climate change, the U.S. and others should engage African military forces in activity that helps adapt to and mitigate climate change-related effects, easing human suffering, lessening further environmental degradation, reducing tensions and the potential for armed conflict, and strengthening challenged states.¹¹⁷

Clean drinking water supply projects are fruitful areas for Sino-American collaboration, even projects such as the ultimately ill-fated Shidley well in Kenya, a little known Joint Task Force Horn of Africa undertaking involving military-to-military cooperation between Navy Seabees and the Kenyan army.¹¹⁸ First, clean water alleviates many of the conflict-inducing tensions that water scarcity instigates, and thus aids appreciably in adapting to climate change stresses. Second, clean water projects are well suited to the humanitarian aspects and long-term development orientation of sustainable security. And third, these projects have legal and funding mandates, and an organizational mechanism.

The Senator Paul Simon Water for the Poor Act (2005), Public Law 109-121, requires the Department of State, USAID, and other federal agencies, e.g., the Centers for Disease Control, to aid poor countries to achieve clean water and sanitation. Billions have been spent on such projects; sixteen Sub-Saharan countries have been identified as high-priority for future funding. AFRICOM is well positioned to play an enabling role for this undertaking, not just in the U.S. interagency process, but through outreach to African militaries and China's People's Liberation Army (PLA). Like AFRICOM, the PLA also has a presence in Sub-Saharan states through its own military-to-military relations.¹¹⁹ The synergism of multilateral collaboration would yield greater benefit for all.

How significant it would be, for Africa and the world, if the U.S. and China worked cooperatively, between themselves and among African states, to promote peace, sustainable security, and sustainable development. China and the U.S., under the auspices of the United Nations and through the African Union, must provide critical leadership and resources to peoples and states that will likely perish without them.¹²⁰ If China and the U.S. do so, it will serve more than altruistic motives; it will advance vital interests.

Conclusions and Recommendations

From a national security perspective, too much and too little can be made of climate change. Thus far, too little has been made. Conversely, the Obama Administration must avoid the pitfall of making too much of climate change, lest its response be perceived as yet another pretext for American hegemony. The security challenge of climate change must be taken up, however, and soon, while options are more numerous, the prospects for success are greater, and the likelihood of major conflict is far less.

Climate change will have dramatic, accelerating, and long lasting consequences with profound security implications. Adapting to and mitigating climate change and its destabilizing effects are vital efforts the United States must undertake earnestly and remain committed to indefinitely. The security implications will be most pronounced in places where the effects of climate change are greatest, particularly weak states already especially vulnerable to environmental destabilization. Two things are paramount: stemming the tide of climate change and promoting stability.

At first blush, adapting to and mitigating climate change does not sound like a military mission. Reluctance on the part of the U.S. Armed Services to pursue yet another non-traditional mission, perhaps at the further expense of their pre-eminent war fighting skills, would be understandable. But by law, climate change is now an essential consideration in DOD planning and operations.¹²¹ Planning, of course, cannot succeed in a vacuum of strategic guidance.

The National Security Strategy, the National Defense Strategy, and the Quadrennial Defense Review must address the environmental security considerations of climate change. The current National Security Strategy is outmoded, and the National Defense Strategy is inadequate. Climate change is more than merely cause for uncertainty in the strategic environment. It is, rather, one of the four sides of the environmental security conundrum of the hot, flat, and crowded Energy-Climate Era.

Building on the work of the National Intelligence Council, the Center for Naval Analyses, the American Security Project, the Center for a New American Security, and others,¹²² DOD should champion a necessary and central, but measured and balanced ,role for American forces. Preparing for and responding to the security challenges of climate change must be part of a whole-of-government approach toward sustainable development and sustainable security.

Climate change, as Undersecretary Flounoy described it, is indeed an accelerant of destabilization and conflict, but that is not all. If some or all of the more dire predictions of climate change come true, especially in Sub-Saharan Africa, the impact of climate change will be much more, and much worse. The region and the international state system will suffer.

Addressing environmental security and climate change more concretely and more prominently in the National Security Strategy, National Defense Strategy, and Quadrennial Defense Review is an essential foundation for an effective, U.S.-led, multifaceted, multilateral approach. Diplomacy and development are not DOD's primary mission but DOD, not without historical precedent, must widen and strengthen its capabilities in these areas. For this something more robust and permanent than an inter-agency working group is required for leadership, planning, and coordination.

The U.S. military is the best vehicle, most notably in areas in which conflict is occurring or where civil government is ineffective or not present, for enabling diplomacy, development, and defense as part of a preventative, collective security construct. The military's reach, capability, and durability in these circumstances are obvious (but not limitless) advantages.¹²³ So, too, is the military's capacity to connect and coordinate external and internal entities, not merely indigenous and foreign security forces, but also regional and international governing organizations and non-governmental organizations.

Sub-Saharan Africa would be a particularly good place to address the challenges that climate change is causing and will produce. It is also a particularly good place to take advantage of opportunities that environmental engagement offers. Working together with African militaries, AFRICOM and the PLA can enable security and

stability projects focused on global warming and other climate change phenomena.¹²⁴ This would not only alleviate human suffering, aid sustainable development, and contribute to good governance, it would at the same time promote regional stability, enhance Sino-American relations, and improve U.S. security. Phase 0 stability operations and theater security cooperation projects are good ways to integrate military capabilities with development assistance.¹²⁵

How such projects would be selected and implemented is a complex strategic question in its own right, one that needs extensive further study. Working with the combatant commands, the U.S. Army War College Strategic Studies Institute; the National Defense University Institute for National Strategy Studies, Energy and Environmental Security Program; and the Center for Naval Analyses, would all be good choices for this effort. ¹²⁶

Endnotes

1 Carolyn Pumphrey, ed., *Global Climate Change: National Security Implications* (Carlisle Barracks, PA: Strategic Studies Institute, 2008), <http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=862> (accessed May 6, 2009). This book compiles presentations from a March 2007 colloquium entitled "Global Climate Change: National Security Implications," conducted by the Strategic Studies Institute and the Triangle Institute for Security Studies. The book is a must-read for anyone interested in the security implications of climate change. A consensus of the colloquium is that climate change strategy must have three foci: mitigation of global warming, adaptation to climate change, and stability (social, economic, and political).

2 Man-related might be a more apt descriptor, since methane (CH₄) emissions from cattle and reduction in CO₂ absorption due to deforestation are also significant contributors to the "greenhouse" warming effect.

3 Thomas L. Friedman, *Hot, Flat, and Crowded*, 34-35 (New York: Farrar, Strauss and Giroux, 2008).

4 By one estimate, 25 billion tons of carbon emissions must be cut. Bryan Walsh, "How to Win the War on Global Warming," *Time Magazine Online*, April 16, 2008, http://www.time.com/specials/2007/printout/0,28804,1730759_1731383_1731363,00.html (accessed November 25, 2008).

5 Use of the term "global" in describing atmospheric warming and climate change may be misleading. The best available information is that effects will vary, perhaps widely, from region to region, with Sub-Saharan Africa often cited as the most affected place. Center for a New American Security, "Climatic Cataclysm: The Foreign Policy and National Security Implications of Climate Change," <http://www.cnas.org/node/184> (accessed February 19, 2009).

6 Davis Guggenheim, dir., *An Inconvenient Truth*, DVD (Hollywood, CA: Paramount Home Entertainment, 2007); Albert A. Gore, Jr., *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (Emmaus, PA: Rodale Press, 2006).

7 According to an op-ed piece in *The Washington Post*, authored by the film's producer, 50,000 free copies of *An Inconvenient Truth* were offered to the National Science Teachers Association (NSTA), which reputedly declined to take them, a position NSTA vigorously disputed. National Science Teachers Association Home Page, <http://www.nsta.org/about/pressroom.aspx?id=52977> (accessed February 23, 2009).

8 The science of global warming and climate change is still hotly debated and deeply politicized. Compare Roy W. Spencer, *Climate Confusion* (New York: Encounter Books, 2008), which, like *An Inconvenient Truth*, made the *New York Times* Best Seller list. Mr. Spencer, now with the University of Alabama, Huntsville, was formerly a climate scientist with NASA. Note, however, that Encounter Books is a venture of Encounter for Education and Culture, Inc., which received more than \$8 million in grants from The Lynde and Harry Bradley Foundation, Inc., "the country's largest and most influential right-wing foundation," according to the website Media Transparency. Media Transparency Home Page, <http://www.mediatransparency.org/funderprofile.php?funderID=1> (accessed February 22, 2009). From a legalistic perspective, man-made global warming and resulting climate change have gained general acceptance in the scientific community. American courts have already found a

connection between greenhouse gases and climate change, ruling that greenhouse gas emissions can be regulated by U.S. EPA, and that federal agencies must consider climate change in their environmental impact analyses. Massachusetts v. EPA, 549 U.S. 497, 127 S.Ct. 1438 (2007); Ctr. for Biological Diversity v. Natl Highway Traffic Safety Admin., 538 F.3d 1172 (9th Cir. 2008).

9 Rajendra K. Pachauri et al., eds., Climate Change 2007: Synthesis Report, Summary for Policy Makers (Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2007) 2, 13. The Intergovernmental Panel on Climate Change (IPCC) and its scientific studies is an outgrowth of the 1992 United Nations Framework Convention on Climate Change, a treaty to reduce global warming, to which 192 countries, including the United States, are parties. The treaty's 1997 Kyoto Protocol, which commits countries to greenhouse gas reductions the treaty merely encouraged, entered into force in 2005; the United States, however, is not one of its 184 parties. The Kyoto Protocol expires in 2012, and negotiations are already underway on a replacement, the subject of the U.N. Climate Change Conference to take place in Copenhagen, Denmark in December 2009, where all eyes will surely be on the U.S.

10 Ibid., 13. The Bush Administration endorsed the IPCC's findings. Confronting Climate Change: A Strategy for U.S. Foreign Policy, by George E. Pataki and Thomas J. Vilsack, chairs (New York: Council on Foreign Relations, 2008), 29, Independent Task Force Report No. 61.

11 Pachauri, Climate Change 2007, 3-7.

12 A newly-released NOAA climate study, also published in the Proceedings of the National Academy of Sciences, concludes that climate change will continue even 1000 years after CO₂ emissions are completely stopped. National Oceanic and Atmospheric Administration, "New Study Shows Climate Change Largely Irreversible," http://www.noaanews.noaa.gov/stories2009/20090126_climate.html (accessed January 26, 2009).

13 Katie Howell, "Eroding Alaskan Coastline Threatens Wildlife Habitat, Cultural Resources, Oil and Gas Development," Environment and Energy Daily Online, February 26, 2009, <http://www.eenews.net/l1> (accessed March 2, 2009).

14 Global warming related climate change is not the only environmental condition of concern. Inextricably linked are interrelated environmental impacts (degradation) associated with population growth, natural resource depletion, anthropogenic pollution, and pandemic disease, among other phenomena, all of which pose significant environmental security risks in their own right. While each and all of these are important, global warming related climate change appears to be the most threatening, by far. That said, the response to climate change should not proceed in isolation. Environmental remediation and environmental security do not tolerate piecemeal solutions.

15 Jerome C. Glenn and Theodore J. Gordon, 2007 State of the Future (Washington, DC: World Federation of the United Nations Associations and American Council for the United Nations University, 2007), 2.

16 Henrik Urdal, "Demographic Aspects of Climate Change, Environmental Degradation and Armed Conflict," January 16, 2008, http://www.un.org/esa/population/meetings/EGM_PopDist/P18_Urdal.pdf (accessed November 19, 2008).

17 Friedman, Hot, Flat, and Crowded, 26.

18 Ibid., 44.

19 See, for example, Joe D. Manous, Jr., Environmental Security: A Strategy for the Mitigation of Regional Instabilities?, Strategy Research Project (Carlisle Barracks, PA: U.S. Army War College, April 7, 2003); and Norman Myers "Environmental Security: What's New and Different?," <http://www.envirosecurity.org/conference/working/newanddifferent.pdf> (accessed May 3, 2009).

20 Manous, Environmental Security, 2.

21 Ibid., 18. U.S. Southern Command, for example, hosted a two-day environmental security conference in September 2007. Participants included representatives of the Argentinean, Brazilian, Chilean, and Dominican militaries, along with representatives of EPA, USAID, and the U.S. Geological Survey, as well as Florida International University, the University of Miami, the American Council on Renewable Energy, and Science Applications International Corporation. The U.S. Southern Command Home Page, <http://www.southcom.mil/AppsSC/files/0UI0I1190120383.pdf> (accessed May 22, 2009).

22 Environmental security (or climate security) is on the United Nations Security Council agenda, too. Glenn and Gordon, 2007 State of the Future, 8.

23 Andrew J. Bacevich, *The Limits of Power*, 178 (New York: Metropolitan Books, 2008).

24 "Unchecked climate change is poised to have wide-ranging and potentially disastrous effects over time on human welfare, sensitive ecosystems, and international security." Pataki, *Confronting Climate Change*, 3.

25 Sub-Saharan African, of which the long-suffering Darfur region of Sudan already is an example, is a place where conflict is and will be fueled appreciably by environmentally unsustainable conditions. It is possible, and may be likely, that worsening conditions in and around Sudan will further destabilize its already marginal state structure, with ever greater adverse effect on U.S. interests and security. Worsening environmental conditions should not be considered to be the only source of conflict, however. Some suspect that the well-publicized undersea land-grab now occurring in the Arctic, spurred by the prospect of year-round surface navigation, could lead to conflict. On the subject of its Arctic territorial rights Russia has sounded pugnacious, if not belligerent, and even Canada has been aggressive in asserting its interests.

26 Bacevich, *The Limits of Power*, 180.

27 Center for Naval Analyses, *National Security and the Threat of Climate Change* (Alexandria, VA: The CNA Corporation, 2007), 6-7.

28 Ibid.

29 Ibid., 13-16.

30 Center for Strategic and International Studies and Center for a New American Security, "The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change," November 2007, <http://www.cnas.org/node/126> (accessed February 19, 2009).

31 Environmental problems do not themselves cause wars, but do exacerbate other problems and conflicts that can lead to war. Ken Conca and Geoffrey Dabelko, eds., *Environmental Peacemaking* (Washington, DC: Woodrow Wilson Center Press and Baltimore and London: The Johns Hopkins University Press, 2002), 5. An interesting treatment of the environmental aspects of armed conflict is contained in a World Future Society Global Strategies Forum entitled "Environmental Degradation as Both Consequence and Cause of Armed Conflict," <http://www.wfs.org/fox.htm> (accessed February 19, 2009). Forum participants include Arthur Westing, Michael Renner, and Warwick Fox.

32 "With water becoming more scarce in several regions, cooperation over changing water resources is likely to be increasingly difficult within and between states, straining regional relations. Such regions include the Himalayan region, which feeds the major rivers of China, Pakistan, India, and Bangladesh; Israel Palestinian Territories; along the Jordan River (Israel-Jordan) and the Fergana Valley of Central Asia. Such dire scenarios are not inevitable even with worse-than-anticipated climate change impacts, however. Economic development, the spread of new technologies, and robust new mechanisms for multilateral cooperation to deal with climate change may foster greater global collaboration." National Intelligence Council, "Global Trends 2025: A Transformed World," November 2008, <http://www.dni.gov/nic/NIC 2025 project.html> (accessed April 19, 2009), 66-68, NIC 2008-003. The Council identifies "(h)ow quickly climate change occurs and the locations where its impact is most pronounced" and the fact that "(c)limate change . . . [will] likely . . . exacerbate resource scarcities, particularly

water" as key uncertainties in 2025. The Council, like many others, predicts a global multi-polar system, with China "poised to have more impact on the world over the next 20 years than any other country." Ibid, vi. Also: "Sub-Saharan Africa will remain the region most vulnerable to economic disruption, population stresses, civil conflict, and political instability. Despite increased global demand for commodities for which Sub-Saharan Africa will be a major supplier, local populations are unlikely to experience significant economic gain." Ibid., vii. And on climate change: "Climate change is expected to exacerbate resource scarcities. Although the impact of climate change will vary by region, a number of regions will begin to suffer harmful effects, particularly water scarcity and loss of agricultural production. Regional differences in agricultural production are likely to become more pronounced over time with declines disproportionately concentrated in developing countries, particularly those in Sub-Saharan Africa. Agricultural losses are expected to mount with substantial impacts forecast by most economists by late this century. For many developing countries, decreased agricultural output will be devastating because agriculture accounts for a large share of their economies and many of their citizens live close to subsistence levels." Ibid., viii.

33 U.S. Department of the Army, Army Field Manual 3-0 (Washington, DC: U.S. Department of the Army, February 27, 2008), 1-3.

34 The Boston Globe, "New US Military Report on Global Warming Raises Worry," December, 6, 2008, <http://www.cnas.org/node/604> (accessed February 19, 2009).

35 Glenn and Gordon, 2007 State of the Future, 8.

36 Ban Ki-moon, "The Right War," Time Magazine Online, April 16, 2008, http://www.time.com/time/specials/2007/printout/0,29239,1730759_1731383_1731345,00.html (accessed November 25, 2008).

37 Pachauri, Climate Change 2007, 14.

38 Center for a New American Security, "War Game: Clout and Climate Change," <http://www.cnas.org/node/149> (accessed February 19, 2009).

39 Stew Magnuson, "Climate Change Fears Spill Over to the Defense Community," National Defense Magazine, August 1, 2008, <http://www.cnas.org/node/312> (accessed February 19, 2009).

40 An inaugural meeting was held August 7, 2008, attended by representatives of DOD, the Joint Staff, USAID, the Central Intelligence Agency, the Defense Intelligence Agency, the U.S. Forest Service, the U.S. Geological Survey, and others. The focus of the meeting was the link between environmental security and foreign policy, and how to improve interagency and multilateral coordination. Interest appears to exist at high levels as to how environmental security could be used to promote strategic foreign policy objectives. This paper is geared toward that end. Doug B. Campbell, e-mail message to Major General Robert M. Williams, U.S. Army, August, 8, 2008. For additional background see <http://www.state.gov/gZoes/climate/index.htm> (accessed January 25, 2009).

41 Henrietta H. Fore, "Aligning 'Soft' and 'Hard' Power," Parameters 38, no. 2 (Summer 2008): 14-24.

42 Kelly Hearn, "Washington Times Exclusive: U.S. Military Worries about Climate Change" Washington Times, November 13, 2008, <http://www.cnas.org/node/535> (accessed February 19, 2009). Even before climate change came to the fore, environmental issues were deemed worthy of incorporation into the National Security Strategy. Elizabeth M. Damonte, National Security Strategy: What about the Environment?, Strategy Research Project (Carlisle Barracks, PA: U.S. Army War College, March 15, 2006).

43 The June 2008 National Defense Strategy, describing the Strategic Environment, states: "Over the next twenty years physical pressures - population, resource, energy, climatic and environmental - could combine with rapid social, cultural, technological and geopolitical change to create greater uncertainty" and "Current defense policy must account for these areas of uncertainty. As we plan, we must take account of the implications of demographic trends, particularly population growth in much of the developing world and the population deficit in

much of the developed world. The interaction of these changes with existing and future resource, environmental, and climate pressures may generate new security challenges. Furthermore, as the relative balance of economic and military power between states shifts, some propelled forward by economic development and resource endowment, others held back by physical pressures or economic and political stagnation, new fears and insecurities will arise, presenting new risks for the international community." Robert M. Gates, National Defense Strategy June 2008 (Washington, DC: U.S. Department of Defense, 2008), 4-5, <http://www.defenselink.mil/news/2008%20national%20defense%20strategy.pdf> (accessed February 19, 2009).

44 The 2006 National Security Strategy cites "(e)nvironmental destruction . . . caused by human behavior" as a destabilizing threat to national security, but doesn't mention climate change. George W. Bush, The National Security Strategy - March 2006 (Washington, DC: The White House, March 2006), 47, <http://www.globalsecurity.org/military/library/policy/national/nss-060316.htm> (accessed February 19, 2009).

45 Excerpts from the inaugural address: "(N)ew threats . . . demand even greater . . . cooperation and understanding between nations;" and "(W)e will work tirelessly to . . . roll back the specter of a warming planet." Transcript, "Barack Obama's Inaugural Address," January 20, 2009, <http://www.nytimes.com/2009/01/20/us/politics/20text-obama.html> (accessed May 3, 2009). Bryan Walsh, "Despite the Economy, Obama Vows to Press Green Agenda," Time Magazine Online, November 19, 2008, <http://www.time.com/time/printout/0,8116,1860431,00.html> (accessed November 25, 2008).

46 The White House, "Energy and Environment," <http://www.whitehouse.gov/agenda/energy> and environment (accessed January 21, 2009); The White House, "Defense," <http://www.whitehouse.gov/agenda/defense> (accessed January 21, 2009).

47 Mark Landler, "Clinton Paints China Policy With a Green Hue," The New York Times Online, February 22, 2009, <http://www.nytimes.com/2009/02/22/world/asia/22diplo.html> (accessed February 22, 2009).

48 Editorial, "Ms. Jackson Makes a Change," The New York Times Online, February 23, 2009, <http://www.nytimes.com/2009/02/23/opinion/23mon3.html> (accessed February 23, 2009).

49 InsideEPA, "Intelligence Chief Revives Environmental Security as High Priority," Defense Environment Alert 14, no. 4 (February 17, 2009). Dennis C. Blair, "Annual Threat Assessment of the Intelligence Community for the Senate Select Committee on Intelligence," February 12, 2009, <http://intelligence.senate.gov/090212/blair.pdf> (accessed February 19, 2009). Director Blair cites the 2007 IPCC report.

50 For example, climate change was mentioned, but only in two words, in an April 14, 2008 speech to the Association of American Universities. Speech of Defense Secretary Robert M. Gates, April 14, 2008, <http://www.defenselink.mil/speeches/speech.aspx?speechid=1228> (accessed November 25, 2008).

51 Michele Flournoy, "Rebalancing the Force: Major Issues for QDR 2010," April 29, 2009, http://www.csis.org/media/csis/events/090501_flournoy.pdf (accessed May 3, 2009).

52 Geoffrey Dabelko, "Climate Change and National Security," April 29, 2009, <ftp://ftp.jhuapl.edu/nsadrethink/042909/Dabelkobrief.pdf> (accessed May 7, 2009).

53 Ibid.

54 Ibid.; H. Allen Irish, "A 'Peace Corps with Guns': Can the Military be a Tool of Development?," in The Interagency and Counterinsurgency Warfare: Aligning and Integrating Military and Civilian Roles in Stability, Security, Transition, and Reconstruction Operations, ed. Joseph R. Cerami and Jay W. Boggs (Carlisle Barracks, PA: U.S. Army War College Strategic Studies Institute, 2008), <http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=828> (accessed May 3, 2009).

55 American Security Project, "A New American Arsenal," May 1, 2008,
http://americansecurityproject.org/issues/reports/new_american_arsenal (accessed April 30, 2009), 4.

56 InsideEPA, "High-Level Coalition Stresses Climate, Energy as Major Security Issues," Defense Environment Alert 16, no. 10 (May 13, 2008).

57 American Security Project, "A New American Arsenal," 11.

58 Ibid., 14-15. Note the similarities to sustainable security.

59 Bryan Walsh, "Does Global Warming Compromise National Security," Time Magazine Online, April 16, 2008, <http://www.time.com/time/specials/2007/article/0,28804,1730759,1731383,1731632,00.html> (accessed November 25, 2008).

60 Conca and Dabelko, Environmental Peacemaking, 2.

61 Fareed Zakaria, *The Post-American World* (New York: W.W. Norton & Co., 2008), 43.

62 Zakaria, *The Post-American World*, 45.

63 In what he described as a "Third Turning," Shawn Brimley, a Fellow at the Center for a New American Security, forecasts that the international system will be "almost unrecognizable by 2025." Also: "Along with the rise of new great powers such as China and India, the future is likely to see increased conflict driven by climate change, resource scarcity, and continued proliferation of nuclear technology. This geopolitical turn is not complete nor is it fully understood, but that it has begun is undeniable. The core undertaking for the Obama Administration will be to address the challenges of today while preparing the United States to adapt to a world in which power is more diffuse and the sources of danger more distributed." Shawn Brimley, "Crafting Strategy in an Age of Transition," *Parameters* 38, no.4 (Winter 2009-09): 31.

64 Colin S. Gray, *After Iraq: The Search for a Sustainable National Security Strategy* (Carlisle Barracks, PA: U.S. Army War College Strategic Studies Institute, 2009), 14-16, <http://www.strategicstudiesinstitute.army.mil> (accessed March 17, 2009). Dr. Gray, who sees climate change as a "leading threat" argues that the U.S. should maintain hegemony. Ibid., 16 and 59-60.

65 Zakaria, *The Post-American World* , 93 and 115.

66 Brimley, "Crafting Strategy," 35.

67 China, Defense Secretary Gates said to a National Defense University audience in September 2008, is a competitor, not an enemy. Speech of Defense Secretary Robert M. Gates, September 29, 2008, <http://www.defenselink.mil/transcripts/transcript.aspx?transcriptid=4295> (accessed November 25, 2008). Care must be taken not to adopt policies or strategies that will turn China from the former to the latter.

68 Environmental cooperation is "an effective general catalyst for reducing tensions, broadening cooperation, fostering demilitarization, and promoting peace." Conca and Dabelko, Environmental Peacemaking, 9.

69 Pataki, *Confronting Climate Change*, 42 and 54. Highlighted by air pollution concerns at last summer's Olympic games in Beijing, China's many environmental problems have been widely reported, not the least of which is its own growing problem of desertification. Many sources document the causes, consequences, and China's responses.

70 A February 6, 2009 panel discussion report on China's sixth defense white paper, released January 20, 2009, observes that China sees itself as a key player in an interdependent world of growing multi-polarity, asserting

that it will be an active and constructive participant. Center for Naval Analyses and National Defense University Institute for National Strategic Studies, "China's National Defense in 2008 Panel Discussion Report," February 6, 2009, <http://www.cna.org/documents/PRC%20White%20Paper%20Report.pdf> (accessed May 3, 2009).

71 National Intelligence Council, "Global Trends 2025," xi.

72 Pataki, Confronting Climate Change, 42.

73 Gray, After Iraq, 66.

74 Pataki, Confronting Climate Change, 22.

75 Zakaria, The Post-American World, 31.

76 Pachauri, Climate Change 2007, 14 and 18-19.

77 Blair, "Annual Threat Assessment," 43. The financial burden the developed world must bear has been contentious throughout the life of the Kyoto Protocol. It will assuredly be front-and-center during negotiations in Copenhagen this December.

78 Pataki, Confronting Climate Change, 7.

79 Executive Order 13423, entitled "Strengthening Federal Environmental, Energy, and Transportation Management," requires all federal agencies to be leaders in energy efficiency and other measures the effect of which would be to reduce greenhouse gas emissions and otherwise lessen global warming. George W. Bush, Executive Order 13423 (Washington, DC: The White House, 2007), <http://edocket.access.gpo.gov/2007/pdf/07-374.pdf> (accessed February 19, 2009). The operational impact of making DOD a leader in climate change must be carefully considered. The second- and third-order effects of resource constraints and legal restraints should not be ignored.

80 10 U.S. Code §§ 139b, 2901, 2914, 2916, 2917, 2918, 2922, 2922b, 2922c, 2922d, 2922e, 2922f.

81 Bryan Walsh, "Does Global Warming Compromise National Security?," Time Magazine Online, April 16, 2008, http://www.time.com/time/specials/2007/article/0,28804,1730759_1731383_1731632,00.html (accessed February 19, 2009).

82 Ibid.; Pataki, Confronting Climate Change, 37.

83 Gayle E. Smith, "In Search of Sustainable Security: Linking National Security, Human Security, and Collective Security to Protect America and Our World," 19, June 2008, http://www.americanprogress.org/issues/2008/06/sustainable_security.html (accessed February 19, 2009).

84 Note that AFRICOM's mission is to strengthen stability and security in Africa, and also to professionalize African militaries. It is geared toward non-kinetic, preventative approaches. In other words, it is tailor-made for whole-of-government type sustainable security. According to its website, AFRICOM's mission is, to conduct, in concert with other U.S. government agencies and international partners, sustained security engagement through military-to-military programs, military-sponsored activities, and military operations designed to promote stability and security. U.S. Africa Command Home Page, <http://www.africom.mil/AboutAFRICOM.asp> (accessed May 3, 2009).

85 Environmental security, climate security, and environmental peacemaking, as the concept has variously been called, is "post-Westphalian," focusing on transnational linkages related to "ecosystemic interdependences." Conca and Dabelko, Environmental Peacemaking, 10.

86 A recently seen bumper sticker: "We're making enemies faster than we can kill them."

87 Irish, "A 'Peace Corps with Guns,'" 56-58. Undersecretary Flounoy's April 29, 2009 remarks underscore the point: "(M)ilitary power is necessary but not sufficient to deal with 21st century challenges." The six core principles for U.S. strategy she enunciated are: pragmatism, engagement, selectivity, example, alliance, and integration (whole-of-government). Flounoy, "Rebalancing the Force."

88 Irish, "A 'Peace Corps with Guns,'" 67-70.

89 Reuben E. Brigety, II, "Aid for the Future," July 31, 2008,
http://www.americanprogressaction.org/issues/2008/brigety_testimony.html (accessed April 27, 2009).

90 Smith, "In Search of Sustainable Security," 3-5.

91 Gayle E. Smith, David Sullivan, and Andre Sweet, "The Price of Prevention: Getting Ahead of Global Crises," November 2008, http://www.americanprogress.org/issues/2008/11/price_of_prevention.html (accessed February 19, 2009). This article makes seven recommendations: (1) fully integrate prevention into the national strategies that guide foreign policy formulation and implementation; (2) build an integrated, interagency mechanism for long-range strategic planning that is tied directly to the allocation of resources; (3) organize the government to support prevention and ensure coherence across the executive branch; (4) invest intelligence, diplomatic, and economic resources in the most vulnerable areas and regions; (5) re-engage with the international community, and improve and then support international treaties and norms; (6) develop new tools and capabilities for crisis management; and (7) address the resource and staff shortages of civilian agencies, particularly the State Department and the United States Agency for International Development. These overlap, somewhat, and otherwise harmonize nicely with the Center for Naval Analyses' five recommendations.

92 Smith, "In Search of Sustainable Security," 12.

93 Ibid., 20-21.

94 Brigety, "Aid for the Future."

95 Ibid. It is also useful at such times that the U.S. military can keep "an ear to the ground" from an intelligence gathering and situational awareness point of view. Ruben E. Brigety, II, "Humanity as a Weapon of War: Sustainable Security and the Role of the U.S. Military," June 2008,
http://www.americanprogress.org/issues/2008/06/pdf/sustainable_security2.pdf (accessed April 27, 2009).

96 Brimley, "Crafting Strategy," 36. ("(R)obust development, economic, and military assistance missions will be a critical element of a grand strategy designed to sustain the twenty-first century international system").

97 Regional approaches are best, in that they are more tangible than global approaches and more efficacious than local approaches. Conca and Dabelko, Environmental Peacemaking, 13-16.

98 Irish, "A 'Peace Corps with Guns,'" 73-74.

99 Africa, according to the 2009 National Threat Assessment is "falling further behind," thanks to seemingly intractable conflict. Blair, "Annual Threat Assessment," 3435.

100 The U.S. has already undertaken a number of regional and bilateral climate change initiatives, including a greenhouse gas reduction project with South Africa. The Department of State Home Page,
<http://www.state.gov/g/oes/climate/c22820.htm> (accessed January 25, 2009).

101 An excellent treatment of China's involvement in Africa is contained in an April 2008 report to the Senate Foreign Relations Committee entitled "China's Foreign Policy and 'Soft Power' in South America, Asia, and

Africa," prepared by the Congressional Research Service. The report contends that U.S. soft power in Africa must increase in response to China's many soft power initiatives, by which China is pointedly positioning itself as an alternative to Western/American dominance. Congressional Research Service, "China's Foreign Policy and 'Soft Power' in South America, Asia, and Africa," April 2008, <http://www.gpoaccess.gov/congress/index.html> (accessed February 19, 2009).

102 Two noted environmental security experts, Dr. Kent Butts, director of the National Security Issues Branch in the U.S. Army War College Center for Strategic Leadership, and Mr. Geoff Dabelko, director of the Woodrow Wilson Center Environmental Security Program, urged Sino-American military-to-military environmental collaboration in an April 21, 2009 opinion piece on *CsMonitor.com*. Noting that the People's Liberation Army has been engaged on climate change adaptation since the 1990s, Butts and Dabelko see eagerness in both countries to broaden their cooperation on environmental security issues. Kent H. Butts and Geoffrey D. Dabelko, "One Way to Boost US-China Military Cooperation," April 21, 2009, <http://www.csmonitor.com/2009/0421/p09s01-coop.html> (accessed May 7, 2009).

103 Donovan C. Chau, Political Warfare in Sub-Saharan Africa: U.S Capabilities and Chinese Operations in Ethiopia, Kenya, Nigeria, and South Africa (Carlisle Barracks, PA: U.S. Army War College Strategic Studies Institute, 2007), 50, <http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=766> (accessed February 19, 2009).

104 Smith, "In Search of Sustainable Security," 1.

105 Zakaria, The Post-American World, 116; Blair, "Annual Threat Assessment," 3435.

106 Countries like Ethiopia, Kenya, Nigeria, and South Africa and the African Union. Chau, Political Warfare in Sub-Saharan Africa, vi-vii.

107 Zakaria, The Post-American World, 118.

108 Ibid.

109 According to Dr. Donovan Chau, China has been waging "political warfare" against U.S. interests in Africa since the 1950s. He argues that DOD, USAID, and other U.S. agencies should also wage political warfare in Africa. Chau, Political Warfare in Sub-Saharan Africa, 18 et seq. Military-to-military and other climate change-related activity in Africa, especially if conducted in concert with China, would serve U.S. interests while countering China's.

110 Carlton W. Fulford, Jr., "Thinking Through U.S. Strategic Options for Africa," Naval War College Review 62, no. 1 (Winter 2009): 41.

111 Ibid., 31-43.

112 Ibid., 37.

113 Center for Naval Analyses, National Security, 20-23.

114 Pachauri, Climate Change 2007, 11.

115 Center for Naval Analyses, National Security, 21.

116 Ibid., 22.

117 A variety of environmental roles and missions have been envisioned for military forces for some time. Roberta B. Carr, The Greening of Global Security: The U.S. Military and International Environmental Security,

Master's Thesis (Monterey, CA: Naval Postgraduate School, December 1993).

118 Brigety, "Humanity as a Weapon of War," 1-2. Despite great expense, no producing well was established. A variety of benefits was nonetheless realized.

119 Chau, Political Warfare in Sub-Saharan Africa, 25-26.

120 "Military-to-military environmental partnerships between the United States and countries in southern Africa are a domain pregnant with possibilities." Dan Henk, "The Environment, the US Military, and Southern Africa," *Parameters* 36, no. 2 (Summer 2006): 111. "The environment seemed to be one area in which the US military could collaborate effectively with regional militaries in spite of the vagaries of other political relations." *Ibid.*, 112.

121 The Fiscal Year 2008 National Defense Authorization Act, Public Law 110-181, section 951, amends 10 U.S. Code § 118 to require that the next national security strategy and national defense strategy include guidance for military planners on the risks of climate change, and that the next quadrennial defense review examine capabilities the armed forces will need to respond to climate change.

122 The list is illustrative, not inclusive, and is presented in no particular order.

123 Long duration stability and security operations place heavy sustainment burdens on armed forces which must be carefully considered. Thom Shanker "Pentagon Rethinking Old Doctrine on 2 Wars" *The New York Times Online*, March 15, 2009, <http://www.nytimes.com/2009/02/15/washington/a5military.html> (accessed March 15, 2009).

124 Outside limited participation by the People's Liberation Army-Navy in the anti-piracy task force in the Northern Arabian Sea, China has little history of operating with Western forces, which suggests that China may be reluctant to engage robustly, if at all, in climate change related security and stability projects. On the other hand, these types of projects may prove to be attractive to China, for economic, environmental, and security reasons, if they enhance China's position on the continent and internationally.

125 Irish, "A 'Peace Corps with Guns'," 71-72.

126 The list is illustrative, not inclusive, and is presented in no particular order.

BY

MR. RYMN J. PARSONS

Department of Navy Civilian Defense Leadership and Management Program

DISTRIBUTION STATEMENT A:

Approved for Public Release. Distribution is Unlimited.

USAWC CLASS OF 2009

This PRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The views expressed in this student academic research paper are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

U.S. Army War College

Carlisle Barracks, PA 17013-5050

Topic Approved By Colonel (Ret.) Robert E. Smith, U.S. Army

The views expressed in this student academic research paper are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

* * * * *

Military Implications of Global Warming

* * * * *

ABSTRACT

The 1998 National Security Strategy repeatedly cites global environmental issues as key to the long-term security of the United States. Similarly, U.S. environmental issues also have important global implications. This paper analyzes current U.S. Policy as it pertains to global warming and climate change. It discusses related economic factors and environmental concerns. It assesses current White House policy as it relates to the U.S. military. It reviews the Department of Defense strategy for energy conservation and reduction of greenhouse gases. Finally, it offers recommendations and options for military involvement to reduce global warming. Global warming and other environmental issues are important to the U.S. military. As the United States leadership in environmental matters encourages global stability, the U.S. military will be able to focus more on readiness and on military training and operations.

MILITARY IMPLICATIONS OF GLOBAL WARMING

BACKGROUND

THE KYOTO CONVENTION

ECONOMIC FACTORS

THE ENVIRONMENT AND THE AMERICAS

MILITARY IMPLICATIONS OF GLOBAL WARMING

CONCLUSIONS

ENDNOTES

BIBLIOGRAPHY

MILITARY IMPLICATIONS OF GLOBAL WARMING

The 1998 National Security Strategy repeatedly cites global environmental issues as key to the long-term security of the United States. Similarly, U.S. environmental issues also have important global implications.¹ This paper analyzes current U.S. Policy as it pertains to global warming and climate change. It discusses related economic factors and environmental concerns. It assesses current White House policy as it relates to the U.S. military. It reviews the Department of Defense strategy for energy conservation and reduction of greenhouse gases. Finally, it offers recommendations and options for military involvement to reduce global warming.

BACKGROUND

Global warming is not a myth or voodoo ecology. The 1900's have been the warmest century in the past 600 years. The temperature continues to rise every year. If this trend is not arrested or reversed, it will have a devastating impact on the quality of life and the economy. The President's policy is to set up national and international guidelines and goals with specific target dates, in order to slow or halt global warming and its effects. The overall goal is a higher quality of life and an economically favorable outcome.

Global warming can be defined as the gradual increase in temperature caused by the increased production of carbon dioxide (CO₂) that has occurred during the post-industrialized age. The increased CO₂ emissions are a result of an increasing population that has been burning vast amounts of coal and fuel for most of this century.³ Also, the production and use of specific chemicals by industry is slowly eroding the ozone layer, the atmosphere's protective layer between the Earth and the sun. When the ozone layer is depleted, the Earth receives more ultraviolet rays from the sun. This causes an increased incidence of skin cancer, cataracts, and immune suppression, as well as a higher mean temperature on earth.^{4, 5}

In nature, the presence of CO₂ in the atmosphere keeps the temperature an average 60 degrees Fahrenheit. With steady increases in CO₂ emissions it is expected that the temperature will increase 2-6.5 degrees Fahrenheit by the year 2100.⁶ If the temperature continues to increase, the sea level could rise 3 to 16 feet due to melting of portions of Greenland and the Antarctic icecaps.⁷ An extreme example of global warming is the planet Venus, with its predominantly CO₂ atmosphere. The temperature on Venus is 900 degrees Fahrenheit (482 degrees Celsius), high enough to melt lead.⁹ Global warming may cause human health problems, extreme weather changes, sea level rise, adverse effects on agriculture, and degradation of the ecosystem.¹⁰ Action is needed to prevent such devastating global warming effects.

An increased average temperature will cause a higher number of heat casualties.¹¹ A given rise in mean temperature above 60 degrees Fahrenheit is associated with more fatalities than a similar decrease in temperature.¹² Global warming could also result in an increase in diseases and deaths due to respiratory, cardiovascular and cerebrovascular disease caused by pollution.¹³ In the 1998 heat wave, health care officials warned two-thirds of the eastern United States of health care risks. In the heat wave of 1995, the elderly, children, and asthmatics in Washington, D.C. were encouraged to stay inside due to the increase in air pollution. In Chicago alone, over 700 deaths were attributed to the 1995 heat wave.¹⁴

The increased temperature would provide a more favorable environment for the growth of bacteria. This growth would inevitably be accompanied by bacterial mutation resulting in antibiotic resistance. Also, a warmer climate would allow disease-carrying insects to flourish.¹⁵ For example, mosquitoes carrying dengue fever have been found in the U.S. since 1986. Cases of malaria have recently been found in airport personnel in New York and London, transmitted by mosquitoes brought in by commercial jets from tropical areas. There is no vaccine against malaria and certain forms are resistant to almost all drugs.¹⁶ A possible defense is genetic re-engineering aimed at disease-carrying tropical parasites and mosquitoes that are advancing due to global warming.¹⁷

Global warming can cause diverse disasters. Increases in temperature lead to abnormally hot, dry weather. The resultant devastating fires have governmental, commercial, industrial and human costs. Fires displaced more than 112,000 Florida residents from their homes in July 1998. As the temperature has risen this past century, sea levels have also. Rising sea levels produce flooding, with population displacement and infrastructure damage.¹⁹ A conservative current estimate is that flooding due to rising sea level will threaten 92 million people by the year 2100 if global warming is not halted.²⁰ Climate changes would affect growing seasons. With continued increase in temperature, some areas would receive less rainfall, while other areas would be saturated. Increased flooding would affect the quality and quantity of food production, especially in Third World countries. This would increase malnutrition and hunger, with subsequent impairment of childhood growth and development. Flooding-associated pollution could contaminate drinking water and spread life-threatening diseases, such as cholera.

Imbalances in the ecosystem also affect global warming. Rain forests filter and use the carbon dioxide from the air, which reduces global warming. Loss of the rain forests destroys the cleansing ability of the atmosphere, threatens wildlife, creates new semi-deserts and increases large-scale flooding.²¹ Deforestation, especially by burning, contributes to an increase in CO₂ emissions.

Biological diversity is defined as the variety of plant and animal life that exists on the Earth or in some particular region of the Earth. The greater the diversity of organisms in an area, the healthier that region is likely to be.²² Ninety percent of the planet's biological diversity is located in the tropics, with 60 percent in Latin America.²³ Rain forests make up only 7 percent of all woodlands on Earth, but contain millions of unique species. Tropical forests around the equator are only 7 percent of the Earth's dry land surface, but may contain 50 percent of all species of plants and animals.²⁴

Tropical forests have been the source of 60 percent of the anticancer drugs discovered in the past 10 years. Depletion of the rain forests has caused the extinction of hundreds of species, a loss of potential biological resources for research into the development of new medicines. A current Bristol-Meyers Squibb Pharmaceutical Research Institute project seeks to demonstrate to developing nations the long-term economic benefit of preserving their rainforests.²⁵

The Clinton administration has proposed a vigorous domestic program to research and develop methods for decreasing CO₂ emissions. It provides tax incentives to individuals and industry for using more energy efficient systems. A government/industry program called Partnership for Advancing Technology in Housing encourages more energy-efficient housing. If its 2010 goals are met, consumers will save \$11 billion dollars annually. Also, carbon emissions will be reduced by 24 million tons annually, the amount currently produced by 20 million cars.²⁶

In order to halt global warming, humans must reduce the combustion of fossil fuels, such as coal, oil, and natural gas. Transportation accounts for 80 percent of U.S. petroleum use. Using hydrogen fuel cells to replace turbine and internal combustion engines has great potential for reducing the harmful emissions. A fuel cell converts the chemical energy of fuel into usable electricity and heat without combustion as an intermediate step. Fuel cells provide inexpensive, clean power from hydrogen. They could become the principal energy source for electricity generation as well as for powering transportation. Although some fear that a shift to fuel cells would disrupt the oil industry and the world economy, fossil fuels could be utilized as the hydrogen source. The carbon residue that remains after extracting the hydrogen could be safely stored.²⁷

Daimler-Chrysler Automobile Manufacturers recently announced the production of a car fueled by liquid hydrogen. Liquid hydrogen produces twice the energy of gasoline and has no harmful emissions. The production of the hydrogen fuel from fossil fuel is 70 to 90 percent cleaner than the current process from refining crude oil into gasoline. As the prototype burns fuel, the vehicle emits a small mist of water vapor and heat. Five thousand of these cars will be available by 2004, according to a spokesman. Ford and other U.S. automobile producers have similar plans. California is working with a merged Daimler-Chrysler/Ford team to speed up the transition. The California Fuel Cell Partnership is a unique collaboration between Texaco, Shell, ARCO and the automobile industry. The partnership plans to place about 40 fuel cell passenger cars and 25 fuel cell buses on California roads between 2000 and 2003. Ballard Power Systems will provide the fuel cells for the vehicles and Texaco, Shell and ARCO will provide the fuel.²⁸

THE KYOTO CONVENTION

Representatives of over 150 countries met in Kyoto, Japan December 1997 to address climate change. The Kyoto Protocol, produced by the conference and signed by the United States, is a commitment to lower greenhouse gases worldwide.³⁰ The U.S. emits 22 per cent of the world's greenhouse gases. The former Soviet Union countries, Western Europe, China and Japan account for 14, 13, 10 and 5 percent, respectively.³¹ Clinton will not ask Congress to ratify the Kyoto Protocol until China, India and other key developing nations agree to participate.³²

Prior to the convention, the U.S. perspective was that in order to decrease emissions, people would have to adversely alter their lifestyles. After the Kyoto Convention, the U.S. government decided to emphasize energy efficiency to reduce energy consumption without lowering the standard of living. The Department of Energy has been directed to focus on research and development of technologies to lessen our dependence on current modes of transportation.³³

Figure 1 shows that economic growth, energy consumption and carbon emissions are closely linked.³⁴

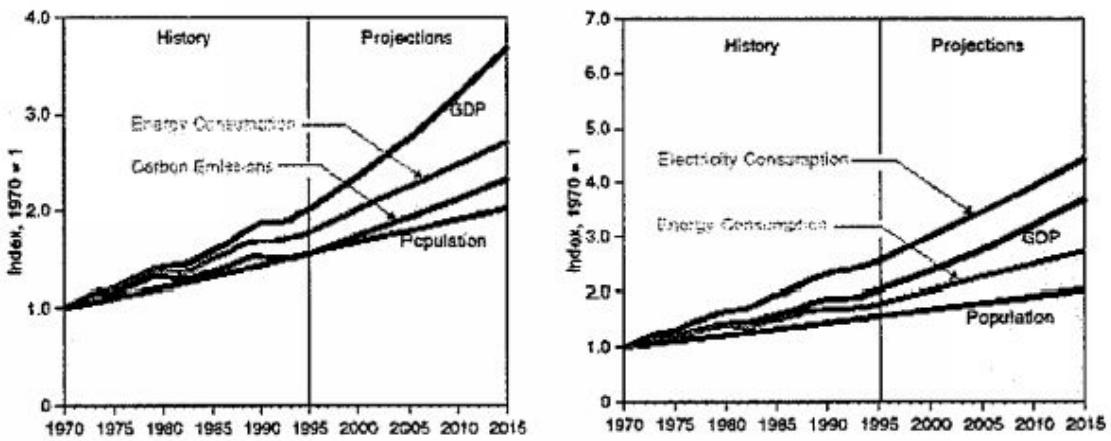


Figure 1. World Carbon Emission, Energy, GDP and Population Trends

In developed countries, there is an approximate 0.75 percent increase in energy consumption for every 1 percent increase in GDP. In underdeveloped or developing countries there is a one to one ratio between GDP growth and increases in energy consumption. In the future, GDP will grow slightly faster than energy demand in developing countries. The challenge is how to promote economic growth without increasing carbon emissions. Currently, less polluting energy sources, such as solar panels, are too costly and would hinder economic growth.³⁵

Energy consumption will continue to rise as populations grow and economies develop. Figure 2 shows that developing nations' energy consumption will surpass that of developed countries within the next 20 years.³⁶

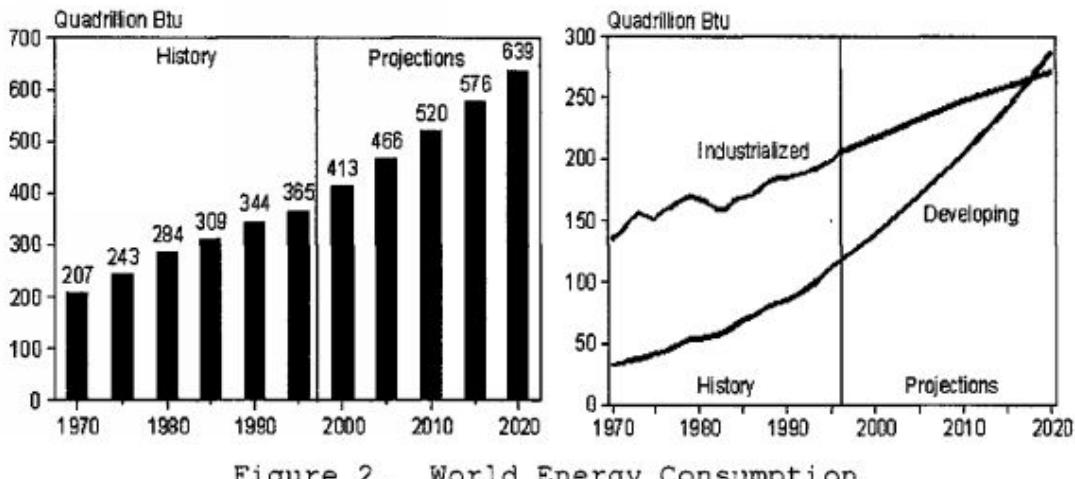


Figure 2. World Energy Consumption

One global approach is to share energy technology with the developing countries. For example, it has taken many stages or phases for the U.S. to research and develop better environmental technologies. The U.S. could offer these technologies to developing countries to speed their transition to environmentally suitable processes.³⁷

Coal is abundant in China, India, and the United States. Although burning coal pollutes and produces greenhouse gases, China, India and the U.S. will not forgo this valuable resource unless there is a better replacement. One possibility is nuclear power. Nuclear reactors do not produce greenhouse emissions. ³⁸ Safe

nuclear power would be a viable replacement for burning coal. Currently, the debate on the use of nuclear power is more political and emotional than scientific. Scientists know of safe methods of producing nuclear energy and storing nuclear waste. Nuclear power produces 20 per cent of all U.S. energy. The U.S. is not dependent on nuclear power because we have other natural resources. France, with fewer natural resources, depends on nuclear reactors for 80% of its power. Unfortunately, new nuclear plants are not being built in the U.S., because political controversy keeps U.S. banks from funding any nuclear projects.³⁹

Prior to 1995, most talks to address ozone depletion were limited to developed countries, since nearly 80 percent of all chlorofluorocarbon (CFC) or ozone depleting gases are produced by the United States, the former USSR, Europe, Japan, and China.⁴⁰ In December 1995, representatives from over 100 countries gathered in Vienna to review the protocol for managing ozone depletion. They committed to restoring the ozone layer by the year 2050. To achieve that, the three main chemicals that deplete the ozone layer will be phased out. For example, the target date for the phase-out of methyl bromide is 2010, with a 25 percent reduction by 2001 and 50 percent by 2005.⁴¹

ECONOMIC FACTORS

A conservative estimate is that a rise in mean temperature of 2.5 degrees Celsius would cost the U.S. \$60 billion annually, 1 percent of Gross Domestic Product (GDP). (See Table 1.) The economic impact of mean temperature rise is not a linear effect, on costs. For example, if the temperature rose 10 degrees Celsius, the economic effect would increase six-fold to \$360 billion dollars or 6 percent of GDP. The costs to other countries, especially island countries at sea level, would be a greater percentage of their GDP.⁴² The demand on resources to repair the damages created by global warming could impact negatively on the military budget.

Category	Costs in Billions*
Agricultural Losses	\$18
Rise in Sea Level	\$ 7
Electrical/ Air Conditioning	\$11
Loss of Water Supply	\$ 7
Increase in Urban Pollution	\$ 4
Heat-Induced Deaths	\$ 6
Deforestation	\$ 3
Ski Industry Losses	\$ 1.5

*1990 estimate

TABLE 1. U.S. Economic Effects of Temperature Rise

Another economic factor that has affected defense spending is health care costs. Between 1940 and 1992, annual U.S. health care costs rose from \$4 billion to \$800 billion. From 1970 to 1998, health care costs rose from 6 percent to 13.4 percent of GDP, while defense spending dropped from 8 percent to approximately 3 percent of GDP.⁴³ If global warming continues, the health of children and future generations will be adversely affected due to the increasing pollutant load. Increasing health care cost at military facilities could impact readiness, with budget shifts required to pay for health care rather than training. Federal budget pressure from rising civilian health care costs could create more pressure for shifting funds from military to health programs.

THE ENVIRONMENT AND THE AMERICAS

Since the end of the Cold War, U.S. interests have increasingly focused on Canada and Latin America. In Latin America and the Caribbean, 34 of the 35 countries are practicing democracy, with Cuba the exception. For these democracies to flourish, they need economic growth and low unemployment. U.S. importation of raw materials and goods produced in countries with lax environmental standards has contributed to Third World environmental degradation. Now the U.S. wants to bolster emerging democracies, and encourage international environmental strategies that will promote Latin American security, stability, and sustainability.⁴⁴ Latin American

countries are keenly aware that, while pushing other countries for environmental reform, the United States produces most of the ozone depleting gases.

Latin America produces less than 3 percent of the degrading gases, with two-thirds of that from Brazil and Mexico.⁴⁵ Canada is concerned about the effects of global warming:

"Global warming causes high temperature, droughts, and rises in tide resulting in increased cost of food, water and land. Animals will be either endangered or extinct due to heat, which can destroy or alter habitat. Cities on or close to coasts will be destroyed because of the rise in tide due to melting of icebergs in the North."⁴⁶

On the other hand, the quality of life could be adversely affected by decreased industrialization and decreased use of cars. Canada has been economically affected by two recent major floods and is seeking ways to prevent this trend.⁴⁷ Another issue in Canada is deforestation. The government regulates the harvesting of trees in Canada. For every tree removed the buyer must plant three that thrive for five to ten years.⁴⁸ Canada has temporarily halted the export of drinking water. Previously, water was exported without environmental assessment. Canada will resume water exportation once the government sets specific guidelines.⁴⁹ The debate in Canada, as in most countries, is how much of the budget should be allotted to improve environmental security.

MILITARY IMPLICATIONS OF GLOBAL WARMING

Originally, the U.S. military was concerned the Kyoto Treaty would limit training and thus reduce readiness. That need not be a concern.

"Both multilateral and unilateral operations are protected under the Kyoto Protocol. When our military forces conduct or train for operations overseas, the greenhouse gases do not count against U.S. limits for several reasons. First, under the Kyoto agreement, emissions count against the country in which they occur (in unilateral and multilateral training and operations). Second, the Kyoto agreement exempts military emissions in international airspace and on high seas (in unilateral and multilateral training and operations). Third, the Kyoto agreement exempts emissions from multilateral military operations."⁵⁰

The Federal Government is the largest energy user in the United States. Since the Government spends \$8 billion annually on energy costs, energy efficient technologies are being placed in federal facilities to reduce cost and emissions. Executive Order 12902 requires DOD to reduce energy usage 30 percent between 1985 and 2005. DOD reduced energy expenditures by \$450 million in 1997 and consumed 17 percent less energy than in 1985. Under the Executive Order, DOD must reduce energy use by another 13 percent by 2005.⁵¹

Methods DOD is employing to reach this goal are numerous. The U.S. Army Corps of Engineers has a newly established program, the Defense Energy Support Center, which assists installations in all 50 states, the District of Columbia and Puerto Rico with Energy Savings Performance Contracts (ESPCs). The ESPCs will require minimal funds to decrease energy expenditures. DOD is using equipment and materials that are in the top 25 percent of energy efficiency. Solar sources are being installed to heat water in 652 family housing units in Fiscal Year 1999. Future building projects will use energy efficient designs, proven to reduce energy use 30 to 50 percent with minimal implementation costs. These efforts by DOD will lower costs, enhance military readiness, and reduce emission of greenhouse gases.⁵²

Increased flooding and natural disasters have a destabilizing effect on foreign countries. The size of the area destroyed directly affects the response of the host nation. If agricultural areas and/or jobs are lost, there tends to be migration to another area or country for food and jobs. This can result in instability, which may require U.S. military intervention to resolve. Changing climate can lead to increased flooding and fires, which will increase the need for humanitarian assistance, often involving the U.S. military.

The effect of global warming on the health of soldiers and future recruits is a concern. Asthma is a condition that disqualifies individuals for military service.⁵³ Global warming has been accompanied by a rise in

childhood asthma, because the higher temperatures increase pollution and smog.⁵⁴ Continued rising temperatures will only worsen existing conditions and create new cases of respiratory illnesses.

The current generation of children has been exposed to a more toxic environment than children in the past. This environmental exposure is thought to be responsible for a rise in chronic illnesses.⁵⁵ The Environmental Protection Agency has published a report on plans to protect children from environmental threats:

*"Throughout the world, children face significant threats from an array of environmental hazards. They may absorb some pollutants more rapidly and eat more foods, drink more liquids and breathe more air in proportion to body weight than the typical adult. Their neurological, immunological, reproductive, digestive, and other bodily systems are still developing, providing windows of vulnerability for adverse effects. Children are less able to recognize and protect themselves from exposure to environmental pollutants, and childhood activities put them in closer contact with environmental hazards. By virtue of their youth, children exposed to environmental pollutants have a long period during which latent effects may become manifest."*⁵⁶

The Army is required to comply with environmental statutes, to include:

- Installation, operation, and maintenance of air and water pollution control technology.
- Quantitative and qualitative limitations on air and water emissions.
- Pollution monitoring, record keeping, and reporting requirements.
- Operating permits for pollution sources and the payment of reasonable permit fees.
- Handling, transportation, storage, treatment, and disposal of solid waste and hazardous waste.
- Reporting and cleanup of spills.
- Monitoring underground storage tanks for leaks.
- Noise control.
- Cleanup of active and closed hazardous waste disposal sites
- Conservation of endangered and threatened species and wetlands.⁵⁷

In 1990, legislation was passed stating that environmental protection is the "primary mission in the planning, design, construction, operating and maintenance of water sources projects—along with navigation and flood control."⁵⁸ This legislation expanded the role of the Corps of Engineers. The Corps is responsible "for restoration of fish and wildlife habitat, by including mitigation in the design of all its projects, by protecting environmental assistance, such as wetlands through its regulatory program, and by its program of environmental compliance at Civil Works project sites."⁵⁹

CONCLUSIONS

Environmental issues are an increasing U.S. priority because of recognition that the quality of the environment affects the quality of life. The 1998 National Security Strategy devoted four times more space to environmental security than did the previous year.⁶⁰ The domestic and global environmental goals of the Clinton Administration are far-reaching. Meeting these goals will positively affect American and global societies. Economic downturns could weaken funding for the environment. However, investments to reduce global warming will bring long-term benefits to human lives and the economy. Clinton will propose a \$4 billion environmental budget for Fiscal Year 2000—\$200 million dedicated to a "clean air partnership" to reduce greenhouse gases caused mainly by the production of CO₂ from burning fossil fuels.⁶¹ Much of the proposed budget, over \$1.4

billion, will provide tax incentives for developing energy efficient technology. Vice President Gore says these funds "help protect public health."⁶² The administration must justify the requested funds necessary to achieve its goals.

As a senator, Gore wrote in 1992 of the complexity of solving global environmental concerns. He suggested the need for a "Global Marshall Plan," referring to the 1947 European Recovery Program that Marshall and Truman wrote to help rebuild Western Europe and thwart communist expansion. Gore suggested six strategic goals to accomplish this:

- stabilizing the world's population
- rapidly creating and developing environmentally appropriate technologies
- comprehensively changing the economic rules by which we measure the impact of our decisions on the environment
- negotiating and approving a new generation of international agreements to decrease global warming
- educating the world's citizens about the global environment
- establishing social and political conditions in the developing world conducive to the emergence of sustainable societies⁶³

Some of the goals are more achievable than others. World population is predicted to continue to grow. Fortunately, technologies are being developed to utilize cleaner fuel systems. Agreements to share energy technology and other efforts to reduce global warming could be made at international conferences. The Kyoto Protocol is an initial effort; China and India may sign if they can realize economic and environmental benefits. There is a need to educate the world on environmental concerns. As the following cartoon shows, not all Americans are enlightened on the subject.

In 1992, Gore blamed consumers for destroying the Earth and wanted the developed countries to implement radical lifestyle changes. Since the 1997 Kyoto Conference, the emerging theme has switched from changing lifestyle to leveraging technology. This appears to be more palatable to society.⁶⁵

In Environmental Gore, a group of experts in various fields evaluated, praised and criticized Vice President Gore's views on environmental improvements. Economists and scientists agree greenhouse gases are degrading the environment, but recommend less costly methods to decrease emissions. They recommend academic and analytical solutions, not just political ones.⁶⁶ Perhaps these experts could be assembled to develop Gore's environmental "Marshall Plan." Both political parties should be represented for mutual agreement on the ends, ways, and means to solve the problem.

The Army Corps of Engineers could work jointly with developing nations to make waterways less susceptible to flooding; and to rebuild roads, schools, and health clinics. Initially, the focus of the military should be in Brazil and Mexico, the leading Latin American contributors to global warming. Goals could include decreasing CFC gases, reforestation, and teaching hazardous waste management.

Finally, the U.S. military should become a leader in compliance with federal, state, and local environmental laws. DOD and experts in the field of environmental security should work together to ensure that specific and mutual goals support the best interests of the United States. More specific goals (the ends) need to be outlined by the Department of Defense to give better guidance (the ways) for what the Army needs to accomplish in the future. The DOD should provide a budget (the means) for the Army to accomplish the environmental mission. By supporting environmental issues, the military could be used in preventive roles that are less costly than reconstruction and reconstitution.

With a decrease in global warming there would be less pollution-induced disease. Military medicine could focus more on preventing rather than treating diseases. Engineer units could assist in constructing adequate roads, bridges, schools, and health clinics, rather than reconstruction during crisis management. The long-term goal is for the U.S. to be a leader in global environmental stability, so the U.S. can concentrate more efforts on domestic issues.

Most do not view global warming as a military issue, but global warming and other environmental issues have important implications for the U.S. military. As the United States leadership in environmental matters encourages global stability, the U.S. military will be able to focus more on readiness, training, and operations.

ENDNOTES

1 White House, A National Security Strategy for a New Century, (Washington: U.S. Government Printing Office, October 1998), 13-14.

2 "White House Climate Control Fact Sheet," June 1998; available from <http://www.usai.gov/topical/global/environ/whfct698.htm>; Internet; accessed 8 October 1998.

3 Ibid.

4 Rafe Pomerance, "Testimony on Ozone Depletion USIS," 25 January 1996; available from <<http://usai.gov/topical/global/environ/promerance.htm>>; Internet; accessed 8 October 1998.

5 Astrid Zwick. "Global Climate Change: Potential impact on Human Health

6 "White House Climate Control Fact Sheet," June 1998.

7 Richard Hillmand, Understanding Contemporary Latin America (Boulder, London: Lynne Rienner Publishers, 1997), 198.

8 Jim Fuller, "Global Warming: The Consequences for life on Earth;" April 1997

9 "Venus Facts;" available from <<http://202.102.153/collect/sun/Venus/HTML/index.html>>; Accessed 5 April 1999.

10 Fuller.

11 Timothy Wirth. "Why We Should Care," April 1997; available from <<http://www.usai.gov/journals/itgiic/047/ijge/gj-4.htm>>; Internet; accessed 8 October 1998.

12 "EPA Global Warming: Impacts-Health," 24 January 1999; available from <<http://www.epa.gov/oppoel/globalwarming/impacts/health/index.html>>; Internet; accessed 19 April 1999.

13 "Social and Economic Effects of Global Warming," available from <<http://www.chem.cm.edu/courses/chem105/projects/group1/page1/html>>; Internet; accessed 24 February 1999.

14 "Heat Wave Grips Much of United States," 26 June 1998; available from <<http://www.crosswalk.com/reuters/nefile5.htm>>; Internet; accessed 17 March 1999.

15 Judith Randal, "A Paradise for Pathogens-Almost Everywhere," November 1996; available from <<http://www.usai.gov/journals/itgc/1196/itje/gi-4.htm>>; Internet; accessed 8 October 1998.

16 Ibid.

17 Mark Moran, "Genetic Engineering Advances Now Targeting Malaria Bugs," *Health and Science* 42 (February 1999): 35-37.

18 Patrick Mazza, "Going to Blazes," 7 July 1998; available from <wysiwyg://11/http://bsd.motherjones.com/news/wire/mazza.html>; Internet; accessed 15 March 1999.

19 Zwick.

20 Wirth.

21 John L. Peterson, *The Road to 2015: Profiles of the Future*. (Corte Madera, CA: Waite Group Press: 1994), 82.

22 David Newton, *Global Warming* (Santa Barbara, CA: ABC-CLIO, 1993), 147.

23 Hillmand, 200.

24 Thomas J. Lovejoy, "Biodiversity: The Most Fundamental Issue," 1 March 1994; available from <<http://www.erin.gov.au/portfolio/esd/biodiv/articles/lovejoy.html>>; Internet; accessed 7 October 1998.

25 "Can Economics Save Suriname Rainforest?" 7 April 1998; available from <<http://www.ennccom/news/enn-stories?1998/04/040798/suriname.asp>>; Internet; accessed 10 May 1999.

26 "White House Climate Change Fact Sheet," June 1998.

27 R. James Caverly, Office of Science and Technology Policy, U.S. Department of Energy, PowerPoint® briefing slides provided during interview by author 26 March 1999, Carlisle, PA.

28 Cable News Network Broadcast, 12 March 1999.

29 Cable News Network Broadcast, 23 April 1999.

30 Michael Tebo, "U.S. Signs Kyoto Protocol," 12 November 1998; available from <<http://www.weathervane.rff.org/negotiable/US%20signs.html>>; Internet; accessed 5 April 1999.

31 Hillmand, 200.

32 Tebo.

33 Caverly.

34 Ibid.

35 Ibid.

36 Ibid.

37 Ibid.

38 John A. Baden, *Environmental Gore* (San Francisco: Pacific Research Institute for Public Policy, 1994), 197-198.

39 Kent H. Butts, United States Army War College George C. Marshall Professor of Military Studies, interview by author, 29 March 1999, Carlisle, PA.

40 Hillmand, 200.

41 Ibid.

42 William R. Cline, Global Warming: The Economic Stakes (Washington: Institute for International Economics, 1992), 49.

43 Peterson, 220-221.

44 L. Erik Kjønnerud, Evolving U.S. Strategy for Latin America and the Caribbean: Mutual Hemisphere Concern and opportunities for the 1990's (Washington: National Defense University Press, 1992), 116-117.

45 Hillmand, 200.

46 "Canada: What We've Learned"; available from <<http://www.hisurf.con/~lena/global/learned.html>>; Internet; accessed 9 March 1999.

47 Ibid.

48 COL Glenn Nordick, Canadian Forces, interview by author, 9 March 1999, Carlisle, PA.

49 Ibid.

50 Sherry W. Goodman, "Kyoto Treaty Doesn't Compromise Our National Security," 6 June 1998; Available from <<http://www.denix.osd.mil/denix/Public/News/OSD/Climate/washtime.s.html>>; Internet; accessed 24 February 1999.

51 Ibid.

52 Ibid.

53 Department of the Army, Standards of Medical Fitness, Army Regulation 40-501 (Washington, D.C.: U.S. Department of the Army, 30 August 1995), 9.

54 Zwick.

55 "Earth Link: March/April 1997;" available from <<http://www.epa.gov/earlinkl/earthlink/97marapr.htm>>; Internet; accessed 28 October 1998.

56 Ibid.

57 How the Army Runs: A Senior Leader Reference Handbook, (Carlisle Barracks, PA: U.S. Army War College, 1997) 21-7,21-8.

58 Ibid.

59 Ibid.

60 National Security Strategy, 13-14.

61 "Clinton Wants \$4 Billion to Fight Global Warming," Carlisle (PA) Sentinel 26 January 1999, sec. A, p.3.

62 Ibid.

63 Senator Al Gore, *Earth in the Balance: Ecology and the Human Spirit* (Boston, New York, London: Houghton Mifflin Company, 1992) 305-307.

64 MacNelly, International Herald Tribune (political cartoon), 19 December 1997.

65 Caverly, Baden, xv-xvi.

BIBLIOGRAPHY

Baden, John A. *Environmental Gore: A Constructive Response to Earth in the Balance*. San Francisco: Pacific Research Institute for Public Policy, 1994.

Butts, Kent H., George C. Marshall Professor of Military Studies, United States Army War College. Interview by author, 29 March 1999, Carlisle, PA.

Cable News Network, 19 March 1999.

Cable News Network, 23 March 1999.

"Canada: What We've Learned." Available from <<http://www.hisurf.conn/~lena/global/learned.html>>. Internet. Accessed 9 March 1999.

"Can Economics Save Suriname Rainforest?" 7 April 1998. Available from <<http://www.ennc.com/news/enn-stories?1998/04/040798/suriname.asp>>. Internet. Accessed 10 May 1999.

Caverly, R. James, Office of Science and Technology Policy, U.S. Department of Energy, PowerPoint® slides provided during interview by author 26 March 1999, Carlisle, PA.

Cline, William R. *Global Warming: The Economic Stakes*. Washington, D.C.: Institute for International Economics, 1992.

"Clinton Wants \$4 billion to fight Global Warming," Carlisle (PA) Sentinel, 26 January 1999, sec. A, p.3.

"Earth Link: March/April 1997." Available from <<http://www.epa.gov/earlinkl/earthlink/97marapr.htm>>. Internet. Accessed 28 October 1998.

"EPA Global Warming: Impacts—Health." Updated 24 January, 1999. Available from <http://www.epa.gov/oppoeeel/global_warming/impacts/health/index.html>. Internet. Accessed 19 April 1999.

Fuller, Jim "Global Warming: The Consequences for Life on Earth." April 1997. Available from <<http://www.usai.gov.journals/itge/gi-3.htm>>. Internet. Accessed 8 October 1998.

Goodman, Sherry W. "Kyoto Treaty Doesn't Compromise Our National Security." 6 June 1998. Available from <http://www.denix.osd.mil/denix/Public/News70SD/Climate/wash_times.html>. Internet. Accessed 24 February 1999.

Gore, Al. *Earth in the Balance: Ecology and the Human Spirit*. Boston, New York, London: Houghton Mifflin Company, 1992.

How the Army Runs: A Senior Leader Reference Handbook. Carlisle, PA: U.S. Army War College, 1997.

"Heat Wave Grips Much of United States." 26 June 1998. Available from <<http://www.crosswalk.com/reuters/nefile5.htm>>. Internet. Accessed 17 March 1999.

Hillmand, Richard S. Understanding Contemporary Latin America. Boulder, London: Lynne Rienner Publishers, 1997.

Kjonnerof, L. Erik. Evolving U.S. Strategy for Latin America and the Caribbean: Mutual Hemispheric Concerns and Opportunities for the 1990's. Washington, National Defense University Press, Fort Lesley J. McNair, 1992.

Lovejoy, Thomas J. "Biodiversity: The Most Fundamental Issue." 1 March 1994. Available from <<http://www.erin.gov.au/portfolio/esd/biodiv/articles/lovejoy.html>>. Internet. Accessed 7 October 1998.

MacNelly. "International Herald Tribune." Political Cartoon. 19 December 1997.

Mazza, Patrick. "Going to Blazes." 7 July 1998. Available from <<http://wysiwyg://11/http://bsd.motherjones.com/news/wire/mazza.htm>>. Internet. Accessed 15 March 1999.

Moran, Mark. "Genetic Engineering Advances Now Targeting Malaria Bugs." Health and Science. Vol.42, no.822. February 1999: 35-37.

Newton, David E. Global Warming: A Reference Handbook. Santa Barbara: Instructional Horizon, Inc., 1993.

Nordick, Glen, Colonel, Canadian Forces. Interview by author, 9 March 1999, Carlisle, PA.

Petersen, John L. The Road to 2015: Profiles of the Future. Corte Madera: Waite Group Press, 1994.

Pomerance, Rafe, "Testimony on Ozone Depletion USIS." 25 January 1996. Available from <<http://www.usai.gov/topical/global/environment/pomerance.htm>> Internet. Accessed 8 October 1998.

Randal, Judith. "A Paradise for Pathogens—Almost Everywhere," November 1996.

"Social and Economic Effects of Global Warming." Available from <<http://www.chem.cm.edu/courses/chem105/projects/group1/page1.html>>. Internet. Accessed 24 February 1999.

Tebo, Michael. "U.S. Signs Kyoto Protocol." 12 November 1998. Available from <<http://www.weathervane.rff.org/negotiable/US%20signs.html>>. Internet. Accessed 5 April 1999.

U.S. Department of the Army. Standards of Medical Fitness. Army Regulation 40-501. Washington, D.C.: U.S. Department of the Army, 30 August 1995.

"Venus Facts." Available from <<http://202.102.153/collect/sun/Venus/HTML/index.html>>. Accessed 5 April 1999.

White House, A National Security Strategy for a New Century, (Washington: U.S. Government Printing Office, October 1998), 13-14 .

"White House Climate Control Fact Sheet." June 1998. Available from <<http://www.usai.gov/topical/global/environment/whfct698.htm>>. Internet. Accessed 8 October 1998.

Wirth, Timothy. "Why We Should Care." April 1997. Available from <<http://www.kusaiii.gov.journals/itgiic/047/ijge/gj-4.htm>>. Internet. Accessed 8 October 1998.

Zwick. "Global Climate Change: Potential Impact on Human Health."

BY

LIEUTENANT COLONEL PATRICE E. GREENE

United States Army

USAWC CLASS OF 1999

U.S. ARMY WAR COLLEGE

CARLISLE RARRACKS, PA 17013-5050

USAWC STRATEGY RESEARCH PROJECT

DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

Colonel Cloyd B. Gatrell

Project Advisor

The views expressed in this academic research paper are those of the author and do not necessarily reflect the official policy or position of the U.S. Government, the Department of Defense, or any of its agencies.

* * * * *

2015 Worldwide Threat Assessment of the U.S. Intelligence Community

Senate Armed Services Committee

James R. Clapper

Director of National Intelligence

February 26, 2015

INTRODUCTION

Chairman McCain, Ranking Member Reed, Members of the Committee, thank you for the invitation to offer the United States Intelligence Community's 2015 assessment of threats to US national security. My statement reflects the collective insights of the Intelligence Community's extraordinary men and women, whom I am privileged and honored to lead. We in the Intelligence Community are committed every day to provide the nuanced, multidisciplinary intelligence that policymakers, warfighters, and domestic law enforcement personnel need to protect American lives and America's interests anywhere in the world. Information available as of February 13, 2015 was used in the preparation of this assessment.

* * * * *

GLOBAL THREATS

Cyber * Counterintelligence * Terrorism * Weapons of Mass Destruction and Proliferation * Space and Counterspace * Transnational Organized Crime * Economics and Natural Resources * Human Security

REGIONAL THREATS

Middle East and North Africa * Iraq * Syria * Islamic State of Iraq and the Levant * Iran * Libya * Yemen * Lebanon * Egypt * Tunisia * Europe * Turkey * Key Partners * Russia and Eurasia * Russia * Ukraine, Moldova, and Belarus * The Caucasus and Central Asia * East Asia * China * North Korea * South Asia * Afghanistan * Pakistan * India * Sub-Saharan Africa * West Africa * Sudan * South Sudan * Nigeria * Somalia * Lord's Resistance Army * Central African Republic * The Sahel * Latin America and the Caribbean * Cuba * Central America * Venezuela * Haiti

GLOBAL THREATS

CYBER

Strategic Assessment

Cyber threats to US national and economic security are increasing in frequency, scale, sophistication, and severity of impact. The ranges of cyber threat actors, methods of attack, targeted systems, and victims are also expanding. Overall, the unclassified information and communication technology (ICT) networks that support US Government, military, commercial, and social activities remain vulnerable to espionage and/or disruption. However, the likelihood of a catastrophic attack from any particular actor is remote at this time. Rather than a "Cyber Armageddon" scenario that debilitates the entire US infrastructure, we envision something different. We foresee an ongoing series of low-to-moderate level cyber attacks from a variety of sources over time, which will impose cumulative costs on US economic competitiveness and national security.

- A growing number of computer forensic studies by industry experts strongly suggest that several nations—including Iran and North Korea—have undertaken offensive cyber operations against private sector targets to support their economic and foreign policy objectives, at times concurrent with political crises.

Risk. Despite ever-improving network defenses, the diverse possibilities for remote hacking intrusions, supply chain operations to insert compromised hardware or software, and malevolent activities by human insiders will hold nearly all ICT systems at risk for years to come. In short, the cyber threat cannot be eliminated; rather, cyber risk must be managed. Moreover, the risk calculus employed by some private sector entities does not adequately account for foreign cyber threats or the systemic interdependencies between different critical infrastructure sectors.

Costs. During 2014, we saw an increase in the scale and scope of reporting on malevolent cyber activity that can be measured by the amount of corporate data stolen or deleted, personally identifiable information (PII) compromised, or remediation costs incurred by US victims. For example:

- After the 2012-13 distributed denial of service (DDOS) attacks on the US financial sector, JPMorgan Chase (JPMorgan) announced plans for annual cyber security expenditures of \$250 million by the end of 2014. After the company suffered a hacking intrusion in 2014, JPMorgan's CEO said he would probably double JPMorgan's annual computer security budget within the next five years.
- The 2014 data breach at Home Depot exposed information from 56 million credit/debit cards and 53 million customer email addresses. Home Depot estimated the cost of the breach to be \$62 million.

- In 2014, unauthorized computer intrusions were detected on the networks of the Office of Personnel Management (OPM) as well as its contractors, US Investigations Services (USIS) and KeyPoint Government Solutions. The two contractors were involved in processing sensitive PI I related to national security clearances for Federal Government employees.

- In August 2014, the US company, Community Health Systems, informed the Securities and Exchange Commission that it believed hackers "originating from China" had stolen PII on 4.5 million individuals.

Attribution. Although cyber operators can infiltrate or disrupt targeted ICT networks, most can no longer assume that their activities will remain undetected. Nor can they assume that if detected, they will be able to conceal their identities. Governmental and private sector security professionals have made significant advances in detecting and attributing cyber intrusions.

- In May 2014, the US Department of Justice indicted five officers from China's Peoples' Liberation Army on charges of hacking US companies.

- In December 2014, computer security experts reported that members of an Iranian organization were responsible for computer operations targeting US military, transportation, public utility, and other critical infrastructure networks.

Deterrence. Numerous actors remain undeterred from conducting economic cyber espionage or perpetrating cyber attacks. The absence of universally accepted and enforceable norms of behavior in cyberspace has contributed to this situation. The motivation to conduct cyber attacks and cyber espionage will probably remain strong because of the relative ease of these operations and the gains they bring to the perpetrators. The result is a cyber environment in which multiple actors continue to test their adversaries' technical capabilities, political resolve, and thresholds. The muted response by most victims to cyber attacks has created a permissive environment in which low-level attacks can be used as a coercive tool short of war, with relatively low risk of retaliation. Additionally, even when a cyber attack can be attributed to a specific actor, the forensic attribution often requires a significant amount of time to complete. Long delays between the cyber attack and determination of attribution likewise reinforce a permissive environment.

Threat Actors

Politically motivated cyber attacks are now a growing reality, and foreign actors are reconnoitering and developing access to US critical infrastructure systems, which might be quickly exploited for disruption if an adversary's intent became hostile. In addition, those conducting cyber espionage are targeting US government, military, and commercial networks on a daily basis. These threats come from a range of actors, including: (1) nation states with highly sophisticated cyber programs (such as Russia or China), (2) nations with lesser technical capabilities but possibly more disruptive intent (such as Iran or North Korea), (3) profit-motivated criminals, and (4) ideologically motivated hackers or extremists. Distinguishing between state and non-state actors within the same country is often difficult—especially when those varied actors actively collaborate, tacitly cooperate, condone criminal activity that only harms foreign victims, or utilize similar cyber tools.

Russia. Russia's Ministry of Defense is establishing its own cyber command, which—according to senior Russian military officials—will be responsible for conducting offensive cyber activities, including propaganda operations and inserting malware into enemy command and control systems. Russia's armed forces are also establishing a specialized branch for computer network operations.

- Computer security studies assert that unspecified Russian cyber actors are developing means to access industrial control systems (ICS) remotely. These systems manage critical infrastructures such as electric power grids, urban mass-transit systems, air-traffic control, and oil and gas distribution networks. These unspecified Russian actors have successfully compromised the product supply chains of three ICS vendors so that customers download exploitative malware directly from the vendors' websites along with routine software updates, according to private sector cyber security experts.

China. Chinese economic espionage against US companies remains a significant issue. The "advanced persistent threat" activities continue despite detailed private sector reports, public indictments, and US demarches, according to a computer security study. China is an advanced cyber actor; however, Chinese hackers often use less sophisticated cyber tools to access targets. Improved cyber defenses would require hackers to use more sophisticated skills and make China's economic espionage more costly and difficult to conduct.

Iran. Iran very likely values its cyber program as one of many tools for carrying out asymmetric but proportional retaliation against political foes, as well as a sophisticated means of collecting intelligence. Iranian actors have been implicated in the 2012-13 DDOS attacks against US financial institutions and in the February 2014 cyber attack on the Las Vegas Sands casino company.

North Korea. North Korea is another state actor that uses its cyber capabilities for political objectives. The North Korean Government was responsible for the November 2014 cyber attack on Sony Pictures Entertainment (SPE), which stole corporate information and introduced hard drive erasing malware into the company's network infrastructure, according to the FBI. This attack coincided with the planned release of a SPE feature film satire that depicted the planned assassination of the North Korean president.

Terrorists. Terrorist groups will continue to experiment with hacking, which could serve as the foundation for developing more advanced capabilities. Terrorist sympathizers will probably conduct low-level cyber attacks on behalf of terrorist groups and attract attention of the media, which might exaggerate the capabilities and threat posed by these actors.

Integrity of Information

Most of the public discussion regarding cyber threats has focused on the confidentiality and availability of information; cyber espionage undermines confidentiality, whereas denial-of-service operations and data-deletion attacks undermine availability. In the future, however, *e might also see more cyber operations that will change or manipulate electronic information in order to compromise its integrity (i.e. accuracy and reliability) instead of deleting it or disrupting access to it. Decisionmaking by senior government officials (civilian and military), corporate executives, investors, or others will be impaired if they cannot trust the information they are receiving.

- Successful cyber operations targeting the integrity of information would need to overcome any institutionalized checks and balances designed to prevent the manipulation of data, for example, market monitoring and clearing functions in the financial sector.

COUNTERINTELLIGENCE

We assess that the leading state intelligence threats to US interests in 2015 will continue to be Russia and China, based on their capabilities, intent, and broad operational scopes. Other states in South Asia, the Near East, and East Asia will pose increasingly sophisticated local and regional intelligence threats to US interests. For example, Iran's intelligence and security services continue to view the United States as a primary threat and have stated publicly that they monitor and counter US activities in the region.

Penetrating the US national decisionmaking apparatus and Intelligence Community will remain primary objectives for foreign intelligence entities. Additionally, the targeting of national security information and proprietary information from US companies and research institutions dealing with defense, energy, finance, dual-use technology, and other areas will be a persistent threat to US interests.

Non-state entities, including transnational organized criminals and terrorists, will continue to employ human, technical, and cyber intelligence capabilities that present a significant counterintelligence challenge. Like state intelligence services, these non-state entities recruit sources and perform physical and technical surveillance to facilitate their illegal activities and avoid detection and capture.

The internationalization of critical US supply chains and service infrastructure, including for the ICT, civil infrastructure, and national security sectors, increases the potential for subversion. This threat includes individuals,

small groups of "hacktivists," commercial firms, and state intelligence services.

Trusted insiders who disclose sensitive US Government information without authorization will remain a significant threat in 2015. The technical sophistication and availability of information technology that can be used for nefarious purposes exacerbates this threat.

TERRORISM

Sunni violent extremists are gaining momentum and the number of Sunni violent extremist groups, members, and safe havens is greater than at any other point in history. These groups challenge local and regional governance and threaten US allies, partners, and interests. The threat to key US allies and partners will probably increase, but the extent of the increase will depend on the level of success that Sunni violent extremists achieve in seizing and holding territory whether or not attacks on local regimes and calls for retaliation against the West are accepted by their key audiences, and the durability of the US-led coalition in Iraq and Syria.

Sunni violent extremists have taken advantage of fragile or unstable Muslim-majority countries to make territorial advances, seen in Syria and Iraq, and will probably continue to do so. They also contribute to regime instability and internal conflict by engaging in high levels of violence. Most will be unable to seize and hold territory on a large scale, however, as long as local, regional, and international support and resources are available and dedicated to halting their progress. The increase in the number of Sunni violent extremist groups also will probably be balanced by a lack of cohesion and authoritative leadership. Although the January 2015 attacks against Charlie Hebdo in Paris is a reminder of the threat to the West, most groups place a higher priority on local concerns than on attacking the so-called far enemy—the United States and the West—as advocated by core al- Qa'ida.

Differences in ideology and tactics will foster competition among some of these groups, particularly if a unifying figure or group does not emerge. In some cases, groups—even if hostile to each other—will ally against common enemies. For example, some Sunni violent extremists will probably gain support from like-minded insurgent or anti-regime groups or within disaffected or disenfranchised communities because they share the goal of radical regime change.

Although most homegrown violent extremists (HVEs) will probably continue to aspire to travel overseas, particularly to Syria and Iraq, they will probably remain the most likely Sunni violent extremist threat to the US homeland because of their immediate and direct access. Some might have been inspired by calls by the Islamic State of Iraq and the Levant (ISIL) in late September for individual jihadists in the West to retaliate for US-led airstrikes on ISIL. Attacks by lone actors are among the most difficult to warn about because they offer few or no signatures.

If ISIL were to substantially increase the priority it places on attacking the West rather than fighting to maintain and expand territorial control, then the group's access to radicalized Westerners who have fought in Syria and Iraq would provide a pool of operatives who potentially have access to the United States and other Western countries. Since the conflict began in 2011, more than 20,000 foreign fighters—at least 3,400 of whom are Westerners—have gone to Syria from more than 90 countries.

WEAPONS OF MASS DESTRUCTION AND PROLIFERATION

Nation-states' efforts to develop or acquire weapons of mass destruction (WMD), their delivery systems, or their underlying technologies constitute a major threat to the security of the United States, its deployed troops, and allies. Syrian regime use of chemical weapons against the opposition further demonstrates that the threat of WMD is real. The time when only a few states had access to the most dangerous technologies is past. Biological and chemical materials and technologies, almost always dual-use, move easily in the globalized economy, as do personnel with the scientific expertise to design and use them. The latest discoveries in the life sciences also diffuse rapidly around the globe.

Iran Preserving Nuclear Weapons Option

We continue to assess that Iran's overarching strategic goals of enhancing its security, prestige, and regional influence have led it to pursue capabilities to meet its civilian goals and give it the ability to build missile-deliverable nuclear weapons, if it chooses to do so. We do not know whether Iran will eventually decide to build nuclear weapons.

We also continue to assess that Iran does not face any insurmountable technical barriers to producing a nuclear weapon, making Iran's political will the central issue. However, Iranian implementation of the Joint Plan of Action (JPOA) has at least temporarily inhibited further progress in its uranium enrichment and plutonium production capabilities and effectively eliminated Iran's stockpile of 20 percent enriched uranium. The agreement has also enhanced the transparency of Iran's nuclear activities, mainly through improved International Atomic Energy Agency (IAEA) access and earlier warning of any effort to make material for nuclear weapons using its safeguarded facilities.

We judge that Tehran would choose ballistic missiles as its preferred method of delivering nuclear weapons, if it builds them. Iran's ballistic missiles are inherently capable of delivering WMD, and Tehran already has the largest inventory of ballistic missiles in the Middle East. Iran's progress on space launch vehicles—along with its desire to deter the United States and its allies—provides Tehran with the means and motivation to develop longer-range missiles, including intercontinental ballistic missiles (ICBMs).

North Korea Developing WMD-Applicable Capabilities

North Korea's nuclear weapons and missile programs pose a serious threat to the United States and to the security environment in East Asia. North Korea's export of ballistic missiles and associated materials to several countries, including Iran and Syria, and its assistance² to Syria's construction of a nuclear reactor, destroyed in 2007, illustrate its willingness to proliferate dangerous technologies.

In 2013, following North Korea's third nuclear test, Pyongyang announced its intention to "refurbish and restart" its nuclear facilities, to include the uranium enrichment facility at Yongbyon, and to restart its graphite-moderated plutonium production reactor that was shut down in 2007. We assess that North Korea has followed through on its announcement by expanding its Yongbyon enrichment facility and restarting the reactor.

North Korea has also expanded the size and sophistication of its ballistic missile forces, ranging from close-range ballistic missiles to ICBMs, while continuing to conduct test launches. In 2014, North Korea launched an unprecedented number of ballistic missiles.

Pyongyang is committed to developing a long-range, nuclear-armed missile that is capable of posing a direct threat to the United States and has publicly displayed its <N08 road-mobile ICBM twice. We assess that North Korea has already taken initial steps toward fielding this system, although the system has not been flight-tested.

Because of deficiencies in their conventional military forces, North Korean leaders are focused on developing missile and WMD capabilities, particularly building nuclear weapons. Although North Korean state media regularly carries official statements on North Korea's justification for building nuclear weapons and threatening to use them as a defensive or retaliatory measure, we do not know the details of Pyongyang's nuclear doctrine or employment concepts. We have long assessed that, in Pyongyang's view, its nuclear capabilities are intended for deterrence, international prestige, and coercive diplomacy.

China's Expanding Nuclear Forces

The People's Liberation Army's (PLA's) Second Artillery Force continues to modernize its nuclear missile force by adding more survivable road-mobile systems and enhancing its silo-based systems. This new generation of missiles is intended to ensure the viability of China's strategic deterrent by providing a second strike capability. In addition, the PLA Navy continues to develop the JL-2 submarine-launched ballistic missile (SLBM) and might produce additional JIN-class nuclear-powered ballistic missile submarines. The JIN-class submarines, armed with

JL-2 SLBMs, will give the PLA Navy its first long-range, sea-based nuclear capability. We assess that the Navy will soon conduct its first nuclear deterrence patrols.

Russia's New Intermediate-Range Cruise Missile

Russia has developed a new cruise missile that the United States has declared to be in violation of the Intermediate-Range Nuclear Forces (INF) Treaty. In 2013, Sergei Ivanov, a senior Russian administration official, commented in an interview how the world had changed since the time the INF Treaty was signed 1987 and noted that Russia was "developing appropriate weapons systems" in light of the proliferation of intermediate- and shorter-range ballistic missile technologies around the world. Similarly, as far back as 2007, Ivanov publicly announced that Russia had tested a ground-launched cruise missile for its Iskander weapon system, whose range complied with the INF Treaty "for now." The development of a cruise missile that is inconsistent with INF, combined with these statements about INF, calls into question Russia's commitment to this treaty.

WMD Security in Syria

In June 2014, Syria's declared CW stockpile was removed for destruction by the international community. The most hazardous chemical agents were destroyed aboard the MV CAPE RAY as of August 2014. The United States and its allies continue to work closely with the Organization for the Prohibition of Chemical Weapons (OPCW) to verify the completeness and accuracy of Syria's Chemical Weapons Convention (CWC) declaration. We judge that Syria, despite signing the treaty, has used chemicals as a means of warfare since accession to the CWC in 2013. Furthermore, the OPCW continues to investigate allegations of chlorine use in Syria.

SPACE AND COUNTERSPACE

Threats to US space systems and services will increase during 2015 and beyond as potential adversaries pursue disruptive and destructive counterspace capabilities. Chinese and Russian military leaders understand the unique information advantages afforded by space systems and services and are developing capabilities to deny access in a conflict. Chinese military writings highlight the need to interfere with, damage, and destroy reconnaissance, navigation and communication satellites. China has satellite jamming capabilities and is pursuing antisatellite systems. In July 2014, China conducted a nondestructive antisatellite missile test. China conducted a previous destructive test of the system in 2007, which created long-lived space debris. Russia's 2010 Military Doctrine emphasizes space defense as a vital component of its national defense. Russian leaders openly assert that the Russian armed forces have antisatellite weapons and conduct antisatellite research. Russia has satellite jammers and is pursuing antisatellite systems.

TRANSNATIONAL ORGANIZED CRIME

Transnational Organized Crime (TOC) is a global, persistent threat to our communities at home and our interests abroad. Savvy, profit-driven criminal networks traffic in drugs, persons, wildlife, and weapons; corrode security and governance; undermine legitimate economic activity and the rule of law; cost economies important revenue; and undercut US development efforts.

Drug Trafficking

Drug trafficking will remain a major TOC threat to the United States. Mexico is the largest foreign producer of US-bound marijuana, methamphetamines, and heroin, and the conduit for the overwhelming majority of US-bound cocaine from South America. The drug trade also undermines US interests abroad, eroding stability in parts of Africa and Latin America; Afghanistan accounts for 80 percent of the world's opium production. Weak Central American states will continue to be the primary transit area for the majority of US-bound cocaine. The Caribbean is becoming an increasingly important secondary transit area for US- and European-bound cocaine. In 2013, the world's capacity to produce heroin reached the second highest level in nearly 20 years, increasing the likelihood that the drug will remain accessible and inexpensive in consumer markets in the United States, where heroin-related deaths have surged since 2007. New psychoactive substances (NPS), including synthetic cannabinoids and synthetic cathinones, pose an emerging and rapidly growing global public health threat. Since

2009, US law enforcement officials have encountered more than 240 synthetic compounds. Worldwide, 348 new psychoactive substances had been identified, exceeding the number of 234 illicit substances under international controls.

Criminals Profiting from Global Instability

Transnational criminal organizations will continue to exploit opportunities in ongoing conflicts to destabilize societies, economies, and governance. Regional unrest, population displacements, endemic corruption, and political turmoil will provide openings that criminals will exploit for profit and to improve their standing relative to other power brokers.

Corruption

Corruption facilitates transnational organized crime and vice versa. Both phenomena exacerbate other threats to local, regional, and international security. Corruption exists at some level in all countries; however, the symbiotic relationship between government officials and TOC networks is particularly pernicious in some countries. One example is Russia, where the nexus among organized crime, state actors, and business blurs the distinction between state policy and private gain.

Human Trafficking

Human trafficking remains both a human rights concern and a challenge to international security. Trafficking in persons has become a lucrative source of revenue - estimated to produce tens of billions of dollars annually. Human traffickers leverage corrupt officials, porous borders, and lax enforcement to ply their illicit trade. This exploitation of human lives for profit continues to occur in every country in the world - undermining the rule of law and corroding legitimate institutions of government and commerce.

Wildlife Trafficking

Illicit trade in wildlife, timber, and marine resources endangers the environment, threatens rule of law and border security in fragile regions, and destabilizes communities that depend on wildlife for biodiversity and ecotourism. Increased demand for ivory and rhino horn in Asia has triggered unprecedented increases in poaching in Africa. Criminal elements, often in collusion with corrupt government officials or security forces, are involved in poaching and movement of ivory and rhino horn across Africa. Poaching presents significant security challenges for militaries and police forces in African nations, which often are outgunned by poachers and their allies. Illegal, unreported, and unregulated fishing threatens food security and the preservation of marine resources. It often occurs concurrently with forced labor in the fishing industry.

Theft of Cultural Properties, Artifacts, and Antiquities

Although the theft and trafficking of cultural heritage and art are traditions as old as the cultures they represent, transnational organized criminals are acquiring, transporting, and selling valuable cultural property and art more swiftly, easily, and stealthily. These criminals operate on a global scale without regard for laws, borders, nationalities or the significance of the treasures they smuggle.

ECONOMICS AND NATURAL RESOURCES

The global economy continues to adjust to and recover from the global financial crisis that began in 2008; economic growth since that period is lagging behind that of the previous decade. Resumption of sustained growth has been elusive for many of the world's largest economies, particularly in European countries and Japan. The prospect of diminished or forestalled recoveries in these developed economies as well as disappointing growth in key developing countries has contributed to a readjustment of energy and commodity markets.

Energy and Commodities

Energy prices experienced sharp declines during the second half of 2014. Diminishing global growth prospects, OPEC's decision to maintain its output levels, rapid increases in unconventional oil production in Canada and the United States, and the partial resumption of some previously sidelined output in Libya and elsewhere helped drive down prices by more than half since July, the first substantial decline since 2008-09. Lower-priced oil and gas will give a boost to the global economy, with benefits enjoyed by importers more than outweighing the costs to exporters.

Macroeconomic Stability

Extraordinary monetary policy or "quantitative easing" has helped revive growth in the United States since the global financial crisis. However, this recovery and the prospect of higher returns in the United States will probably continue to draw investment capital from the rest of the world, where weak growth has left interest rates depressed.

Global output improved slightly in 2014 but continued to lag the growth rates seen before 2008. Since 2008, the worldwide GDP growth rate has averaged about 3.2 percent, well below its 20-year, pre-GFC average of 3.9 percent. Looking ahead, prospects for slowing economic growth in Europe and China do not bode well for the global economic environment.

Economic growth has been inconsistent among developed and developing economies alike. Outside of the largest economies—the United States, the EU, and China—economic growth largely stagnated worldwide in 2014, slowing to 2.1 percent. As a result, the difference in growth rates of developing countries and developed countries continued to narrow—to 2.6 percentage points. This gap, smallest in more than a decade, underscores the continued weakness in emerging markets, whose previously much-higher average growth rates helped drive global growth.

HUMAN SECURITY

Critical Trends Converging

Several trends are converging that will probably increase the frequency of shocks to human security in 2015. Emerging infectious diseases and deficiencies in international state preparedness to address them remain a threat, exemplified by the epidemic spread of the Ebola virus in West Africa. Extremes in weather combined with public policies that affect food and water supplies will probably exacerbate humanitarian crises. Many states and international institutions will look to the United States in 2015 for leadership to address human security issues, particularly environment and global health, as well as those caused by poor or abusive governance.

Global trends in governance are negative and portend growing instability. Poor and abusive governance threatens the security and rights of individuals and civil society in many countries throughout the world. The overall risk for mass atrocities—driven in part by increasing social mobilization, violent conflict, and a diminishing quality of governance—is growing. Incidents of religious persecution also are on the rise. Legal restrictions on NGOs and the press, particularly those that expose government shortcomings or lobby for reforms, will probably continue.

Infectious Disease Continues To Threaten Human Security Worldwide

Infectious diseases are among the foremost health security threats. A more crowded and interconnected world is increasing the opportunities for human and animal diseases to emerge and spread globally. This has been demonstrated by the emergence of Ebola in West Africa on an unprecedented scale. In addition, military conflicts and displacement of populations with loss of basic infrastructure can lead to spread of disease. Climate change can also lead to changes in the distribution of vectors for diseases.

- The Ebola outbreak, which began in late 2013 in a remote area of Guinea, quickly spread into neighboring Liberia and Sierra Leone and then into dense urban transportation hubs, where it began spreading out of control. Gaps in disease surveillance and reporting, limited health care resources, and other factors contributed to the

outpacing of the international community's response in West Africa. Isolated Ebola cases appeared outside of the most affected countries—notably in Spain and the United States—and the disease will almost certainly continue in 2015 to threaten regional economic stability, security, and governance.

- Antimicrobial drug resistance is increasingly threatening global health security. Seventy percent of known bacteria have acquired resistance to at least one antibiotic that is used to treat infections, threatening a return to the pre-antibiotic era. Multidrug-resistant tuberculosis has emerged in China, India, Russia, and elsewhere. During the next twenty years antimicrobial drug-resistant pathogens will probably continue to increase in number and geographic scope, worsening health outcomes, straining public health budgets, and harming US interests throughout the world.

- MERS, a novel virus from the same family as SARS, emerged in 2012 in Saudi Arabia. Isolated cases migrated to Southeast Asia, Europe, and the United States. Cases of highly pathogenic influenza are also continuing to appear in different regions of the world. HIV/AIDS and malaria, although trending downward, remain global health priorities. In 2013, 2.1 million people were newly infected with HIV and 584,000 were killed by malaria, according to the World Health Organization. Diarrheal diseases like cholera continue to take the lives of 800,000 children annually.

- The world's population remains vulnerable to infectious diseases because anticipating which pathogen might spread from animals to humans or if a human virus will take a more virulent form is nearly impossible. For example, if a highly pathogenic avian influenza virus like H7N9 were to become easily transmissible among humans, the outcome could be far more disruptive than the great influenza pandemic of 1918. It could lead to global economic losses, the unseating of governments, and disturbance of geopolitical alliances.

Extreme Weather Exacerbating Risks to Global Food and Water Security

Extreme weather, climate change, and public policies that affect food and water supplies will probably create or exacerbate humanitarian crises and instability risks. Globally averaged surface temperature rose approximately 0.8 degrees Celsius (about 1.4 degrees Fahrenheit) from 1951 to 2014; 2014 was warmest on earth since recordkeeping began. This rise in temperature has probably caused an increase in the intensity and frequency of both heavy precipitation and prolonged heat waves and has changed the spread of certain diseases. This trend will probably continue. Demographic and development trends that concentrate people in cities—often along coasts—will compound and amplify the impact of extreme weather and climate change on populations. Countries whose key systems - food, water, energy, shelter, transportation, and medical - are resilient will be better able to avoid significant economic and human losses from extreme weather.

- Global food supplies will probably be adequate for 2015 but are becoming increasingly fragile in Africa, the Middle East, and South Asia. The risks of worsening food insecurity in regions of strategic importance to the United States will increase because of threats to local food availability, lower purchasing power, and counterproductive government policies. Price shocks will result if extreme weather or disease patterns significantly reduce food production in multiple areas of the world, especially in key exporting countries.

- Risks to freshwater supplies—due to shortages, poor quality, floods, and climate change—are growing. These problems hinder the ability of countries to produce food and generate energy, potentially undermining global food markets and hobbling economic growth. Combined with demographic and economic development pressures, such problems will particularly hinder the efforts of North Africa, the Middle East, and South Asia to cope with their water problems. Lack of adequate water might be a destabilizing factor in countries that lack the management mechanisms, financial resources, political will, or technical ability to solve their internal water problems.

- Some states are heavily dependent on river water controlled by upstream nations. When upstream water infrastructure development threatens downstream access to water, states might attempt to exert pressure on their neighbors to preserve their water interests. Such pressure might be applied in international forums and also includes pressing investors, nongovernmental organizations, and donor countries to support or halt water infrastructure projects. Some countries will almost certainly construct and support major water projects. Over the longer term, wealthier developing countries will also probably face increasing water-related social disruptions.

Developing countries, however, are almost certainly capable of addressing water problems without risk of state failure. Terrorist organizations might also increasingly seek to control or degrade water infrastructure to gain revenue or influence populations.

Increase in Global Instability Risk

Global political instability risks will remain high in 2015 and beyond. Mass atrocities, sectarian or religious violence, and curtailed NGO activities will all continue to increase these risks. Declining economic conditions are contributing to risk of instability or internal conflict.

- Roughly half of the world's countries not already experiencing or recovering from instability are in the "most risk" and "significant risk" categories for regime-threatening and violent instability through 2015.
- Overall international will and capability to prevent or mitigate mass atrocities will probably diminish in 2015 owing to reductions in government budgets and spending.
- In 2014, about two dozen countries increased restrictions on NGOs. Approximately another dozen also plan to do so in 2015, according to the International Center for Nonprofit Law.

REGIONAL THREATS

MIDDLE EAST AND NORTH AFRICA

Iraq

Over six months into the coalition campaign against the Islamic State of Iraq and the Levant (ISIL), the frontlines against the group in Iraq have largely stabilized; no side is able to muster the resources necessary to attain its territorial ambitions. The Iraqi Security Forces (ISF), Peshmerga, Shia militants, and a few tribal allies—bolstered by air and artillery strikes, weapons, and advice from the United States, Arab and Western allies, and Iran—have prevented ISIL from gaining large swaths of additional territory.

Sectarian conflict in mixed Shia-Sunni areas in and around Baghdad that can undermine progress against ISIL is growing. ISF and Shia militants are conducting a campaign of retribution killings and forced displacement of Sunni civilians in several areas contested by Sunni militants.

Since taking office, Prime Minister al-Abadi has taken steps to change the ethno-sectarian tone in Baghdad, including engaging Sunni tribal leaders and reaching a tentative oil agreement with the Kurdistan Regional Government. However, the ethnosectarian nature of security operations and persistent distrust among Iraqi leaders risk undermining Abadi's nascent political progress.

Syria

The Syrian regime made consistent gains in 2014 in parts of western Syria that it considers key, retaking ground in eastern Damascus, Horns, and Latakia; it is close to surrounding Aleppo city. The regime will require years to reassert significant control over the country.

- The bulk of the opposition in the north is fighting on three fronts—against the regime, the al-Qa'ida-affiliated Nusra Front, and ISIL. The opposition in the south has made steady gains in areas that the regime has not made a priority and where ISIL has only a limited presence.

The stability of Syria's neighbors is at risk due to the country's prolonged conflict, which will strain regional economies forced to absorb millions of refugees. The conflict will also encourage regional sectarianism and continue to incubate extremist groups that will use Syria as a launching pad for attacks across the Middle East.

- The Syrian conflict is also putting huge economic and resource strains on countries in the region primarily due to the nearly 4 million refugees fleeing the conflict. Most of the refugees have fled to neighboring states. More than 620,000 are in Jordan; almost 1.6 million are in Turkey; almost 1.2 million are in Lebanon; and more than 240,000 are in Iraq. These states have requested additional international support to manage the influx.

Islamic State of Iraq and the Levant

In an attempt to strengthen its self-declared caliphate, ISIL probably plans to conduct operations against regional allies, Western facilities, and personnel in the Middle East; it has already executed Western and Japanese hostages as well as a Jordanian Air Force pilot. ISIL leader Abu Bakr al-Baghdadi outlined the group's ambitious external goals, including the expansion of the caliphate into the Arabian Peninsula and North Africa and attacks against Western, regional, and Shia interests, according to a public statement in November 2014.

- In September 2014, ISIL publicly called on all Sunnis to retaliate for US-led airstrikes in Iraq and Syria, advocating the targeting of law enforcement and other government officials using any means available. Individuals from Europe and North America who have trained and fought with ISIL can return home and conduct attacks either on their own or on ISIL's behalf. The French citizen arrested in May 2014 for a shooting at a Jewish museum in Brussels had returned from fighting, probably with ISIL in Syria, and was wrapped in a flag with ISIL inscriptions when he was apprehended. We do not know whether he acted at ISIL's behest.

Iran

The Islamic Republic of Iran is an ongoing threat to US national interests because of its support to the Asad regime in Syria, promulgation of anti-Israeli policies, development of advanced military capabilities, and pursuit of its nuclear program. President Ruhani—a longstanding member of the regime establishment—will not depart from Iran's national security objectives of protecting the regime and enhancing Iranian influence abroad, even while attempting different approaches to achieve these goals. He requires Supreme Leader Khamenei's support to continue engagement with the West, moderate foreign policy, and ease social restrictions within Iran.

Iran possesses a substantial inventory of theater ballistic missiles capable of reaching as far as some areas of southeastern Europe. Tehran is developing increasingly sophisticated missiles and improving the range and accuracy of its other missile systems. Iran is also acquiring advanced naval and aerospace capabilities, including naval mines, small but capable submarines, coastal defense cruise missile batteries, attack craft, anti-ship missiles, and armed unmanned aerial vehicles.

In Iraq and Syria, Iran seeks to preserve friendly governments, protect Shia interests, defeat Sunni extremists, and marginalize US influence. The rise of ISIL has prompted Iran to devote more resources to blunting Sunni extremist advances that threaten Iran's regional allies and interests. Iran's security services have provided robust military support to Baghdad and Damascus, including arms, advisers, funding, and direct combat support. Both conflicts have allowed Iran to gain valuable on-the-ground experience in counterinsurgency operations. Iranian assistance has been instrumental in expanding the capabilities of Shia militants in Iraq. The ISIL threat has also reduced Iraqi resistance to integrating those militants, with Iranian help, into the Iraqi Security Forces, but Iran has uneven control over these groups.

Despite Iran's intentions to dampen sectarianism, build responsive partners, and deescalate tensions with Saudi Arabia, Iranian leaders—particularly within the security services—are pursuing policies with negative secondary consequences for regional stability and potentially for Iran. Iran's actions to protect and empower Shia communities are fueling growing fears and sectarian responses.

Libya

We assess that Libya will remain volatile in 2015. Political polarization and broadening militia violence have pushed Libya into a civil war. Nearly four years since the evolution that toppled Qadhafi, rival governments have emerged, leaving the country with no clear legitimate political authority or credible security forces. Militias aligned with the rival governments continue to vie for dominance in Tripoli and Benghazi.

- In Benghazi, fighting that began in May 2014 is ongoing between forces aligned with former General Khalifa Hater's Operation Dignity forces and Ansar al-Sharia (AAS) and allied groups. In Tripoli, the Libya Dawn militias have driven their Zintani militia rivals out of the city, but fighting continues southwest of Tripoli.

- UN efforts to facilitate a negotiated resolution between Libya's rival governments have shown limited momentum but as of early February 2015 have not made tangible progress toward a unity government or a durable cease-fire.

Extremists and terrorists from al-Qa'ida-affiliated and allied groups are using Libya's permissive security environment as a safe haven to plot attacks, including against Western interests in Libya and the region. ISIL also has declared the country part of its caliphate, and ISIL-aligned extremists are trying to institute sharia in parts of the country.

Yemen

The Huthis have emerged as the most powerful group in Yemen since taking Sanaa last fall and are poised to dominate the political process after President's Hadi's resignation and their dissolution of the government. The group, however, continues to face resistance as it expands toward the south and east. Southern Yemeni leaders have been alarmed by the Huthi's consolidation of control in Sanaa and are poised to oppose further Huthi expansion south. Al-Qa'ida in the Arabian Peninsula (AQAP) has taken advantage of many Sunni tribes' opposition to Huthi expansion to gain recruits to fight against the Huthis.

Chronic and severe economic and humanitarian problems, exacerbated by repeated pipeline attacks and the Huthis' push to reinstate costly fuel subsidies, will continue to undercut government control and legitimacy. Yemen will probably continue pressuring donor nations to make good on aid pledges while negotiating with tribes outside of Sanaa's control to keep oil exports flowing.

Huthi ascendency in Yemen has increased Iran's influence as well.

Lebanon

Lebanon continues to struggle with spillover from the Syrian conflict, including periodic sectarian violence; terrorist attacks; and the economic, political, and sectarian strain associated with refugees.

- Lebanon faces growing threats from terrorist groups, including the al-Nusrah Front and ISIL. Sunni extremists are trying to establish networks in Lebanon and have increased attacks against Lebanese army and Hezbollah positions along the Lebanese-Syrian border. Lebanon potentially faces a protracted conflict in northern and eastern parts of the country from extremist groups seeking to seize Lebanese territory, supplies, and hostages.

- The presence of over one million mostly Sunni Syrian refugees in Lebanon, which has a population of only 4.1 million, has significantly altered Lebanon's sectarian demographics and is a continuing burden on the Lebanese economy. In October 2014, the cabinet further tightened entry restrictions to allow only "extreme humanitarian cases" into the country. Arrivals have declined 75 to 90 percent since August, most recently due in part to the new restrictions.

Egypt

Egyptian officials have announced that legislative elections will start in March 2015 and that voting will be staggered in phases over seven weeks. Egypt faces a persistent threat of terrorist and militant violence that is directed primarily at the state security forces both in the Sinai Peninsula and mainland Egypt. Since mid-2013, Sinai-based terrorist group Ansar Bayt al-Maqdis (ABM)—affiliated since November with ISIL—has claimed responsibility for some of the most sophisticated and deadly attacks against Egyptian security forces in decades.

Tunisia

Tunisia has transitioned to a permanent democratic government. Beji Caid Essebsi was elected President in the presidential runoff election in December 2014. In January 2015, Essebsi's political party Nidaa Tounes selected former Interior Minister Essid to become Prime Minister.

- In early February, Prime Minister Habib Essid formed a broad-based coalition government, led by Nidaa Tounes, which included Islamist party al-Nahda and several smaller parties. The new government almost certainly recognizes Tunisia's economic and security challenges.

The permanent government will inherit one of the highest youth unemployment rates in the world, a high budget deficit, and decreasing Foreign Direct Investment and balance of payments. It will struggle to meet public expectations for swift economic progress.

EUROPE

Turkey

Turkey will remain a critical partner in a wide range of US security policy priorities, including anti-ISIL and broader counterterrorism efforts. Joint US-Turkish efforts to stem instability in Iraq and Syria share the same goals but employ different approaches, increasing tension in the bilateral relationship. Turkish President Erdogan and leaders of the ruling Justice and Development Party (AKP) are focused on the general elections, which are scheduled to be held in June 2015

- Ankara will be more inclined to support the anti-ISIL coalition if the coalition agrees to focus efforts against Asad, including setting up an internationally guaranteed buffer zone in Syria.
- Turkey is concerned that the Kurdish Democratic Union (PYD)—a group it believes is affiliated with the Kurdistan People's Congress (KGK/former PKK)—will gain international legitimacy.

Key Partners

The Transatlantic partnership remains vital as the United States works with European leaders to maintain a concerted response to Russia's action in Ukraine and to other security challenges on the European continent and beyond. Europeans are working to address fiscal challenges and encourage economic growth while maintaining and strengthening financial governance.

- The Transatlantic Trade and Investment Partnership has the potential to help generate economic growth for both the United States and Europe, reinforce the transatlantic link, and address public concerns about data privacy and food and health standards.

RUSSIA AND EURASIA

Russia

The Ukrainian crisis has profoundly affected Russia's relations with the West and will have far-reaching effects on Russia's domestic politics, economic development, and foreign policy.

President Vladimir Putin enjoys some of his highest domestic approval ratings in all his years in office. An intense state media propaganda campaign has stoked Russians' perception that Putin righted a historical wrong in orchestrating Russia's seizure of Crimea and reasserted Russia's great-power interests against a hostile West.

At the same time, the crisis in Ukraine has exacerbated preexisting domestic problems in Russia. The fall of former Ukrainian President Viktor Yanukovych's government in February 2014 has almost certainly deepened the Kremlin's concerns over the dangers of mass demonstrations and has intensified the Kremlin's efforts to defuse what it sees as potential catalysts for protests in Russia.

Russia's economy was in decline even before the crisis began. Growth stagnated in 2014 due to declining oil prices, large capital outflows, and a sharply declining ruble. In addition, economic sanctions cut off some Russian firms from Western financing. These factors have increased the real and perceived risks of doing business in Russia, raised the overall cost of international credit, and will probably drive Russia into recession in 2015.

Moscow is pushing for greater regional integration, pressing neighboring states to follow the example of Belarus and Kazakhstan and join the Moscow-led Eurasian Economic Union. The Kremlin is also cultivating its relationship with China, seeking to maintain some influence in Europe and emphasizing multilateral forums to counter what Moscow views as US unilateralism. These trends were already present in Russian diplomacy, but the Ukrainian crisis has almost certainly lent emphasis to these policies.

Russia is taking information warfare to a new level, working to fan anti-US and anti-Western sentiment both within Russia and globally. Russian state-controlled media publish false and misleading information in an effort to discredit the West, undercut consensus on Russia, and build sympathy for Russian positions.

In Ukraine, Russia has demonstrated its willingness to covertly use military and paramilitary forces in a neighboring state—a development that raises anxieties in states along Russia's periphery. Future Russian deployments and force posture changes will probably be designed to maximize their diplomatic and public impact in Europe. Russian military officials have announced plans to conduct more "out-of-area" air and naval deployments, to include greater activity in the Caribbean and Mediterranean Seas.

Moscow has made headway in modernizing its nuclear and conventional forces, improving its training and joint operational proficiency, modernizing its military doctrine to integrate new methods of warfare, and developing long-range, precision-strike capabilities. Despite its economic difficulties, Moscow is committed to modernizing its military.

Ukraine, Moldova, and Belarus

Ukraine faces a daunting array of problems after nearly a year of conflict with Russia and its proxies in eastern Ukraine. At the same time, the crisis has fostered a sense of national identity and unity. Public opinion has shifted heavily in favor of pursuing integration with the EU while views of Russia have become sharply negative. Moreover, for the first time, a narrow majority of the population supports NATO membership.

Negotiations over the status of the separatist-held territory in eastern Ukraine will almost certainly be difficult and protracted. Russia has supplied substantial quantities of heavy weapons to strengthen the separatists' forces and covertly supports them with its own troops, both within Ukraine and from across the border. More importantly, Moscow has demonstrated that it is willing to intervene directly to prevent the separatists from being defeated on the battlefield. Further fighting is likely in 2015.

Ukraine's dire economic situation presents no less a challenge to Kyiv than the conflict in the east. Ukraine will be highly dependent on substantial outside financial assistance for years to come.

In Moldova, the narrow victory of pro-EU parties in the latest parliamentary elections suggests that Moldova will push ahead with its European integration agenda. However, Chisinau still faces numerous challenges in seeking to overcome economic difficulties, entrenched corruption, and Moscow's displeasure with Moldova's rejection of closer integration with Russia. Any progress on resolving the political status of the ethnic-Russian separatist region of Transnistria is unlikely.

On 1 January 2015, Belarus became, along with Kazakhstan, a founding member of the Eurasian Economic Union (EEU), a regional integration project that Moscow eventually plans to transform into a Eurasian Union as a counterpart to the EU. President Lukashenko has tread carefully in regard to the Ukrainian crisis, declining to recognize Russia's seizure of Crimea, but agreeing nevertheless to deepen military cooperation with Moscow.

The Caucasus and Central Asia

In Georgia, progress is unlikely on the core disputes between Tbilisi and Moscow, including Georgia's NATO aspirations and the status of the occupied territories of Abkhazia and South Ossetia. Tensions with Russia will remain high, and we assess that Moscow will press Tbilisi to abandon closer EU and NATO ties.

Armenia and Azerbaijan saw an increase in 2014 of ceasefire violations and a record number of casualties along the Line of Contact (LOC), which separates ethnic Armenian and Azerbaijani forces near the separatist region of Nagorno-Karabakh. The increased violence highlights how the close proximity of opposing military forces continues to pose a risk of miscalculation and unintended escalation. Prospects for a peaceful resolution in the foreseeable future are dim.

Central Asian states remain concerned about regional instability in light of a reduced Coalition presence in Afghanistan. Although they have long been alarmed about the activities of Central Asian militant groups operating in Afghanistan and Pakistan, they are increasingly worried about the threat posed by the return of the small but growing number of their nationals who have traveled to Syria to join violent Islamist extremist groups. On the whole, however, the Central Asian states will probably face more acute risks of instability in 2015 from internal issues such as unclear political succession plans, weak economies, ethnic tensions, and political repression—any of which could produce a crisis with little warning.

EAST ASIA

China

China will continue to pursue an active foreign policy—especially within the Asia Pacific—bolstered by increasing capabilities and its firm stance on East and South China Sea territorial disputes with rival claimants. The chances for sustained tensions will persist because competing claimants will probably pursue actions—including energy exploration—that others perceive as infringing on their sovereignty. China will probably seek to expand its economic role and outreach in the region, pursuing broader acceptance of its economic initiatives, including the Asia Infrastructure Investment Bank. Although China remains focused on regional issues, it will seek a greater voice on major international issues and in making new international rules.

Notwithstanding this external agenda, Chinese leaders will focus primarily on addressing domestic concerns. The Chinese Communist Party leadership under President Xi Jinping announced an ambitious agenda of legal reforms in late 2014 that built on its previous agenda of ambitious economic reforms—all aimed at improving government efficiency and accountability and strengthening the control of the Communist Party. The difficulty of implementing these reforms and bureaucratic resistance to them create the possibility of rising internal frictions as the agenda moves forward. Beijing will also remain concerned about the potential for domestic unrest or terrorist acts in Xinjiang and Tibet, which might lead to renewed human rights abuses. Following months of pro-democracy protests in late 2014, Chinese leaders will monitor closely political developments in Hong Kong for signs of instability.

North Korea

Three years after taking the helm of North Korea, Kim Jong Un has further solidified his position as unitary leader and final decision authority through purges, executions, and leadership shuffles. Kim was absent from public view for 40 days in late 2014, leading to widespread foreign media speculation about his health and the regime's stability. The focus on Kim's health is a reminder that the regime's stability might hinge on Kim's personal status. Kim has no clearly identified successor and is inclined to prevent the emergence of a clear "number two" who could consolidate power in his absence. Kim and the regime have publicly emphasized his focus on improving the country's troubled economy and the livelihood of the North Korean people while maintaining the tenets of a command economy. He has codified this approach via his dual-track policy of economic development and advancement of nuclear weapons. (Information on North Korea's nuclear weapons program and intentions can be found above in the section on WMD and Proliferation.) Despite renewed efforts at diplomatic outreach, Kim continues to challenge the international community with provocative and threatening behavior in pursuit of his goals, as prominently demonstrated in the November 2014 cyber attack on Sony.

SOUTH ASIA

Afghanistan

President Ashraf Ghani and Chief Executive Officer Abdullah Abdullah secured Parliament's approval of the Bilateral Security Agreement and NATO Status of Forces Agreement prior to the NATO Ministerial in December 2014. Despite the 12 January announcement of the r cabinet nominees, Ghani and Abdullah have yet to win legislative approval for all of those nominated or resolve the final details of their shared political powers derived from their national unity government agreement. Resolving these issues will require continued international engagement and support.

International financial aid remains the most important external determinant of the Kabul government's strength. However, the slow economic recovery from the global financial crisis has created fiscal challenges for many of Afghanistan's primary donors, particularly in Europe and Japan. These economic hurdles at home have reduced donors' enthusiasm and capacity to provide Afghanistan additional long-term financial aid above levels pledged through 2017 and reaffirmed in 2014 at the London Conference and NATO Wales Summit.

The Afghan National Security Forces (ANSF) prevented the Taliban from achieving a decisive military advantage in 2014. The ANSF, however, will require continued international security sector support and funding to stave off an increasingly aggressive Taliban insurgency through 2015. The ANSF, with the help of anti-Taliban powerbrokers and international funding, will probably maintain control of most major population centers. However, the forces will most likely cede control of some rural areas. Without international funding, the ANSF will probably not remain a cohesive or viable force.

The Taliban will probably remain largely cohesive under the leadership of Mullah Omar and sustain its countrywide campaign to take territory in outlying areas and steadily reassert influence over significant portions of the Pashtun countryside, positioning itself for greater territorial gains in 2015. Reliant on Afghanistan's opiate trade as a key domestic source of funding, the Taliban will be able to exploit increasing opium poppy cultivation and potential heroin production for ready revenue. The Taliban has publicly touted the end of the mission of the International Security and Assistance Force (ISAF) and coalition drawdown as a sign of its inevitable victory, reinforcing its commitment to returning to power.

Pakistan

Pakistan will probably continue to implement some economic reforms and target anti-Pakistan militants and their activities.

- Prime Minister Sharif's promises to address economic, energy, and security issues almost certainly fell short of high public expectations. Furthermore, his standing weakened when he reportedly asked the Army to step in and handle opposition protests in late 2014.

- We assess that Islamabad will approve some additional economic reforms in 2015. Undertaking future economic and energy reforms will be more challenging and will probably face greater political and popular opposition.

- The Pakistan Government will probably focus in 2015 on diminishing the capabilities of the Tehrik-i-Taliban (TTP), which claimed the attack on a school in December - leaving over 100 children dead.

We judge that Pakistan will aim to establish positive rapport with the new Afghan Government, but longstanding distrust and unresolved disputes between the countries will prevent substantial progress.

- Pakistan's provision of safe haven to Lashkar-e Tayyiba will probably continue to be a key irritant in relations with India.

India

Prime Minister Narendra Modi's decisive leadership style, combined with the 2014 election of an absolute majority in the lower house of Parliament of his Bharatiya Janata Party (BJP), will enable more decisive Indian decisionmaking on domestic and foreign policy. Although India has a long-standing position that it maintain an independent policy, Modi will probably seek to work more closely with the United States on security, terrorism, and economic issues.

India wants to maintain a stable peace with Pakistan but views Pakistan as a direct terrorism threat and a regional source of instability.

India is concerned about the stability of Afghanistan and its own presence there following the drawdown of international forces and is looking for options to blunt the influence of Pakistani-supported groups and ensure that Afghanistan does not revert to a haven for anti-Indian militants.

Indian leaders will almost certainly pursue stronger economic ties with China that support the government's economic agenda of closing the trade gap and attracting investment in infrastructure. New Delhi's concern over perceived Chinese aggressiveness along the disputed border and in the Indian Ocean is probably growing in light of border incidents and the visit of a Chinese submarine to Sri Lanka in 2014.

SUB-SAHARAN AFRICA

Sub-Saharan Africa will face political and security challenges in 2015 including numerous presidential elections, ongoing insurgencies, and continuing intrastate conflict. The ongoing Ebola virus epidemic will undoubtedly challenge both Western African nations and the larger international community in trying to contain the virus' spread and counter economic degradation in fragile West African nations. Stability in South Sudan, Nigeria, Somalia, and the Central African Republic (CAR) will almost certainly remain tenuous throughout 2015.

West Africa

The Ebola virus will persist throughout West Africa in 2015, posing a significant threat to the economic viability and consequently the stability of the region. The continued drain on resources and unprecedented need for medical personnel will strain governments and economies in Liberia, Sierra Leone, and Guinea—the three worst-affected countries. Sustained financial and materiel assistance from the international community, continued domestic support for the governments' anti-Ebola efforts, and community engagement to change local misperceptions about the disease's cause, treatment options, and burial practices will remain critical to slowing the epidemic. Economic growth in the outbreak zone has already slowed and will continue to slow during 2015, straining budgets and probably increasing dependence on international donor aid. A prolonged or severe outbreak that continues well into 2015 might prompt Guinea to delay Presidential elections, increasing the possibility of election-related violence. Military and security services in the key outbreak countries will probably successfully contain isolated unrest and local hostility toward Ebola-response personnel.

Sudan

Khartoum will almost certainly confront a range of challenges, including continued insurgencies in the periphery, public dissatisfaction over continued economic decline, and potential protests surrounding its April 2015 elections. Sudanese economic conditions since South Sudan's independence in 2011 continue to deteriorate. Such conditions, including rising prices on staple goods, fuel opposition to the Sudanese Government.

South Sudan

Clashes between opposition forces and the Sudan People's Liberation Army (SPLA) will almost certainly increase during the dry season—which lasts from November to April—undermining ongoing peace talks and

putting tenuous humanitarian gains at risk. Peace talks between Juba and opposition elements will probably remain slow-going.

Nigeria

Instability in Nigeria will probably increase in 2015, given contentious elections delayed until March and April, plummeting oil revenue, and the military's inability to check Boko Haram's ascendancy in the northeast. The election will occasion violence, with prospects for protests in the months following the election. In addition, militants might remobilize in the Niger Delta and attack the oil industry. Boko Haram will probably continue to solidify control over its self-declared Islamic state in northeastern Nigeria and expand its terror campaign in neighboring Nigerian states, Cameroon, Niger, and Chad. Abuja's reliance on oil exports for revenue will almost certainly ensure that Nigeria remains vulnerable to fluctuations in the global oil market in 2015. Declining oil prices will probably squeeze government revenues and drain currency reserves. Abuja's overtaxed security forces will have limited ability to anticipate and preempt threats.

Somalia

In Somalia, al-Shabaab is conducting asymmetric attacks against government facilities and Western targets in and around Mogadishu. The credibility and effectiveness of the young Somali Government will be further threatened by persistent political infighting; ill-equipped government institutions; and pervasive technical, political, and administrative shortfalls.

Lord's Resistance Army

The Lord's Resistance Army (LRA), even in its weakened state, probably has the ability to regenerate if counter-LRA operations are reduced. The LRA continues to display great agility in its geographic areas of operation and in the operational security of its activities.

Central African Republic

Despite the presence of international peacekeeping forces, the risk of continued ethno-religious clashes between Christians and Muslims throughout the country, including in the capital, remains high.

The Sahel

Governments in Africa's Sahel region—particularly Chad, Niger, Mali, and Mauritania—will remain at risk of terrorist attacks and possible internal conflict. Al-Qa'ida in the Lands of the Islamic Maghreb (AQIM) and affiliated groups are committed to continuing their terrorist activity in the Sahel, including against Western interests. They will probably seek to increase the frequency and scale of attacks in northern Mali. Sahelian militaries will struggle to handle a wide array of security threats.

LATIN AMERICA AND THE CARIBBEAN

Cuba

Cuban President Raul Castro's focus will almost certainly be preparing the country for the eventual end of the Castro era and maintaining tight political control. He is cautiously implementing economic and leadership reforms and released dozens of political prisoners in early January. Cuba's principal interest in normalizing relations with the United States is probably linked to its recognition of the need to ease discontent over dismal living conditions and poor economic prospects. The slow rollout of economic reforms and a fall in nickel output cut GDP growth to 1.2 percent in 2014. Crucial components of the economic reform program—reducing the state role in the economy and opening up a few opportunities for self-employment—will probably produce numerous, short-term economic dislocations before gradually increasing productivity and jobs.

Cuba's population of 11 million has been declining since about 2005 because of falling birthrates and emigration. Cuban migrant arrivals at the US southwest border rose from 10,400 in FY12 to 17,300 in FY14. Maritime arrivals and interdictions will probably increase in 2015 because of rumors that if the two countries normalize relations, the United States would change immigration policies that allow Cubans who reach the United States to obtain status.

Central America

Weak institutions, poor economic prospects, and the growing strength of criminal gangs will probably limit the ability of the governments of Central America's northern tier—El Salvador, Guatemala, and Honduras—to improve rule of law, job opportunities, and citizen security, which will probably continue to fuel immigration to the United States in 2015. Fractured legislatures, political challenges, and entrenched business interests will probably slow agreement on raising some of the lowest tax collection rates in the world or adopting economic and social policies that would help reduce the high rates of poverty that spur migration to the United States. About 25 percent of El Salvador's population has emigrated during the past two decades, mostly to the United States, because of lack of economic opportunities and widespread insecurity. El Salvador's economy has experienced the lowest economic growth rates in the region for eight consecutive years. Guatemala's weak fiscal position will undermine efforts to ameliorate extreme poverty, particularly in rural areas. About 1.6 million Guatemalans reside in the United States and send about \$5.5 billion in remittances back home each year. Honduras, one of the hemisphere's poorest countries, is struggling to make headway against ineffective, corrupt institutions. Honduras has the world's highest rate of homicides per capita, despite a reported modest decline in 2014, and criminal gangs are forcibly recruiting youth and extorting businesses and individuals.

Venezuela

Like most oil-exporting nations, Venezuela is experiencing the economic consequences of policy choices and the decline in global oil prices. Oil accounts for about 95 percent of Venezuelan export earnings and 45 percent of government revenue. Caracas will face a strained fiscal environment in 2015 along with rising inflation and shortages of essential goods.

Legislative elections are slated to occur by the end of 2015; voters will be concerned about public security, the economy, and political rights. President Nicolas Maduro appointed a presidential commission to review the country's police system and recommend reforms after the high-profile murder of a national assembly deputy and a violent law enforcement confrontation in October 2014 with a radical, armed group known as a *colectivo*.

Haiti

Political tensions between Haitian President Martelly and his opponents will probably flare during 2015 and might undermine preparations for overdue local and parliamentary elections as well as for the vote for a new president in November 2015. Haiti will need substantial technical and financial support from the international community to organize and hold elections. Some violent protests are probable and might become more intense or widespread if political opponents believe that electoral preparations favor Martelly's party or allies.

* * * * *

DIA Director Worldwide Threat Assessment

Armed Services Committee

United States Senate

Vincent R. Stewart

Lieutenant General, U.S. Marine Corps

Director, Defense Intelligence Agency

Information available as of February 20, 2015 was used in the preparation of this assessment

* * * * *

INTRODUCTION

Iraq and Afghanistan Terrorism * Al-Qa'ida in the Arabian Peninsula (AQAP) * Al-Qa'ida in Lands of the Islamic Maghreb (AQIM) * Al-Nusrah Front * Khorasan Group * Islamic Revolutionary Guard Corps-Qods Force (IRGC-QF) * Boko Haram

REGIONAL THREATS

Russia * East Asia * China * North Korea * Middle East and North Africa * Iran * Syria * Libya * Egypt * Yemen * South Asia * Pakistan * India * Africa * Somalia * Nigeria * Latin America * Mexico * Colombia * Venezuela * Honduras, El Salvador, and Guatemala

GLOBAL THREATS

U.S. Space Systems and Services * Cyber * Proliferation of WMD and Ballistic Missiles * Proliferation of Advanced Conventional Weapons * Infectious Diseases * Foreign Intelligence & Insider Threats

* * * * *

INTRODUCTION

Chairman McCain, Ranking Member Reed, and Members of the Committee, thank you for the invitation to provide the Defense Intelligence Agency's (DIA) assessment of the global security environment and to address the threats facing the nation. A confluence of global political, military, social, and technological developments, taken in aggregate, have created security challenges more diverse and complex than those we have experienced in our lifetimes.

Our challenges range from highly capable, near-peer competitors to empowered individuals and the concomitant reduction in our own capacity will make those challenges all the more stressing on our defense and intelligence establishments. This strategic environment will be with us for some time, and the threat's increasing scope, volatility, and complexity will be the "new normal."

The 16,500 men and women of DIA stationed around the globe are confronting this rapidly evolving defense landscape head-on, and leading the Intelligence Community (IC) in providing unique defense intelligence from the strategic to the tactical level to deliver a decision advantage to warfighters, defense planners, the defense acquisition community, and policymakers. The men and women - both uniformed and civilian - of your DIA know they have a vital responsibility to the American people and take great pride in their work. I am privileged to serve with them and present their analysis to you. My hope is that this hearing will help the nation - through the important oversight role of Congress - to better understand the diversity of the global challenges we face and to support this committee in developing possible responses to these threats. Thank you for your confidence and support.

I will begin first with an assessment of Iraq, followed by Afghanistan, where the Department of Defense (DoD), DIA, the IC, and our Coalition partners are on the front lines, actively supporting military operations against threats from the Islamic State of Iraq and the Levant (ISIL), al-Qa'ida, and the Taliban. I will then transition to a selected group of violent extremist organizations, and conclude with other regional challenges and global threats.

IRAQ AND AFGHANISTAN

ISIL's resurgence since the withdrawal of U.S. forces from Iraq in 2011 was vividly displayed by the group's rapid advance across much of northern and western Iraq last spring. Since that time, Coalition airstrikes have removed a number of ISIL senior leaders and degraded the group's ability to operate openly in Iraq and Syria. We expect ISIL to continue entrenching itself and consolidating gains in Sunni areas of Iraq and Syria while also fighting for territory outside those areas. We also expect ISIL to continue limited offensive operations, such as the group's recent operations in Syria and Anbar province of Iraq. Seizing and holding Shia and Kurdish-populated areas of Iraq have been, and will continue to be difficult for ISIL in 2015. ISIL's ability to govern the areas it has captured in Iraq and Syria, and its ability to keep the support - or at least acquiescence - of the Sunni population will be key indicators of the success or failure of the self-declared "Islamic state." With affiliates in Algeria, Egypt, and Libya, the group is beginning to assemble a growing international footprint that includes ungoverned and under-governed areas. Similarly, the flow of foreign fighters into, and out of, Syria and Iraq - many of whom are aligned with ISIL - is troubling.

Defeats of Iraqi Security Forces (ISF) and the collapse of multiple army divisions highlight large-scale institutional deficiencies within the ISF. Several of the more concerning deficiencies include poor logistics and endemic corruption that has bred ineffective commanders and led to poor morale. Force generation efforts will be complicated by a lack of experienced and qualified soldiers. Local and tribal pro-government forces suffer from similar supply and manning shortages.

The ISF remains unable to defend against external threats or sustain conventional military operations against internal challenges without foreign assistance. Iraq is diversifying its defense acquisitions through numerous foreign military sales including with Russia and other non-U.S. suppliers to overcome equipment shortfalls and capability gaps. These decisions are reducing ISF interoperability.

Turning to Afghanistan, the still-developing Afghan National Security Forces (ANSF) remain stalemated with the Taliban-led insurgency. In 2015, we expect the ANSF to maintain stability and security in Kabul and key urban areas while retaining freedom of movement on major highways. However, the Taliban, al-Qa'ida, and their extremist allies will likely seek to exploit the reduced Coalition presence by pressuring ANSF units in rural areas, conducting high profile attacks in major population centers, and expanding their safe havens.

ANSF will remain reliant on Coalition enablers for air, intelligence, and maintenance support. As NATO and our allies carry out their scheduled drawdown, the ANSF will struggle to effectively replace these lost enablers, deal with interoperability challenges between the army and police, and address persistent maintenance and logistical issues.

The Afghan National Army (ANA) is the most proficient security institution in Afghanistan, and has shown the capacity to plan and conduct multi-corps operations in high-threat areas. However, the ANA will continue to struggle with permanently denying the insurgents freedom of movement in rural areas, and will remain constrained by its stretched airlift and logistical capacity. High attrition also continues to plague the force, which has struggled to keep its numbers near full capacity.

The Afghan National Police (ANP) provide sufficient presence and security within urban centers and provincial and district hubs, but remain vulnerable in controlling high-threat, rural areas. ANP challenges include manpower shortages, inadequate training, attrition, logistics shortfalls, and the corrosive influence of corruption. These factors have diminished the effectiveness of the ANP and undermined its popular image.

In 2014, the Afghan Air Force (AAF) improved its support to ground operations, significantly increasing the number of casualty evacuation missions and forward deployments of Mi-17 transport helicopters and Mi-35 gunships into contested areas. Despite these improvements, the AAF is not a reliable source of close air support and still struggles with recruiting qualified pilots and technicians.

The development of ANSF capabilities in 2015 will be critical as the insurgency will again attempt to increase its influence in rural areas, operate in larger formations, and continue to test security forces by temporarily

seizing a number of vulnerable rural Afghan checkpoints and district centers. This will include increased high profile attacks, particularly in Kabul, where the Taliban seeks to undermine perceptions of Afghan security. The Taliban will probably sustain the capability to propagate a rural-based insurgency that can project intermittent attacks in urban areas through at least 2018.

TERRORISM

Al-Qa'ida core is now focused on physical survival following battlefield losses. At the same time, the group is trying to retain its status as the vanguard of the global extremist movement, being eclipsed now by ISIL's rising global prominence and powerful competition for adherents. Al-Qa'ida core in Pakistan continues to retain the loyalty of its global affiliates in Yemen, Somalia, North Africa, Syria, and South Asia.

Despite ongoing counterterrorism (CT) pressure and competition from ISIL, al-Qa'ida will likely retain a transnational attack capability, and will likely try to expand its limited presence in eastern Afghanistan as Western CT operations there decline. Beyond core al-Qa'ida, I would like to highlight for the committee a handful of other violent extremist groups that are of particular concern to DIA.

Al-Qa'ida in the Arabian Peninsula (AQAP) remains committed to attacking the West, probably by targeting commercial aviation with innovative explosives, and will leverage instability in Yemen to its advantage.

Al-Qa'ida in Lands of the Islamic Maghreb (AQIM) recently increased efforts to expand its operating areas across North and West Africa by working with, and through, other regional terrorist groups. AQIM almost certainly continues to plan attacks and kidnapping operations against U.S. allies in the region.

As part of the larger al-Qa'ida network, we are concerned about the support al-Nusrah Front provides to transnational terrorist attack plotting against U.S. and Western interests.

The Khorasan Group is a cadre of experienced al-Qa'ida operatives that works closely with al-Nusrah Front. Although coalition airstrikes have killed a number of senior Khorasan Group members, the group almost certainly will maintain the intent to continue plotting against Western interests unless completely destroyed.

Islamic Revolutionary Guard Corps-Qods Force (IRGC-QF) and Lebanese Hizballah are instruments of Iran's foreign policy and its ability to project power in Iraq, Syria, and beyond. Hizballah continues to support the Syrian regime, pro-regime militants and Iraqi Shia militants in Syria. Hizballah trainers and advisors in Iraq assist Iranian and Iraqi Shia militias fighting Sunni extremists there. Select Iraqi Shia militant groups also warned of their willingness to fight U.S. forces returning to Iraq.

Boko Haram's (BH) offensive in northeastern Nigeria, largely against the Nigerian government, includes near daily attacks. If continued, BH's successes could grow into a significant regional crisis with implications outside northwest Africa.

REGIONAL THREATS RUSSIA

Russia has made significant progress modernizing its nuclear and conventional forces, improving its training and joint operational proficiency, modernizing its military doctrine to integrate new methods of warfare, and developing long range precision strike capabilities. Despite its economic difficulties, Moscow is fully committed to modernizing both nuclear and conventional forces. At the same time, Russian forces have conducted exercises and a record number of out-of-area air and naval operations. We expect these to continue this year to include greater activity in the Caribbean and Mediterranean Seas.

In 2014, Moscow moved to shape events in Ukraine, employing its improved military capabilities to create a long-term conflict in Ukraine's Donetsk and Luhansk regions. All indications are that Moscow will continue to employ a mix of military and nonmilitary pressure against Kyiv this year, to include the use of propaganda and information operations, cyberspace operations, covert agents, regular military personnel operating as "volunteers,"

mercenaries, arms transfers to the separatists, and the threat of military intervention. These actions are consistent with Russia's new military doctrine Moscow affirmed its intent to improve the military's capability to control the Russian Arctic region, stressing the area's current and future strategic and economic importance.

In December Moscow announced the activation of a Joint Service Command (OSK) North, highlighting the importance of the Arctic to Russian leaders.

Russia will continue to place the highest priority on the maintenance of a robust and capable arsenal of strategic nuclear weapons. Priorities for the strategic nuclear forces include the modernization of its road-mobile intercontinental ballistic missiles (ICBMs) and upgrades to strategic forces' command and control facilities. In the next year, Russia will field more road-mobile SS-27 Mod-2 ICBMs with multiple independently targetable re-entry vehicles. It also will continue development of the RS-26 ballistic missile, the Dolgorukiy ballistic missile submarine, its SS-N-32 Bulava submarine-launched ballistic missile, and next-generation air-and ground-launched cruise missiles.

EAST ASIA

China's People's Liberation Army (PLA) is building a modern military capable of defending China's "core interests" of preserving its political system, protecting territorial integrity and sovereignty (China views these to include Taiwan and other contested claims to land and water), and ensuring sustainable economic and social development.

The PLA remains focused on transforming the army into a fully mechanized force. The PLA is converting its divisions into brigades to increase lethality and improve combat capabilities. China's national-level training focus has been on brigade-level exercises that stress unit combat mission capabilities under realistic conditions, long distance mobility, and command and control. We expect these trends to continue.

The PLA Navy continues to expand its operational and deployment areas. China's first aircraft carrier, commissioned in late 2012, will not reach its full potential until it acquires a fully operational fixed-wing air regiment, but we expect the navy will make progress toward its goal this year.

The South China Sea (SCS) remains a potential flashpoint. Overlapping claims among China, Vietnam, the Philippines, Malaysia, Taiwan, and Brunei- exacerbated by large-scale construction or major steps to militarize or expand law enforcement- has increased tensions among claimants. This has prompted an increase in defense acquisition, to include submarine capabilities, in some of these countries.

In 2014, China twice deployed submarines to the Indian Ocean. The submarines probably conducted area familiarization to form a baseline for increasing China's power projection. China continues production of JIN-class nuclear-powered ballistic missile submarines and submarine-launched ballistic missiles. We expect China to conduct its first nuclear deterrence patrols this year.

The PLA Air Force (PLAAF) is approaching modernization on a scale unprecedented in its history. China now has two stealth fighter programs - the third and fourth J-20 prototypes, which conducted their first flights in March and July 2014. Further PLAAF developments are anticipated.

China's nuclear arsenal currently consists of 50-60 ICBMs. China is adding more survivable road-mobile systems, enhancing its silo-based systems, and developing a sea-based nuclear deterrent. They are also augmenting more than 1,200 conventional short-range ballistic missiles deployed opposite Taiwan with a limited but growing number of conventionally armed, medium-range ballistic missiles, including the DF-16, which will improve China's ability to strike regional targets. China continues to deploy growing numbers of the DF-21D antiship ballistic missile and is developing a tiered ballistic missile defense system, having successfully tested the upper-tier capability on two occasions.

The Democratic People's Republic of Korea's (DPRK) primary goals are preserving the control of the Kim family regime, improving its poor economy, and deterring attack by improving its strategic and conventional

military capabilities. Pyongyang maintains that nuclear and ballistic missile capabilities are essential to ensure its sovereignty.

The DPRK continues to prioritize maintaining the readiness of its large, forward-deployed forces. While Pyongyang is stressing increased realism in military training, exercises still appear to do little more than maintain basic competencies. Because of its conventional military deficiencies, the DPRK is also concentrating on improving its deterrence capabilities, especially its nuclear technology and ballistic missile forces.

We believe the DPRK continues to develop its nuclear weapons and missile programs which pose a serious threat to the U.S. and regional allies. We remain concerned that the DPRK will conduct a nuclear test in the future. Following the United Nations' (U.N.) condemnation of its human rights record in November 2014, Pyongyang indicated it would "not refrain any further from conducting a nuclear test." This followed a statement in March 2014 wherein North Korea's Foreign Ministry warned it "would not rule out a new form of nuclear test."

Pyongyang is also making efforts to expand and modernize its deployed close-, short-, medium-, and intermediate-range systems. It seeks to develop longer-range ballistic missiles capable of delivering nuclear weapons to the U.S., and continues efforts to bring its KN08 road-mobile ICBM to operational capacity. In 2015, North Korea will continue improving the combat proficiency of its deployed ballistic missile force, and will work to improve missile designs to boost overall capability. Pyongyang likely will launch additional ballistic missiles as part of its training and research and development process. We remain concerned by North Korea's illicit proliferation activities and attempts to evade U.N. sanctions.

MIDDLE EAST AND NORTH AFRICA

The Islamic Republic of Iran continues to threaten U.S. strategic interests in the Middle East. Iran's actions and policies are designed to further its goal of becoming the dominant regional power, as well as enhance its strategic depth.

Tehran views the U.S. as its most capable adversary and has fashioned its military strategy and doctrine accordingly. Iran's military posture is primarily defensive and is designed to deter an attack, survive an initial attack if deterrence fails, and retaliate against its aggressor to force a diplomatic resolution. Iran's numerous underground facilities have helped reduce its military vulnerabilities. We do not anticipate any changes to this posture in 2015.

We continue to assess Iran's goal is to develop capabilities that will allow it to build missile-deliverable nuclear weapons, should a decision be made to do so. The regime faces no insurmountable technical barriers to producing a nuclear weapon, making Iran's political will the central issue.

Iran's overall defense strategy relies on a substantial inventory of theater ballistic missiles capable of reaching as far as southeastern Europe. Iran continues to develop more sophisticated missiles, and is improving the range and accuracy of its current missile systems. Iran publicly stated that it intends to launch a space-launch vehicle as early as this year capable of ICBM ranges, if configured as such.

Iran is also steadily improving its military capabilities. The navy is developing faster, more lethal surface vessels, growing its submarine force, expanding its cruise missile defense capabilities, and increasing its presence in international waters. The navy aspires to travel as far as the Atlantic Ocean.

Iran is laboring to modernize its air and air defense forces under the weight of international sanctions. Each year, Iran unveils what it claims are state-of-the-art, Iranian-made systems, including surface-to-air missiles (SAMs), radars, and unmanned aerial vehicles. It continues to seek an advanced long-range SAM.

We assess the conflict in Syria is trending in the Asad regime's favor, which holds the military advantage in Aleppo - Syria's largest city. In 2015, we anticipate the regime's strategy will be to encircle Aleppo, cut opposition supply lines, and besiege the opposition. Hezbollah and Iran, Damascus' key allies in its fight against the opposition, continue to provide training, advice, and extensive logistical support to the Syrian government and its

supporters. Despite the regime's military advantage - particularly in firepower and air superiority - it will continue to struggle and be unable to decisively defeat the opposition in 2015.

In Libya, political instability and ongoing militia violence have worsened over the year, exacerbating conditions that have already made Libya an attractive terrorist safe haven. ISIL has increased its presence and influence in Libya, particularly in Darnah, where it has begun establishing Islamic institutions. Without a unified government and capable military, there is limited possibility of stability in the near-term.

As Egypt prepares for parliamentary elections this spring, its leaders are facing numerous security concerns driven by regional unrest and several major terrorist attacks in 2014. Egyptian security forces face frequent attacks in Sinai and the Nile Valley despite suppressing most of the political unrest last year. Egyptians have also been attacked from and within Libyan territory. Egypt has responded to these attacks by increasing its CT campaign in Sinai and tightening security on the Gaza and Libya borders to reduce militant and arms flow into Egypt. Egypt has also responded to attacks on its citizens in Libya with airstrikes and has called on the international coalition fighting ISIL to include Libya in the fight. The upcoming year will likely see Egyptian security forces stressed by internal terrorist activities and efforts to manage instability in Libya.

In Yemen, instability has increased since the Huthis, a northern Zaydi Shia group with Iranian ties, captured the Presidential Palace in mid-January and attained senior positions in nearly all key Yemeni government and security institutions. Current conditions are providing AQAP operational space. Meanwhile, Yemen's neighbors are increasingly concerned about instability spilling across their borders, potentially spreading another humanitarian crisis in the region.

SOUTH ASIA

Pakistan Army ground operations in North Waziristan Agency (NWA) have cleared antistate militants from most population centers, and we expect the military will continue targeting remaining militant strongholds in 2015. The December 2014 Tehrik-e Taliban Pakistan (TTP) Peshawar attack against the army-run school that killed more than 140 people, mostly children, spurred the government and military to implement a national action plan against terrorism, including the establishment of military courts.

Despite ongoing military operations, Pakistan will continue to face internal security threats from militant, sectarian, and separatist groups and remains concerned about ISIL outreach and propaganda in South Asia.

India is in the midst of a major military modernization effort to address problems with its aging equipment and to better posture itself to defend against both Pakistan and China. New Delhi is working to address impediments to modernization, such as its cumbersome procurement process, budget constraints, and an inefficient domestic defense industry. India's relationship with Pakistan remains strained, marked by periodic skirmishes on or near the Line of Control that separates Indian and Pakistani Kashmir, resulting in the highest number of civilian casualties since 2003. Occasional unofficial Track-II dialogue resulted in little progress in resolving bilateral disputes.

New Delhi and Beijing maintain limited military-to-military engagement and continue to discuss their longstanding border dispute, despite occasional altercations between troops patrolling the border. India's concern over increased Chinese activity in South Asia has pushed New Delhi to base advanced fighter aircraft and to raise additional ground forces opposite the China border.

India continues to conduct periodic tests of its nuclear-capable missiles to enhance and verify missile reliability and capabilities. India will continue developing an ICBM, the Agni-VI, which will reportedly carry multiple warheads, and is working on the development of several variants of a submarine-launched ballistic missile.

AFRICA

Security conditions in Somalia improved in 2014 as progress was made against al-Shabaab, but challenges remain. The African Union Mission in Somalia (AMISOM) and the Somali National Army (SNA) conducted two rounds of offensive operations, liberating several al-Shabaab-held towns in south-central Somalia, including the lucrative port city of Baraawe. Somali militia participated in these operations, but remains unable to maintain control of cleared areas due to a number of factors, including endemic corruption and underlying clan tensions. Mogadishu's focus on governance and force integration efforts should help decrease prospects for instability as regional administrations evolve during the next year.

Nigeria's presidential election, now scheduled for 28 March to allow for additional security measures, will probably be the closest and most contentious since civilian rule was restored in 1999. Violence throughout the election - and probably thereafter - will stretch security and military forces thin. The military leadership - often focused on advancing private gain over strategic imperatives - has failed to properly resource and train troops. Nigeria recently acquired new weapons systems, but troops lack the training and motivation to effectively employ them. This instability is likely to lead to massive population displacements, more civilian deaths and kidnappings, growing extremist safe havens, and refugee spillover into neighboring countries.

LATIN AMERICA

In Latin America, transnational threats such as drug- and arms- trafficking and special interest alien transit, coupled with porous borders, have increased insecurity and challenged stability and prosperity. Moreover, outside actors are increasingly seeking to challenge the U.S. as the defense partner of choice in the region.

Mexico remains the principal transit country for U.S.-bound cocaine, and the primary foreign supplier of methamphetamine, heroin, and marijuana to the U. S. Civilian and military security force pressure on all major drug trafficking groups has likely contributed to the decline in drug-related homicides.

The Colombian government has made significant progress reducing cocaine production. While no longer the top cocaine producer globally, it remains the principal supplier of cocaine to the U.S. Drug profits fund insurgent and illegal armed groups, which increasingly work directly with Mexican drug cartels.

Venezuelan President Nicolas Maduro has not resolved the factors that contributed to nationwide anti-government protests in 2014, including a poor economy, shortages of basic goods, unchecked violent crime, and the government's authoritarian tactics against the political opposition. We anticipate student organizations and the political opposition will stage protests in the months leading up to 2015 legislative elections. Military leaders have remained loyal and will continue to quell anti-government protests. We anticipate security forces occasionally will use heavy-handed tactics to restore order.

In Honduras, El Salvador, and Guatemala, violence levels tied to gang, drug, and criminal activity remain amongst the highest in the world.

GLOBAL THREATS

The threat to U.S. space systems and services will increase as potential adversaries pursue disruptive and destructive counterspace capabilities. Rapidly evolving commercial space technology will support the global pursuit of enhanced space and counterspace capabilities that may narrow the technological gap with the U.S.

Chinese and Russian military leaders understand the unique information advantages afforded by space systems and are developing capabilities to deny U.S. use of space in the event of a conflict. Chinese military writings specifically highlight the need to interfere with, damage, and destroy reconnaissance, navigation, and communication satellites. China has satellite jamming capabilities and is pursuing other antisatellite systems. In July 2014, China conducted a non-destructive antisatellite missile test. A previous destructive test with this same system in 2007 created long-lived space debris.

Russia's military doctrine emphasizes space defense as a vital component of its national defense. Russian leaders openly assert that the Russian armed forces have antisatellite weapons and conduct antisatellite research.

The global cyber threat environment presents numerous persistent challenges to the security and integrity of DoD networks and information. Threat actors now demonstrate an increased ability and willingness to conduct aggressive cyberspace operations—including both service disruptions and espionage—against U.S. and allied defense information networks. Similarly, we note with increasing concern recent destructive cyber actions against U.S. private-sector networks demonstrating capabilities that could hold U.S. government and defense networks at risk.

For 2015, we expect espionage against U.S. government defense and defense contractor networks to continue largely unabated, while destructive network attack capabilities continue to develop and proliferate worldwide. We are also concerned about the threat to the integrity of U.S. defense procurement networks posed by supply chain vulnerabilities from counterfeit and sub-quality components.

Threat actors increasingly are willing to incorporate cyber options into regional and global power projection capabilities. The absence of universally accepted and enforceable norms of behavior in cyberspace contributes to this situation. In response, states worldwide are forming "cyber command" organizations and developing national capabilities. Similarly, cyberspace operations are playing increasingly important roles in regional conflicts—for example, in eastern Ukraine—where online network disruptions, espionage, disinformation and propaganda activities are now integral to the conflict.

Iran and North Korea now consider disruptive and destructive cyberspace operations a valid instrument of statecraft, including during what the U.S. considers peacetime. These states likely view cyberspace operations as an effective means of imposing costs on their adversaries while limiting the likelihood of damaging reprisals.

Non-state actors often express the desire to conduct malicious cyber attacks, but likely lack the capability to conduct high-level cyber operations. However, non-state actors, such as Hizballah, AQAP, and ISIL will continue during the next year to effectively use the Internet for communication, propaganda, fundraising and recruitment.

The proliferation and potential use of weapons of mass destruction (WMD) and ballistic missiles is a grave and enduring threat. Securing nuclear weapons, materials, and the scientific capabilities to develop chemical and biological weapons is a worldwide imperative. The time when only a few states had access to the most dangerous technologies is past, and the use of chemicals in Syria further demonstrates the threat of WMD is real. China will continue to be a source of dual-use WMD-applicable goods, equipment, and materials to countries of concern, like Iran, North Korea, and Syria. North Korea is among the world's leading suppliers of ballistic missiles and related technologies and, despite the adoption of U.N. Security Council resolutions, the DPRK continues proliferating weapons-related materiel. Russia, China, Iran, and North Korea engage in national-level military denial and deception programs that include the use of underground facilities to conceal and protect WMDs, and command, control, and other strategic assets and functions.

The proliferation of advanced conventional weapons, especially air defense systems and antiship cruise missiles, is a military issue of growing concern. Russian exports of these arms, including the SA-17, SA-22, SA-20 SAM systems and the SS-N-26 Yakhont supersonic antiship cruise missile is particularly troubling. Russia has exported several of these systems to countries of concern, including the SA-17 to Venezuela, and the SA-17, SA-22 and Yakhont to Syria. The 300-kilometer-range Yakhont poses a major threat to U.S. naval operations particularly in the eastern Mediterranean. There are no signs these sales will abate in 2015. If Russia was to sell the SA-20 to Iran, it would significantly increase Iranian military capabilities.

Infectious diseases are emerging as a global health concern. The Ebola epidemic in West Africa is the most visible reminder that health issues can suddenly materialize from anywhere and threaten American lives and interests. Our ability to mitigate and control health threats before they impact the U. S. relies on early warning, despite the absence of precise indicators of when and where new diseases will emerge. Pandemic warning likely will become more challenging and complex in 2015.

Finally, foreign intelligence threats from Russian, Chinese, and Cuban intelligence services continue to be a challenge. Trusted insiders who disclose sensitive U.S. information for nefarious purposes will also remain a significant threat in 2015. The technical sophistication of this insider threat exacerbates the challenge.

* * * * *

Testimony before Senate Armed Services Committee - 27 January 2015

William J. Fallon, Admiral, U.S. Navy (Retired)

Madame Chairwoman, Senator Reed, members of the Committee. Thank you for your essential and enduring support for our men and women in uniform and the opportunity to address this distinguished body and to offer my perspective on current threats to national security, American Foreign Policy and National Defense topics.

There are certainly many areas of concern around the world and we see the most spectacular and troubling highlighted regularly in the media. I believe that a coherent national security strategy requires a long term focus with well thought out objectives. We should resist reactive responses and attempts to find near term fixes for pop up issues which arise continuously and compete for attention with what we should determine are higher priority interests.

In surveying the worldscape today, I would suggest that we focus on where we, as a nation, want to be in the future. My vote would be for improving world security and stability with more people around the world enjoying a better life in conditions of their choosing, with responsible elected leaders providing good governance and respect for human dignity. This scenario, clearly in our better national interest, is not going to happen without lots of hard work, informed and guided by an effective national security strategy.

The United States government has provided, and must continue to provide; leadership, good example and active political, economic and military security assistance in working toward these desired objectives.

The fundamental prerequisite for any successful national security strategy is a sound and strong domestic foundation. Our credibility in the world is based on the example of our actions and how people perceive we might act in current and future situations. It is fair to wonder if people in other parts of the world take us seriously when they observe partisan political bickering preclude agreement on fundamental issues like national operating budgets or cyber policies, and seemingly ever changing policies and priorities.

Our military capability is an essential element of national power but only one of many key tools which include diplomacy, development, economic, financial and political and certainly, moral leadership. We face tough choices ahead, about when, where and if to engage our forces. We also face tough choices about capabilities and what to acquire. We cannot afford everything.

As we contemplate myriad challenges to world stability and U.S. security, we should first acknowledge, distasteful as it might be, the reality that nuclear weapons, and aspirations for them, continue to proliferate. In this regard, it is discouraging to note that after more than two decades of nuclear counterproliferation progress, fueled in large measure by the Nunn-Lugar initiative, Russian-U.S. cooperation appears to have ground to a halt in the wake of dangerous Russian bad behavior.

U.S. strategy for dealing with the potential use of these weapons of mass destruction has been our heretofore successful National Strategic Deterrent Force. But the critical components of this force have been aging without significant upgrade. Modernization of the force, particularly the survivability of the sea based deterrent, should be a top priority consideration for us to remain credible in deterring worst case scenarios.

In my view, one of our most important strategic interests, with huge implications for national security and the stability of the vast Asia-Pacific region, is our long term relationship with China. Mutually beneficial in many respects, it has other dimensions, notably in the areas of cyber security, military expansion and regional disputes with neighboring countries, which are a cause for concern and need to be addressed.

A key focal point of this hearing is conflict in the Middle East and the spread of violent extremism in the region, and from it, to other places in the world. The Middle East, an area of high interest to us for many reasons,

continues to be buffeted by challenges which have vexed years of U.S. attempts to improve stability in the area. Nonetheless, we should continue to engage in the region, using all aspects of national power, but with the understanding that we are not likely to be successful by mandating U.S. solutions. People in the region are sooner or later going to have to step up and address the issues which torment and divide them. We can and should assist but we are not going to resolve their problems.

Some recommendations for addressing the current challenge from the so called Daesh in Iraq and Syria include; (1) Recognition that success in Iraq will rest on the ability of the new government of Haider al Abadi to convince the majority of his countrymen, particularly the Sunni minority, that they will get a fair shake going forward. Absent this political foundation, nothing we do will be effective in the long term. (2) Getting Islamic leaders, the elites of the Arab countries, to actively counter the extremist ideology and cut funding to Daesh and other extremists. In a positive note here, I would highlight recent remarks by Egyptian leader Abdel al Sisi. And (3) Continue U.S. military efforts to work closely with the Iraqi military to enhance capabilities, increase combat effectiveness and support them with training, airpower and SOF as required to defeat Daesh and reclaim areas overrun last summer. Simultaneously pressing Daesh rear areas in Syria to degrade and deny their ability to expand or sustain operations in Iraq. No single one of these actions will defeat the threat. All need to occur.

Combating violent extremism worldwide will be a long term effort requiring close cooperation with allies and willing nations, especially in areas of intelligence sharing and U.S. military training and assistance for less capable colleagues.

In summary, strategic coherence in foreign policy and national security would benefit from strong, credible and consistent domestic policies and actions to return this great nation to the position of exemplary leadership it earned and enjoyed not that long ago. Building on this position of domestic strength, a thoughtful, focused and collaborative strategy formulation process to agree on a relatively few high priority national security goals and objectives should set us on a fair course.

At the international level, active engagement using all aspects of national power underpinned with a strong forward presence by U.S. military forces, with credible capabilities, is our best deterrent and response to security threats.

Thank you. I will be pleased to address specific questions you may have.

* * * * *

National Security Strategy

February 2015

The White House

Washington

Today, the United States is stronger and better positioned to seize the opportunities of a still new century and safeguard our interests against the risks of an insecure world.

America's growing economic strength is the foundation of our national security and a critical source of our influence abroad. Since the Great Recession, we have created nearly 11 million new jobs during the longest private sector job growth in our history. Unemployment has fallen to its lowest level in 6 years. We are now the world leader in oil and gas production. We continue to set the pace for science, technology, and innovation in the global economy.

We also benefit from a young and growing workforce, and a resilient and diversified economy. The entrepreneurial spirit of our workers and businesses undergirds our economic edge. Our higher education system is

the finest in the world, drawing more of the best students globally every year. We continue to attract immigrants from every corner of the world who renew our country with their energy and entrepreneurial talents.

Globally, we have moved beyond the large ground wars in Iraq and Afghanistan that defined so much of American foreign policy over the past decade. Compared to the nearly 180,000 troops we had in Iraq and Afghanistan when I took office, we now have fewer than 15,000 deployed in those countries. We possess a military whose might, technology, and geostrategic reach is unrivaled in human history. We have renewed our alliances from Europe to Asia.

Now, at this pivotal moment, we continue to face serious challenges to our national security, even as we are working to shape the opportunities of tomorrow. Violent extremism and an evolving terrorist threat raise a persistent risk of attacks on America and our allies. Escalating challenges to cybersecurity, aggression by Russia, the accelerating impacts of climate change, and the outbreak of infectious diseases all give rise to anxieties about global security. We must be clear-eyed about these and other challenges and recognize the United States has a unique capability to mobilize and lead the international community to meet them.

Any successful strategy to ensure the safety of the American people and advance our national security interests must begin with an undeniable truth—America must lead. Strong and sustained American leadership is essential to a rules-based international order that promotes global security and prosperity as well as the dignity and human rights of all peoples. The question is never whether America should lead, but how we lead.

A broad, we are demonstrating that while we will act unilaterally against threats to our core interests, we are stronger when we mobilize collective action. That is why we are leading international coalitions to confront the acute challenges posed by aggression, terrorism, and disease. We are leading over 60 partners in a global campaign to degrade and ultimately defeat the Islamic State of Iraq and the Levant (ISIL) in Iraq and Syria, including by working to disrupt the flow of foreign fighters to those countries, while keeping pressure on al-Qa'ida. We are leading a global effort to stop the deadly spread of the Ebola virus at its source. In lockstep with our European allies, we are enforcing tough sanctions on Russia to impose costs and deter future aggression.

Even as we meet these pressing challenges, we are pursuing historic opportunities. Our rebalance to Asia and the Pacific is yielding deeper ties with a more diverse set of allies and partners. When complete, the Trans-Pacific Partnership will generate trade and investment opportunities—and create high-quality jobs at home—across a region that represents more than 40 percent of global trade. We are primed to unlock the potential of our relationship with India. The scope of our cooperation with China is unprecedented, even as we remain alert to China's military modernization and reject any role for intimidation in resolving territorial disputes. We are deepening our investment in Africa, accelerating access to energy, health, and food security in a rapidly rising region. Our opening to Cuba will enhance our engagement in our own hemisphere, where there are enormous opportunities to consolidate gains in pursuit of peace, prosperity, democracy, and energy security.

Globally, we are committed to advancing the Prague Agenda, including by stopping the spread of nuclear weapons and securing nuclear materials. We are currently testing whether it is possible to achieve a comprehensive resolution to assure the international community that Iran's nuclear program is peaceful, while the Joint Plan of Action has halted the progress of Iran's program. We are building on our own energy security—and the groundbreaking commitment we made with China to reduce greenhouse gas emissions—to cement an international consensus on arresting climate change. We are shaping global standards for cybersecurity and building international capacity to disrupt and investigate cyber threats. We are playing a leading role in defining the international community's post-2015 agenda for eliminating extreme poverty and promoting sustainable development while prioritizing women and youth.

Underpinning it all, we are upholding our enduring commitment to the advancement of democracy and human rights and building new coalitions to combat corruption and to support open governments and open societies. In doing so, we are working to support democratic transitions, while also reaching out to the drivers of change in this century: young people and entrepreneurs.

Finally, I believe that America leads best when we draw upon our hopes rather than our fears. To succeed, we must draw upon the power of our example—that means viewing our commitment to our values and the rule of law as a strength, and not an inconvenience. That is why I have worked to ensure that America has the capabilities we need to respond to threats abroad, while acting in line with our values—prohibiting the use of torture; embracing constraints on our use of new technologies like drones; and upholding our commitment to privacy and civil liberties. These actions are a part of our resilience at home and a source of our influence abroad.

On all these fronts, America leads from a position of strength. But, this does not mean we can or should attempt to dictate the trajectory of all unfolding events around the world. As powerful as we are and will remain, our resources and influence are not infinite. And in a complex world, many of the security problems we face do not lend themselves to quick and easy fixes. The United States will always defend our interests and uphold our commitments to allies and partners. But, we have to make hard choices among many competing priorities, and we must always resist the over-reach that comes when we make decisions based upon fear. Moreover, we must recognize that a smart national security strategy does not rely solely on military power. Indeed, in the long-term, our efforts to work with other countries to counter the ideology and root causes of violent extremism will be more important than our capacity to remove terrorists from the battlefield.

The challenges we face require strategic patience and persistence. They require us to take our responsibilities seriously and make the smart investments in the foundations of our national power. Therefore, I will continue to pursue a comprehensive agenda that draws on all elements of our national strength, that is attuned to the strategic risks and opportunities we face, and that is guided by the principles and priorities set out in this strategy. Moreover, I will continue to insist on budgets that safeguard our strength and work with the Congress to end sequestration, which undercuts our national security.

This is an ambitious agenda, and not everything will be completed during my Presidency. But I believe this is an achievable agenda, especially if we proceed with confidence and if we restore the bipartisan center that has been a pillar of strength for American foreign policy in decades past. As Americans, we will always have our differences, but what unites us is the national consensus that American global leadership remains indispensable. We embrace our exceptional role and responsibilities at a time when our unique contributions and capabilities are needed most, and when the choices we make today can mean greater security and prosperity for our Nation for decades to come.

Barack Obama

Table of Contents

I. Introduction

II. Security

Strengthen Our National Defense

Reinforce Homeland Security

Combat the Persistent Threat of Terrorism

Build Capacity to Prevent Conflict

Prevent the Spread and Use of Weapons of Mass Destruction

Confront Climate Change

Assure Access to Shared Spaces

Increase Global Health Security

III. Prosperity

Put Our Economy to Work

Advance Our Energy Security

Lead in Science, Technology, and Innovation

Shape the Global Economic Order

End Extreme Poverty

IV. Values

Live Our Values

Advance Equality

Support Emerging Democracies

Empower Civil Society and Young Leaders

Prevent Mass Atrocities

V. International Order

Advance Our Rebalance to Asia and the Pacific

Strengthen Our Enduring Alliance with Europe

Seek Stability and Peace in the Middle East and North Africa

Invest in Africa's Future

Deepen Economic and Security Cooperation in the Americas

VI. Conclusion

I. Introduction

In a young century, opportunities for America abound, but risks to our security remain. This new National Security Strategy positions the United States to safeguard our national interests through strong and sustainable leadership. It sets out the principles and priorities to guide the use of American power and influence in the world. It advances a model of American leadership rooted in the foundation of America's economic and technological strength and the values of the American people. It redoubles our commitment to allies and partners and welcomes the constructive contributions of responsible rising powers. It signals our resolve and readiness to deter and, if necessary, defeat potential adversaries. It affirms America's leadership role within a rules-based international order that works best through empowered citizens, responsible states, and effective regional and international organizations. And it serves as a compass for how this Administration, in partnership with the Congress, will lead the world through a shifting security landscape toward a more durable peace and a new prosperity.

This strategy builds on the progress of the last 6 years, in which our active leadership has helped the world recover from a global economic crisis and respond to an array of emerging challenges. Our progress includes strengthening an unrivaled alliance system, underpinned by our enduring partnership with Europe, while investing in nascent multilateral forums like the G-20 and East Asia Summit. We brought most of our troops home after more than a decade of honorable service in two wars while adapting our counterterrorism strategy for an evolving terrorist threat. We led a multinational coalition to support the Afghan government to take responsibility for the security of their country, while supporting Afghanistan's first peaceful, democratic transition of power. The United States led the international response to natural disasters, including the earthquake in Haiti, the earthquake and tsunami in Japan, and the typhoon in the Philippines to save lives, prevent greater damage, and support efforts to rebuild. We led international efforts to stop the proliferation of nuclear weapons, including by building an unprecedented international sanctions regime to hold Iran responsible for failing to meet its international obligations, while pursuing a diplomatic effort that has already stopped the progress of Iran's nuclear program and rolled it back in key respects. We are rebalancing toward Asia and the Pacific while seeking new opportunities for partnership and investment in Africa and the Americas, where we have spurred greater agriculture and energy-related investments than ever before. And at home and abroad, we are taking concerted action to confront the dangers posed by climate change and to strengthen our energy security.

Still, there is no shortage of challenges that demand continued American leadership. The potential proliferation of weapons of mass destruction, particularly nuclear weapons, poses a grave risk. Even as we have decimated al-Qa'ida's core leadership, more diffuse networks of al-Qa'ida, ISIL, and affiliated groups threaten U.S. citizens, interests, allies, and partners. Violent extremists exploit upheaval across the Middle East and North Africa. Fragile and conflict-affected states incubate and spawn infectious disease, illicit weapons and drug smugglers, and destabilizing refugee flows. Too often, failures in governance and endemic corruption hold back the potential of rising regions. The danger of disruptive and even destructive cyber-attack is growing, and the risk of another global economic slowdown remains. The international community's ability to respond effectively to these and other risks is helped or hindered by the behaviors of major powers. Where progress has been most profound, it is due to the steadfastness of our allies and the cooperation of other emerging powers.

These complex times have made clear the power and centrality of America's indispensable leadership in the world. We mobilized and are leading global efforts to impose costs to counter Russian aggression, to degrade and ultimately defeat ISIL, to squelch the Ebola virus at its source, to stop the spread of nuclear weapons materials, and to turn the corner on global carbon emissions. A strong consensus endures across our political spectrum that the question is not whether America will lead, but how we will lead into the future.

First and foremost, **we will lead with purpose**. American leadership is a global force for good, but it is grounded in our enduring national interests as outlined in the 2010 National Security Strategy:

- The security of the United States, its citizens, and U.S. allies and partners;
- A strong, innovative, and growing U.S. economy in an open international economic system that promotes opportunity and prosperity;
- Respect for universal values at home and around the world; and
- A rules-based international order advanced by U.S. leadership that promotes peace, security, and opportunity through stronger cooperation to meet global challenges.

Especially in a changing global environment, these national interests will continue to guide all we do in the world. To advance these interests most effectively, we must pursue a comprehensive national security agenda, allocate resources accordingly, and work with the Congress to end sequestration. Even so, our resources will never be limitless. Policy tradeoffs and hard choices will need to be made. In such instances, we will prioritize efforts that address the top strategic risks to our interests:

- Catastrophic attack on the U.S. homeland or critical infrastructure;

- Threats or attacks against U.S. citizens abroad and our allies;
- Global economic crisis or widespread economic slowdown;
- Proliferation and/or use of weapons of mass destruction;
- Severe global infectious disease outbreaks;
- Climate change;
- Major energy market disruptions; and
- Significant security consequences associated with weak or failing states (including mass atrocities, regional spillover, and transnational organized crime).

We will seize strategic opportunities to shape the economic order and cultivate new relationships with emerging economic powers and countries newly committed to peaceful democratic change. We will also capitalize on the potential to end extreme poverty and build upon our comparative advantages in innovation, science and technology, entrepreneurship, and greater energy security.

We will lead with strength. After a difficult decade, America is growing stronger every day. The U.S. economy remains the most dynamic and resilient on Earth. We have rebounded from a global recession by creating more jobs in the United States than in all other advanced economies combined. Our military might is unrivaled. Yet, American exceptionalism is not rooted solely in the strength of our arms or economy. Above all, it is the product of our founding values, including the rule of law and universal rights, as well as the grit, talent, and diversity of the American people.

In the last 6 years alone, we arrested the worst financial crisis since the Great Depression and catalyzed a new era of economic growth. We increased our competitive edge and leadership in education, energy, science and technology, research and development, and healthcare. We achieved an energy transformation in North America. We are fortifying our critical infrastructure against all hazards, especially cyber espionage and attack. And we are working hard to safeguard our civil liberties while advancing our security.

America's strategic fundamentals are strong but should not be taken for granted. We must be innovative and judicious in how we use our resources to build up our national power. Going forward, we will strengthen our foundation by growing our economy, modernizing our defense, upholding our values, enhancing the resilience of our homeland, and promoting talent and diversity in our national security workforce.

We will lead by example. The strength of our institutions and our respect for the rule of law sets an example for democratic governance. When we uphold our values at home, we are better able to promote them in the world. This means safeguarding the civil rights and liberties of our citizens while increasing transparency and accountability. It also means holding ourselves to international norms and standards that we expect other nations to uphold, and admitting when we do not. We must also demonstrate our ability to forge diverse partnerships across our political spectrum. Many achievements of recent years were made possible by Democrats and Republicans; Federal, state and local governments; and the public and private sectors working together. But, we face continued challenges, including political dysfunction in Washington that undermines national unity, stifles bipartisan cooperation, and ultimately erodes the perception and strength of our leadership abroad. American leadership is always most powerful when we are able to forge common ground at home around key national priorities.

We will lead with capable partners. In an interconnected world, there are no global problems that can be solved without the United States, and few that can be solved by the United States alone. American leadership remains essential for mobilizing collective action to address global risks and seize strategic opportunities. Our closest partners and allies will remain the cornerstone of our international engagement. Yet, we will continuously expand the scope of cooperation to encompass other state partners, non-state and private actors, and international

institutions—particularly the United Nations (U.N.), international financial institutions, and key regional organizations. These partnerships can deliver essential capacity to share the burdens of maintaining global security and prosperity and to uphold the norms that govern responsible international behavior. At the same time, we and our partners must make the reforms and investments needed to make sure we can work more effectively with each other while growing the ranks of responsible, capable states. The United States is safer and stronger when fewer people face destitution, when our trading partners are flourishing, and when societies are freer.

We will lead with all the instruments of U.S. power. Our influence is greatest when we combine all our strategic advantages. Our military will remain ready to defend our enduring national interests while providing essential leverage for our diplomacy. The use of force is not, however, the only tool at our disposal, and it is not the principal means of U.S. engagement abroad, nor always the most effective for the challenges we face. Rather, our first line of action is principled and clear-eyed diplomacy, combined with the central role of development in the forward defense and promotion of America's interests. We will continue pursuing measures to enhance the security of our diplomats and development professionals to ensure they can fulfill their responsibilities safely in high-risk environments. We will also leverage a strong and well-regulated economy to promote trade and investment while protecting the international financial system from abuse. Targeted economic sanctions will remain an effective tool for imposing costs on irresponsible actors and helping to dismantle criminal and terrorist networks. All our tools are made more effective by the skill of our intelligence professionals and the quality of intelligence they collect, analyze, and produce. Finally, we will apply our distinct advantages in law enforcement, science and technology, and people-to-people relationships to maximize the strategic effects of our national power.

We will lead with a long-term perspective. Around the world, there are historic transitions underway that will unfold over decades. This strategy positions America to influence their trajectories, seize the opportunities they create, and manage the risks they present. Five recent transitions, in particular, have significantly changed the security landscape, including since our last strategy in 2010.

First, power among states is more dynamic. The increasing use of the G-20 on global economic matters reflects an evolution in economic power, as does the rise of Asia, Latin America, and Africa. As the balance of economic power changes, so do expectations about influence over international affairs. Shifting power dynamics create both opportunities and risks for cooperation, as some states have been more willing than others to assume responsibilities commensurate with their greater economic capacity. In particular, India's potential, China's rise, and Russia's aggression all significantly impact the future of major power relations.

Second, power is shifting below and beyond the nation-state. Governments once able to operate with few checks and balances are increasingly expected to be more accountable to sub-state and non-state actors—from mayors of mega-cities and leaders in private industry to a more empowered civil society. They are also contending with citizens enabled by technology, youth as a majority in many societies, and a growing global middle class with higher expectations for governance and economic opportunity. While largely positive, these trends can foster violent non-state actors and foment instability—especially in fragile states where governance is weak or has broken down—or invite backlash by authoritarian regimes determined to preserve the power of the state.

Third, the increasing interdependence of the global economy and rapid pace of technological change are linking individuals, groups, and governments in unprecedented ways. This enables and incentivizes new forms of cooperation to establish dynamic security networks, expand international trade and investment, and transform global communications. It also creates shared vulnerabilities, as interconnected systems and sectors are susceptible to the threats of climate change, malicious cyber activity, pandemic diseases, and transnational terrorism and crime.

Fourth, a struggle for power is underway among and within many states of the Middle East and North Africa. This is a generational struggle in the aftermath of the 2003 Iraq war and 2011 Arab uprisings, which will redefine the region as well as relationships among communities and between citizens and their governments. This process will continue to be combustible, especially in societies where religious extremists take root, or rulers reject democratic reforms, exploit their economies, and crush civil society.

Fifth, the global energy market has changed dramatically. The United States is now the world's largest natural gas and oil producer. Our dependence on foreign oil is at a 20-year low—and declining—and we are

leading a new clean energy economy. While production in the Middle East and elsewhere remains vitally important for the global market, increased U.S. production is helping keep markets well-supplied and prices conducive to economic growth. On the other hand, energy security concerns have been exacerbated by European dependence on Russian natural gas and the willingness of Russia to use energy for political ends. At the same time, developing countries now consume more energy than developed ones, which is altering energy flows and changing consumer relationships.

Today's strategic environment is fluid. Just as the United States helped shape the course of events in the last century, so must we influence their trajectory today by evolving the way we exercise American leadership. This strategy outlines priorities based on a realistic assessment of the risks to our enduring national interests and the opportunities for advancing them. This strategy eschews orienting our entire foreign policy around a single threat or region. It establishes instead a diversified and balanced set of priorities appropriate for the world's leading global power with interests in every part of an increasingly interconnected world.

II. Security

The United States government has no greater responsibility than protecting the American people. Yet, our obligations do not end at our borders. We embrace our responsibilities for underwriting international security because it serves our interests, upholds our commitments to allies and partners, and addresses threats that are truly global. There is no substitute for American leadership whether in the face of aggression, in the cause of universal values, or in the service of a more secure America. Fulfilling our responsibilities depends on a strong defense and secure homeland. It also requires a global security posture in which our unique capabilities are employed within diverse international coalitions and in support of local partners. Such a shift is possible after a period of prolonged combat. Six years ago, there were roughly 180,000 U.S. troops in Iraq and Afghanistan. Today, there are fewer than 15,000. This transition has dramatically reduced U.S. casualties and allows us to realign our forces and resources to meet an evolving set of threats while securing our strategic objectives.

In so doing, we will prioritize collective action to meet the persistent threat posed by terrorism today, especially from al-Qa'ida, ISIL, and their affiliates. In addition to acting decisively to defeat direct threats, we will focus on building the capacity of others to prevent the causes and consequences of conflict to include countering extreme and dangerous ideologies. Keeping nuclear materials from terrorists and preventing the proliferation of nuclear weapons remains a high priority, as does mobilizing the international community to meet the urgent challenges posed by climate change and infectious disease. Collective action is needed to assure access to the shared spaces—cyber, space, air, and oceans—where the dangerous behaviors of some threaten us all.

Our allies will remain central to all these efforts. The North Atlantic Treaty Organization (NATO) is the world's preeminent multilateral alliance, reinforced by the historic close ties we have with the United Kingdom, France, Germany, Italy, and Canada. NATO is stronger and more cohesive than at any point in its history, especially due to contributions of the Nordic countries and newer members like Poland and the Baltic countries. Our alliances in Asia underwrite security and enable prosperity throughout Asia and the Pacific. We will continue to modernize these essential bilateral alliances while enhancing the security ties among our allies. Japan, South Korea, and Australia, as well as our close partner in New Zealand, remain the model for interoperability while we reinvigorate our ties to the Philippines and preserve our ties to Thailand. And our allies and partners in other regions, including our security partnership and people-to-people ties with Israel, are essential to advancing our interests.

Strengthen Our National Defense

A strong military is the bedrock of our national security. During over a decade of war, the All-Volunteer Force has answered our Nation's call. To maintain our military edge and readiness, we will continue to insist on reforms and necessary investment in our military forces and their families. Our military will remain ready to deter and defeat threats to the homeland, including against missile, cyber, and terrorist attacks, while mitigating the effects of potential attacks and natural disasters. Our military is postured globally to protect our citizens and interests, preserve regional stability, render humanitarian assistance and disaster relief, and build the capacity of our partners to join with us in meeting security challenges.

U.S. forces will continue to defend the homeland, conduct global counterterrorism operations, assure allies, and deter aggression through forward presence and engagement. If deterrence fails, U.S. forces will be ready to project power globally to defeat and deny aggression in multiple theaters.

As we modernize, we will apply the lessons of past drawdowns. Although our military will be smaller, it must remain dominant in every domain. With the Congress, we must end sequestration and enact critical reforms to build a versatile and responsive force prepared for a more diverse set of contingencies. We will protect our investment in foundational capabilities like the nuclear deterrent, and we will grow our investment in crucial capabilities like cyber; space; and intelligence, surveillance, and reconnaissance. We will safeguard our science and technology base to keep our edge in the capabilities needed to prevail against any adversary. Above all, we will take care of our people. We will recruit and retain the best talent while developing leaders committed to an ethical and expert profession of arms. We will honor our sacred trust with Veterans and the families and communities that support them, making sure those who have served have the benefits, education, and opportunities they have earned.

We will be principled and selective in the use of force. The use of force should not be our first choice, but it will sometimes be the necessary choice. The United States will use military force, unilaterally if necessary, when our enduring interests demand it: when our people are threatened; when our livelihoods are at stake; and when the security of our allies is in danger. In these circumstances, we prefer to act with allies and partners. The threshold for military action is higher when our interests are not directly threatened. In such cases, we will seek to mobilize allies and partners to share the burden and achieve lasting outcomes. In all cases, the decision to use force must reflect a clear mandate and feasible objectives, and we must ensure our actions are effective, just, and consistent with the rule of law. It should be based on a serious appreciation for the risk to our mission, our global responsibilities, and the opportunity costs at home and abroad. Whenever and wherever we use force, we will do so in a way that reflects our values and strengthens our legitimacy.

Reinforce Homeland Security

Our homeland is more secure. But, we must continue to learn and adapt to evolving threats and hazards. We are better able to guard against terrorism—the core responsibility of homeland security—as well as illicit networks and other threats and hazards due to improved information sharing, aviation and border security, and international cooperation. We have emphasized community-based efforts and local law enforcement programs to counter homegrown violent extremism and protect vulnerable individuals from extremist ideologies that could lead them to join conflicts overseas or carry out attacks here at home. Through risk-based approaches, we have countered terrorism and transnational organized crime in ways that enhance commerce, travel, and tourism and, most fundamentally, preserve our civil liberties. We are more responsive and resilient when prevention fails or disaster strikes as witnessed with the Boston Marathon bombings and Hurricane Sandy.

The essential services that underpin American society must remain secure and functioning in the face of diverse threats and hazards. Therefore, we take a Whole of Community approach, bringing together all elements of our society—individuals, local communities, the private and non-profit sectors, faith-based organizations, and all levels of government—to make sure America is resilient in the face of adversity.

We are working with the owners and operators of our Nation's critical cyber and physical infrastructure across every sector—financial, energy, transportation, health, information technology, and more—to decrease vulnerabilities and increase resilience. We are partnering with states and local communities to better plan for, absorb, recover from, and adapt to adverse events brought about by the compounding effects of climate change. We will also continue to enhance pandemic preparedness at home and address the threat arising from new drug-resistant microbes and biological agents.

Combat the Persistent Threat of Terrorism

The threat of catastrophic attacks against our homeland by terrorists has diminished but still persists. An array of terrorist threats has gained traction in areas of instability, limited opportunity, and broken governance. Our adversaries are not confined to a distinct country or region. Instead, they range from South Asia through the Middle East and into Africa. They include globally oriented groups like al-Qa'ida and its affiliates, as well as a growing

number of regionally focused and globally connected groups—many with an al-Qa'ida pedigree like ISIL, which could pose a threat to the homeland.

We have drawn from the experience of the last decade and put in place substantial changes to our efforts to combat terrorism, while preserving and strengthening important tools that have been developed since 9/11. Specifically, we shifted away from a model of fighting costly, large-scale ground wars in Iraq and Afghanistan in which the United States—particularly our military—bore an enormous burden. Instead, we are now pursuing a more sustainable approach that prioritizes targeted counterterrorism operations, collective action with responsible partners, and increased efforts to prevent the growth of violent extremism and radicalization that drives increased threats. Our leadership will remain essential to disrupting the unprecedented flow of foreign terrorist fighters to and from conflict zones. We will work to address the underlying conditions that can help foster violent extremism such as poverty, inequality, and repression. This means supporting alternatives to extremist messaging and greater economic opportunities for women and disaffected youth. We will help build the capacity of the most vulnerable states and communities to defeat terrorists locally. Working with the Congress, we will train and equip local partners and provide operational support to gain ground against terrorist groups. This will include efforts to better fuse and share information and technology as well as to support more inclusive and accountable governance.

In all our efforts, we aim to draw a stark contrast between what we stand for and the heinous deeds of terrorists. We reject the lie that America and its allies are at war with Islam. We will continue to act lawfully. Outside of areas of active hostilities, we endeavor to detain, interrogate, and prosecute terrorists through law enforcement. However, when there is a continuing, imminent threat, and when capture or other actions to disrupt the threat are not feasible, we will not hesitate to take decisive action. We will always do so legally, discriminately, proportionally, and bound by strict accountability and strong oversight. The United States—not our adversaries—will define the nature and scope of this struggle, lest it define us.

Our counterterrorism approach is at work with several states, including Somalia, Afghanistan and Iraq. In Afghanistan, we have ended our combat mission and transitioned to a dramatically smaller force focused on the goal of a sovereign and stable partner in Afghanistan that is not a safe haven for international terrorists. This has been made possible by the extraordinary sacrifices of our U.S. military, civilians throughout the interagency, and our international partners. They delivered justice to Osama bin Laden and significantly degraded al-Qa'ida's core leadership. They helped increase life expectancy, access to education, and opportunities for women and girls. Going forward, we will work with partners to carry out a limited counterterrorism mission against the remnants of core al-Qa'ida and maintain our support to the Afghan National Security Forces (ANSF). We are working with NATO and our other partners to train, advise, and assist the ANSF as a new government takes responsibility for the security and well-being of Afghanistan's citizens. We will continue to help improve governance that expands opportunity for all Afghans, including women and girls. We will also work with the countries of the region, including Pakistan, to mitigate the threat from terrorism and to support a viable peace and reconciliation process to end the violence in Afghanistan and improve regional stability.

We have undertaken a comprehensive effort to degrade and ultimately defeat ISIL. We will continue to support Iraq as it seeks to free itself from sectarian conflict and the scourge of extremists. Our support is tied to the government's willingness to govern effectively and inclusively and to ensure ISIL cannot sustain a safe haven on Iraqi territory. This requires professional and accountable Iraqi Security Forces that can overcome sectarian divides and protect all Iraqi citizens. It also requires international support, which is why we are leading an unprecedented international coalition to work with the Iraqi government and strengthen its military to regain sovereignty. Joined by our allies and partners, including multiple countries in the region, we employed our unique military capabilities to arrest ISIL's advance and to degrade their capabilities in both Iraq and Syria. At the same time, we are working with our partners to train and equip a moderate Syrian opposition to provide a counterweight to the terrorists and the brutality of the Assad regime. Yet, the only lasting solution to Syria's civil war remains political—an inclusive political transition that responds to the legitimate aspirations of all Syrian citizens.

Build Capacity to Prevent Conflict

We will strengthen U.S. and international capacity to prevent conflict among and within states. In the realm of inter-state conflict, Russia's violation of Ukraine's sovereignty and territorial integrity—as well as its belligerent stance toward other neighboring countries—endangers international norms that have largely been taken for granted

since the end of the Cold War. Meanwhile, North Korean provocation and tensions in the East and South China Seas are reminders of the risks of escalation. American diplomacy and leadership, backed by a strong military, remain essential to deterring future acts of inter-state aggression and provocation by reaffirming our security commitments to allies and partners, investing in their capabilities to withstand coercion, imposing costs on those who threaten their neighbors or violate fundamental international norms, and embedding our actions within wider regional strategies.

Within states, the nexus of weak governance and widespread grievance allows extremism to take root, violent non-state actors to rise up, and conflict to overtake state structures. To meet these challenges, we will continue to work with partners and through multilateral organizations to address the root causes of conflict before they erupt and to contain and resolve them when they do. We prefer to partner with those fragile states that have a genuine political commitment to establishing legitimate governance and providing for their people. The focus of our efforts will be on proven areas of need and impact, such as inclusive politics, enabling effective and equitable service delivery, reforming security and rule of law sectors, combating corruption and organized crime, and promoting economic opportunity, particularly among youth and women. We will continue to lead the effort to ensure women serve as mediators of conflict and in peacebuilding efforts, and they are protected from gender-based violence.

We will continue to bolster the capacity of the U.N. and regional organizations to help resolve disputes, build resilience to crises and shocks, strengthen governance, end extreme poverty, and increase prosperity, so that fragile states can provide for the basic needs of their citizens and can avoid being vulnerable hosts for extremism and terrorism. We will meet our financial commitments to the U.N., press for reforms to strengthen peacekeeping, and encourage more contributions from advanced militaries. We will strengthen the operational capacity of regional organizations like the African Union (AU) and broaden the ranks of capable troop-contributing countries, including through the African Peacekeeping Rapid Response Partnership, which will help African countries rapidly deploy to emerging crises.

Prevent the Spread and Use of Weapons of Mass Destruction

No threat poses as grave a danger to our security and well-being as the potential use of nuclear weapons and materials by irresponsible states or terrorists. We therefore seek the peace and security of a world without nuclear weapons. As long as nuclear weapons exist, the United States must invest the resources necessary to maintain—without testing—a safe, secure, and effective nuclear deterrent that preserves strategic stability. However, reducing the threat requires us to constantly reinforce the basic bargain of the Nuclear Non-Proliferation Treaty, which commits nuclear weapons states to reduce their stockpiles while non-nuclear weapons states remain committed to using nuclear energy only for peaceful purposes. For our part, we are reducing the role and number of nuclear weapons through New START and our own strategy. We will continue to push for the entry into force of important multilateral agreements like the Comprehensive Nuclear Test-Ban Treaty and the various regional nuclear weapons-free zone protocols, as well as the creation of a Fissile Material Cut-Off Treaty.

Vigilance is required to stop countries and non-state actors from developing or acquiring nuclear, chemical, or biological weapons, or the materials to build them. The Nuclear Security Summit process has catalyzed a global effort to lock down vulnerable nuclear materials and institutionalize nuclear security best practices. Our commitment to the denuclearization of the Korean Peninsula is rooted in the profound risks posed by North Korean weapons development and proliferation. Our efforts to remove and destroy chemical weapons in Libya and Syria reflect our leadership in implementation and progress toward universalization of the Chemical Weapons Convention.

We have made clear Iran must meet its international obligations and demonstrate its nuclear program is entirely peaceful. Our sanctions regime has demonstrated that the international community can—and will—hold accountable those nations that do not meet their obligations, while also opening up a space for a diplomatic resolution. Having reached a first step arrangement that stops the progress of Iran's nuclear program in exchange for limited relief, our preference is to achieve a comprehensive and verifiable deal that assures Iran's nuclear program is solely for peaceful purposes. This is the best way to advance our interests, strengthen the global nonproliferation regime, and enable Iran to access peaceful nuclear energy. However, we retain all options to achieve the objective of preventing Iran from producing a nuclear weapon.

Confront Climate Change

Climate change is an urgent and growing threat to our national security, contributing to increased natural disasters, refugee flows, and conflicts over basic resources like food and water. The present day effects of climate change are being felt from the Arctic to the Midwest. Increased sea levels and storm surges threaten coastal regions, infrastructure, and property. In turn, the global economy suffers, compounding the growing costs of preparing and restoring infrastructure.

America is leading efforts at home and with the international community to confront this challenge. Over the last 6 years, U.S. emissions have declined by a larger total magnitude than those of any other country. Through our Climate Action Plan and related executive actions, we will go further with a goal of reducing greenhouse gas emissions by 26 to 28 percent of 2005 levels by 2025. Working with U.S. states and private utilities, we will set the first-ever standards to cut the amount of carbon pollution our power plants emit into the air. We are also working to strengthen resilience and address vulnerabilities to climate impacts.

These domestic efforts contribute to our international leadership. Building on the progress made in Copenhagen and in ensuing negotiations, we are working toward an ambitious new global climate change agreement to shape standards for prevention, preparedness, and response over the next decade. As the world's two largest emitters, the United States and China reached a landmark agreement to take significant action to reduce carbon pollution. The substantial contribution we have pledged to the Green Climate Fund will help the most vulnerable developing nations deal with climate change, reduce their carbon pollution, and invest in clean energy. More than 100 countries have also joined with us to reduce greenhouse gases under the Montreal Protocol—the same agreement the world used successfully to phase out ozone-depleting chemicals. We are partnering with African entrepreneurs to launch clean energy projects and helping farmers practice climate-smart agriculture and plant more durable crops. We are also driving collective action to reduce methane emissions from pipelines and to launch a free trade agreement for environmental goods.

Assure Access to Shared Spaces

The world is connected by shared spaces—cyber, space, air, and oceans—that enable the free flow of people, goods, services, and ideas. They are the arteries of the global economy and civil society, and access is at risk due to increased competition and provocative behaviors. Therefore, we will continue to promote rules for responsible behavior while making sure we have the capabilities to assure access to these shared spaces.

Cybersecurity

As the birthplace of the Internet, the United States has a special responsibility to lead a networked world. Prosperity and security increasingly depend on an open, interoperable, secure, and reliable Internet. Our economy, safety, and health are linked through a networked infrastructure that is targeted by malicious government, criminal, and individual actors who try to avoid attribution. Drawing on the voluntary cybersecurity framework, we are securing Federal networks and working with the private sector, civil society, and other stakeholders to strengthen the security and resilience of U.S. critical infrastructure. We will continue to work with the Congress to pursue a legislative framework that ensures high standards. We will defend ourselves, consistent with U.S. and international law, against cyber attacks and impose costs on malicious cyber actors, including through prosecution of illegal cyber activity. We will assist other countries to develop laws that enable strong action against threats that originate from their infrastructure. Globally, cybersecurity requires that long-standing norms of international behavior—to include protection of intellectual property, online freedom, and respect for civilian infrastructure—be upheld, and the Internet be managed as a shared responsibility between states and the private sector with civil society and Internet users as key stakeholders.

Space Security

Space systems allow the world to navigate and communicate with confidence to save lives, conduct commerce, and better understand the human race, our planet, and the depths of the universe. As countries increasingly derive benefits from space, we must join together to deal with threats posed by those who may wish to

deny the peaceful use of outer space. We are expanding our international space cooperation activities in all sectors, promoting transparency and confidence-building measures such as an International Code of Conduct on Outer Space Activities, and expanding partnerships with the private sector in support of missions and capabilities previously claimed by governments alone. We will also develop technologies and tactics to deter and defeat efforts to attack our space systems; enable indications, warning, and attributions of such attacks; and enhance the resiliency of critical U.S. space capabilities.

Air and Maritime Security

The United States has an enduring interest in freedom of navigation and overflight as well as the safety and sustainability of the air and maritime environments. We will therefore maintain the capability to ensure the free flow of commerce, to respond quickly to those in need, and to deter those who might contemplate aggression. We insist on safe and responsible behaviors in the sky and at sea. We reject illegal and aggressive claims to airspace and in the maritime domain and condemn deliberate attacks on commercial passenger traffic. On territorial disputes, particularly in Asia, we denounce coercion and assertive behaviors that threaten escalation. We encourage open channels of dialogue to resolve disputes peacefully in accordance with international law. We also support the early conclusion of an effective code of conduct for the South China Sea between China and the Association of Southeast Asian States (ASEAN). America's ability to press for the observance of established customary international law reflected in the U.N. Convention on the Law of the Sea will be enhanced if the Senate provides its advice and consent—the ongoing failure to ratify this Treaty undermines our national interest in a rules-based international order. Finally, we seek to build on the unprecedented international cooperation of the last few years, especially in the Arctic as well as in combatting piracy off the Horn of Africa and drug-smuggling in the Caribbean Sea and across Southeast Asia.

Increase Global Health Security

The spread of infectious diseases constitute a growing risk. The Ebola epidemic in West Africa highlights the danger of a raging virus. The spread of new microbes or viruses, the rise and spread of drug resistance, and the deliberate release of pathogens all represent threats that are exacerbated by the globalization of travel, food production and supply, and medical products. Despite important scientific, technological, and organizational accomplishments, most countries have not yet achieved international core competencies for health security, and many lack sufficient capacity to prevent, detect, or respond to disease outbreaks.

America is the world leader in fighting pandemics, including HIV/AIDS, and in improving global health security. At home, we are strengthening our ability to prevent outbreaks and ensure sufficient capacity to respond rapidly and manage biological incidents. As an exemplar of a modern and responsive public health system, we will accelerate our work with partners through the Global Health Security Agenda in pursuit of a world that is safer and more secure from infectious disease. We will save lives by strengthening regulatory frameworks for food safety and developing a global system to prevent avoidable epidemics, detect and report disease outbreaks in real time, and respond more rapidly and effectively. Finally, we will continue to lead efforts to combat the rise of antibiotic resistant bacteria.

III. Prosperity

Our economy is the largest, most open, and innovative in the world. Our leadership has also helped usher in a new era of unparalleled global prosperity. Sustaining our leadership depends on shaping an emerging global economic order that continues to reflect our interests and values. Despite its success, our rules-based system is now competing against alternative, less-open models. Moreover, the American consumer cannot sustain global demand—growth must be more balanced. To meet this challenge, we must be strategic in the use of our economic strength to set new rules of the road, strengthen our partnerships, and promote inclusive development.

Through our trade and investment policies, we will shape globalization so that it is working for American workers. By leveraging our improved economic and energy position, we will strengthen the global financial system and advance high-standard trade deals. We will ensure tomorrow's global trading system is consistent with our interests and values by seeking to establish and enforce rules through international institutions and regional

initiatives and by addressing emerging challenges like state-owned enterprises and digital protectionism. U.S. markets and educational opportunities will help the next generation of global entrepreneurs sustain momentum in growing a global middle class. To prevent conflict and promote human dignity, we will also pursue policies that eradicate extreme poverty and reduce inequality.

Put Our Economy to Work

The American economy is an engine for global economic growth and a source of stability for the international system. In addition to being a key measure of power and influence in its own right, it underwrites our military strength and diplomatic influence. A strong economy, combined with a prominent U.S. presence in the global financial system, creates opportunities to advance our security.

To ensure our economic competitiveness, we are investing in a new foundation for sustained economic growth that creates good jobs and rising incomes. Because knowledge is the currency of today's global economy, we must keep expanding access to early childhood and affordable higher education. The further acceleration of our manufacturing revolution will create the next generation of high technology manufacturing jobs. Immigration reform that combines smart and effective enforcement of the law with a pathway to citizenship for those who earn it remains an imperative. We will deliver quality, affordable healthcare to more and more Americans. We will also support job creation, strengthen the middle class, and spur economic growth by opening markets and leveling the playing field for American workers and businesses abroad. Jobs will also grow as we expand our work with trading partners to eliminate barriers to the full deployment of U.S. innovation in the digital space. These efforts are complemented by more modern and reliable infrastructure that ensures safety and enables growth.

In addition to the positive benefits of trade and commerce, a strong and well-regulated economy positions the United States to lead international efforts to promote financial transparency and prevent the global financial system from being abused by transnational criminal and terrorist organizations to engage in, or launder the proceeds of illegal activity. We will continue to work within the Financial Action Task Force, the G-20, and other fora to enlist all nations in the fight to protect the integrity of the global financial system.

Advance Our Energy Security

The United States is now the world leader in oil and gas production. America's energy revival is not only good for growth, it offers new buffers against the coercive use of energy by some and new opportunities for helping others transition to low-carbon economies. American oil production has increased dramatically, impacting global markets. Imports have decreased substantially, reducing the funds we send overseas. Consumption has declined, reducing our vulnerability to global supply disruption and price shocks. However, we still have a significant stake in the energy security of our allies in Europe and elsewhere. Seismic shifts in supply and demand are underway across the globe. Increasing global access to reliable and affordable energy is one of the most powerful ways to support social and economic development and to help build new markets for U.S. technology and investment.

The challenges faced by Ukrainian and European dependence on Russian energy supplies puts a spotlight on the need for an expanded view of energy security that recognizes the collective needs of the United States, our allies, and trading partners as well as the importance of competitive energy markets. Therefore, we must promote diversification of energy fuels, sources, and routes, as well as encourage indigenous sources of energy supply. Greater energy security and independence within the Americas is central to these efforts. We will also stay engaged with global suppliers and our partners to reduce the potential for energy-related conflict in places like the Arctic and Asia. Our energy security will be further enhanced by living up to commitments made in the Rome Declaration and through our all-of-the-above energy strategy for a low-carbon world. We will continue to develop American fossil resources while becoming a more efficient country that develops cleaner, alternative fuels and vehicles. We are demonstrating that America can and will lead the global economy while reducing our emissions.

Lead in Science, Technology, and Innovation

Scientific discovery and technological innovation empower American leadership with a competitive edge that secures our military advantage, propels our economy, and improves the human condition. Sustaining that edge requires robust Federal investments in basic and applied research. We must also strengthen science, technology, engineering, and mathematics (STEM) education to produce tomorrow's discoverers, inventors, entrepreneurs, and high-skills workforce. Our commitment remains strong to preparation and compensation for STEM teachers, broadband connectivity and high-tech educational tools for schools, programs that inspire and provide opportunities for girls and underrepresented minorities, and support for innovation in STEM teaching and inclusion in higher education. We will also keep our edge by opening our national labs to more commercial partnerships while tapping research and development in the private sector, including a wide range of start-ups and firms at the leading edge of America's innovation economy.

Shape the Global Economic Order

We have recovered from the global economic crisis, but much remains to be done to shape the emerging economic order to avoid future crises. We have responsibilities at home to continue to improve our banking practices and forge ahead with regulatory reform, even as we press others to align with our robust standards. In addition to securing our immediate economic interests, we must drive the inclusive economic growth that creates demand for American exports. We will protect the free movement of information and work to prevent the risky behavior that led to the recent crisis, while addressing resurgent economic forces, from state capitalism to market-distorting free-riding.

American leadership is central to strengthening global finance rules and making sure they are consistent and transparent. We will work through the G-20 to reinforce the core architecture of the international financial and economic system, including the World Trade Organization, to ensure it is positioned to foster both stability and growth. We remain committed to governance reforms for these same institutions, including the World Bank and the International Monetary Fund, to make them more effective and representative. In so doing, we seek to ensure institutions reinforce, rather than undermine, an effective global financial system.

We believe trade agreements have economic and strategic benefits for the United States. We will therefore work with the Congress to achieve bipartisan renewal of Trade Promotion Authority and to advance a trade agenda that brings jobs to our shores, increases standards of living, strengthens our partners and allies, and promotes stability in critical regions. The United States has one of the most open economies in the world. Our tariffs are low, and we do not use regulation to discriminate against foreign goods. The same is not true throughout the world, which is why our trade agenda is focused on lowering tariffs on American products, breaking down barriers to our goods and services, and setting higher standards to level the playing field for American workers and firms.

Through the Trans-Pacific Partnership (TPP) and Transatlantic Trade and Investment Partnership (T-TIP), we are setting the world's highest standards for labor rights and environmental protection, while removing barriers to U.S. exports and putting the United States at the center of a free trade zone covering two-thirds of the global economy. Our goal is to use this position, along with our highly skilled workforce, strong rule of law, and abundant supply of affordable energy, to make America the production platform of choice and the premier investment destination. In addition to these major regional agreements, we will work to achieve groundbreaking agreements to liberalize trade in services, information technology, and environmental goods—areas where the United States is a global leader in innovation. And we will make it easier for businesses of all sizes to expand their reach by improving supply chains and regulatory cooperation.

All countries will benefit when we open markets further, extend and enhance tools such as the African Growth and Opportunity Act (AGOA), and reduce inefficiencies in the global trading system through trade facilitation improvements. And through our development initiatives—such as Power Africa, Trade Africa, Feed the Future, and the Open Government Partnership—we will continue to work closely with governments, the private sector, and civil society to foster inclusive economic growth, reduce corruption, and build capacity at the local level. Investment in critical infrastructure and security will facilitate trade among countries, especially for developing and emerging economies.

End Extreme Poverty

We have an historic opportunity to end extreme poverty within a generation and put our societies on a path of shared and sustained prosperity. In so doing, we will foster export markets for U.S. businesses, improve investment opportunities, and decrease the need for costly military interventions. Growth in the global economy has lifted hundreds of millions out of extreme poverty. We have already made significant progress guided in part through global consensus and mobilization around the Millennium Development Goals. The world cut the percentage of people living in extreme poverty in half between 1990 and 2010. In that period, nearly 800 million people rose above the international poverty line. By 2012, child deaths were down almost 50 percent since 1990. Twenty-nine countries registered as low-income in 2000 have today achieved middle-income status, and private capital and domestic resources far outstrip donor assistance as the primary means for financing development. Trends in economic growth also signal what is possible; sub-Saharan Africa has averaged an aggregate annual growth rate of over 5 percent for the last decade despite the disruptions of the world financial crisis.

We are now working with many partners to put ending extreme poverty at the center of a new global sustainable development agenda that will mobilize action for the next 15 years. We will press for transformative investments in areas like women's equality and empowerment, education, sustainable energy, and governance. We will use trade and investment to harness job-rich economic growth. We will concentrate on the clear need for country ownership and political commitment and reinforce the linkage between social and economic development. We will lead the effort to marshal diverse resources and broad coalitions to advance the imperative of accountable, democratic governance.

We will use our leadership to promote a model of financing that leverages billions in investment from the private sector and draws on America's scientific, technological, and entrepreneurial strengths to take to scale proven solutions in partnership with governments, business, and civil society. And we will leverage our leadership in promoting food security, enhancing resilience, modernizing rural agriculture, reducing the vulnerability of the poor, and eliminating preventable child and maternal deaths as we drive progress toward an AIDS-free generation.

IV. Values

To lead effectively in a world experiencing significant political change, the United States must live our values at home while promoting universal values abroad. From the Middle East to Ukraine to Southeast Asia to the Americas, citizens are more empowered in seeking greater freedoms and accountable institutions. But these demands have often produced an equal and opposite reaction from backers of discredited authoritarian orders, resulting in crackdowns and conflict. Many of the threats to our security in recent years arose from efforts by authoritarian states to oppose democratic forces—from the crisis caused by Russian aggression in Ukraine to the rise of ISIL within the Syrian civil war. By the same token, many of our greatest opportunities stem from advances for liberty and rule of law—from sub-Saharan Africa to Eastern Europe to Burma.

Defending democracy and human rights is related to every enduring national interest. It aligns us with the aspirations of ordinary people throughout the world. We know from our own history people must lead their own struggles for freedom if those struggles are to succeed. But America is also uniquely situated—and routinely expected—to support peaceful democratic change. We will continue mobilizing international support to strengthen and expand global norms of human rights. We will support women, youth, civil society, journalists, and entrepreneurs as drivers of change. We will continue to insist that governments uphold their human rights obligations, speak out against repression wherever it occurs, and work to prevent, and, if necessary, respond to mass atrocities.

Our closest allies in these efforts will be, as they always have, other democratic states. But, even where our strategic interests require us to engage governments that do not share all our values, we will continue to speak out clearly for human rights and human dignity in our public and private diplomacy. Any support we might provide will be balanced with an awareness of the costs of repressive policies for our own security interests and the democratic values by which we live. Because our human rights advocacy will be most effective when we work in concert with a wide range of partners, we are building coalitions with civil society, religious leaders, businesses, other governments, and international organizations. We will also work to ensure people enjoy the same rights—and security—online as they are entitled to enjoy offline by opposing efforts to restrict information and punish speech.

Live Our Values

Our values are a source of strength and security, and our ability to promote our values abroad is directly tied to our willingness to abide by them at home. In recent years, questions about America's post-9/11 security policies have often been exploited by our adversaries, while testing our commitment to civil liberties and the rule of law at home. For the sake of our security and our leadership in the world, it is essential we hold ourselves to the highest possible standard, even as we do what is necessary to secure our people.

To that end, we strengthened our commitment against torture and have prohibited so-called enhanced interrogation techniques that were contrary to American values, while implementing stronger safeguards for the humane treatment of detainees. We have transferred many detainees from Guantanamo Bay, and we are working with the Congress to remove the remaining restrictions on detainee transfers so that we can finally close it. Where prosecution is an option, we will bring terrorists to justice through both civilian and, when appropriate, reformed military commission proceedings that incorporate fundamental due process and other protections essential to the effective administration of justice.

Our vital intelligence activities are also being reformed to preserve the capabilities needed to secure our interests while continuing to respect privacy and curb the potential for abuse. We are increasing transparency so the public can be confident our surveillance activities are consistent with the rule of law and governed by effective oversight. We have not and will not collect signals intelligence to suppress criticism or dissent or to afford a competitive advantage to U.S. companies. Safeguards currently in place governing how we retain and share intelligence are being extended to protect personal information regardless of nationality.

Advance Equality

American values are reflective of the universal values we champion all around the world—including the freedoms of speech, worship, and peaceful assembly; the ability to choose leaders democratically; and the right to due process and equal administration of justice. We will be a champion for communities that are too frequently vulnerable to violence, abuse, and neglect—such as ethnic and religious minorities; people with disabilities; Lesbian, Gay, Bisexual, and Transgender (LGBT) individuals; displaced persons; and migrant workers.

Recognizing that no society will succeed if it does not draw on the potential of all its people, we are pressing for the political and economic participation of women and girls—who are too often denied their inalienable rights and face substantial barriers to opportunity in too many places. Our efforts include helping girls everywhere get the education they need to participate fully in the economy and realize their potential. We are focused on reducing the scourge of violence against women around the globe by providing support for affected populations and enhancing efforts to improve judicial systems so perpetrators are held accountable.

Support Emerging Democracies

The United States will concentrate attention and resources to help countries consolidate their gains and move toward more democratic and representative systems of governance. Our focus is on supporting countries that are moving in the right direction—whether it is the peaceful transitions of power we see in sub-Saharan Africa; the movement toward constitutional democracy in Tunisia; or the opening taking place in Burma. In each instance, we are creating incentives for positive reform and disincentives for backsliding.

The road from demanding rights in the square to building institutions that guarantee them is long and hard. In the last quarter century, parts of Eastern Europe, Latin America, Africa, and East Asia have consolidated transitions to democracy, but not without setbacks. The popular uprisings that began in the Arab world took place in a region with weaker democratic traditions, powerful authoritarian elites, sectarian tensions, and active violent extremist elements, so it is not surprising setbacks have thus far outnumbered triumphs. Yet, change is inevitable in the Middle East and North Africa, as it is in all places where the illusion of stability is artificially maintained by silencing dissent.

But the direction of that change is not predetermined. We will therefore continue to look for ways to support the success and ease the difficulties of democratic transitions through responsible assistance, investment and trade, and by supporting political, economic, and security reforms. We will continue to push for reforms in authoritarian countries not currently undergoing wholesale transitions. Good governance is also predicated on strengthening the state-society relationship. When citizens have a voice in the decisionmaking that affects them, governments make better decisions and citizens are better able to participate, innovate, and contribute.

The corrosive effects of corruption must be overcome. While information sharing allows us to identify corrupt officials more easily, globalization has also made it easier for corrupt officials to hide the proceeds of corruption abroad, increasing the need for strong and consistent implementation of the international standards on combating illicit finance. The United States is leading the way in promoting adherence to standards of accountable and transparent governance, including through initiatives like the Open Government Partnership. We will utilize a broad range of tools to recover assets stolen by corrupt officials and make it harder for criminals to hide, launder, and benefit from illegal proceeds. Our leadership toward governance that is more open, responsible, and accountable makes clear that democracy can deliver better government and development for ordinary people.

Empower Civil Society and Young Leaders

Democracy depends on more than elections, or even government institutions. Through civil society, citizens come together to hold their leaders accountable and address challenges. Civil society organizations often drive innovations and develop new ideas and approaches to solve social, economic, and political problems that governments can apply on a larger scale. Moreover, by giving people peaceful avenues to advance their interests and express their convictions, a free and flourishing civil society contributes to stability and helps to counter violent extremism.

Still, civil society and individual activists face challenges in many parts of the world. As technology empowers individuals and nongovernmental groups to mobilize around a wide array of issues—from countering corruption and advancing the rule of law to environmental activism—political elites in authoritarian states, and even in some with more democratic traditions, are acting to restrict space for civil society. Restrictions are often seen through new laws and regulations that deny groups the foreign funding they depend on to operate, that criminalize groups of people like the LGBT community, or deny political opposition groups the freedom to assemble in peaceful protest. The United States is countering this trend by providing direct support for civil society and by advocating rollback of laws and regulations that undermine citizens' rights. We are also supporting technologies that expand access to information, enable freedom of expression, and connect civil society groups in this fight around the world.

More than 50 percent of the world's people are under 30 years old. Many struggle to make a life in countries with broken governance. We are taking the initiative to build relationships with the world's young people, identifying future leaders in government, business, and civil society and connecting them to one another and to the skills they need to thrive. We have established new programs of exchange among young Americans and young people from Africa to Southeast Asia, building off the successes of the International Visitor and Young African Leaders initiatives. We are fostering increased education exchanges in our hemisphere. And we are catalyzing economic growth and innovation within societies by lifting up and promoting entrepreneurship.

Prevent Mass Atrocities

The mass killing of civilians is an affront to our common humanity and a threat to our common security. It destabilizes countries and regions, pushes refugees across borders, and creates grievances that extremists exploit. We have a strong interest in leading an international response to genocide and mass atrocities when they arise, recognizing options are more extensive and less costly when we act preventively before situations reach crisis proportions. We know the risk of mass atrocities escalates when citizens are denied basic rights and freedoms, are unable to hold accountable the institutions of government, or face unrelenting poverty and conflict. We affirm our support for the international consensus that governments have the responsibility to protect civilians from mass atrocities and that this responsibility passes to the broader international community when those governments manifestly fail to protect their populations. We will work with the international community to prevent and call to

account those responsible for the worst human rights abuses, including through support to the International Criminal Court, consistent with U.S. law and our commitment to protecting our personnel. Moreover, we will continue to mobilize allies and partners to strengthen our collective efforts to prevent and respond to mass atrocities using all our instruments of national power.

V. International Order

We have an opportunity—and obligation—to lead the way in reinforcing, shaping, and where appropriate, creating the rules, norms, and institutions that are the foundation for peace, security, prosperity, and the protection of human rights in the 21st century. The modern-day international system currently relies heavily on an international legal architecture, economic and political institutions, as well as alliances and partnerships the United States and other like-minded nations established after World War II. Sustained by robust American leadership, this system has served us well for 70 years, facilitating international cooperation, burden sharing, and accountability. It carried us through the Cold War and ushered in a wave of democratization. It reduced barriers to trade, expanded free markets, and enabled advances in human dignity and prosperity.

But, the system has never been perfect, and aspects of it are increasingly challenged. We have seen too many cases where a failure to marshal the will and resources for collective action has led to inaction. The U.N. and other multilateral institutions are stressed by, among other things, resource demands, competing imperatives among member states, and the need for reform across a range of policy and administrative areas. Despite these undeniable strains, the vast majority of states do not want to replace the system we have. Rather, they look to America for the leadership needed to both fortify it and help it evolve to meet the wide range of challenges described throughout this strategy.

The United States will continue to make the development of sustainable solutions in all of these areas a foreign policy priority and devote diplomatic and other resources accordingly. We will continue to embrace the post-World War II legal architecture—from the U.N. Charter to the multilateral treaties that govern the conduct of war, respect for human rights, nonproliferation, and many other topics of global concern—as essential to the ordering of a just and peaceful world, where nations live peacefully within their borders, and all men and women have the opportunity to reach their potential. We will lead by example in fulfilling our responsibilities within this architecture, demonstrating to the world it is possible to protect security consistent with robust values. We will work vigorously both within the U.N. and other multilateral institutions, and with member states, to strengthen and modernize capacities—from peacekeeping to humanitarian relief—so they endure to provide protection, stability, and support for future generations.

At the same time, we will exact an appropriate cost on transgressors. Targeted economic sanctions remain an effective tool for imposing costs on those irresponsible actors whose military aggression, illicit proliferation, or unprovoked violence threaten both international rules and norms and the peace they were designed to preserve. We will pursue multilateral sanctions, including through the U.N., whenever possible, but will act alone, if necessary. Our sanctions will continue to be carefully designed and tailored to achieve clear aims while minimizing any unintended consequences for other economic actors, the global economy, and civilian populations.

In many cases, our use of targeted sanctions and other coercive measures are meant not only to uphold international norms, but to deter severe threats to stability and order at the regional level. We are not allowing the transgressors to define our regional strategies on the basis of the immediate threats they present. Rather, we are advancing a longer-term affirmative agenda in each of the regions, which prioritizes reinvigorating alliances with long-standing friends, making investments in new partnerships with emerging democratic powers with whom our interests are increasingly aligned, and continuing to support the development of capable, inclusive regional institutions to help enforce common international rules.

Advance Our Rebalance to Asia and the Pacific

The United States has been and will remain a Pacific power. Over the next 5 years, nearly half of all growth outside the United States is expected to come from Asia. That said, the security dynamics of the region—including contested maritime territorial claims and a provocative North Korea—risk escalation and conflict. American

leadership will remain essential to shaping the region's long-term trajectory to enhance stability and security, facilitate trade and commerce through an open and transparent system, and ensure respect for universal rights and freedoms.

To realize this vision, we are diversifying our security relationships in Asia as well as our defense posture and presence. We are modernizing our alliances with Japan, South Korea, Australia, and the Philippines and enhancing the interactions among them to ensure they are fully capable of responding to regional and global challenges. We are committed to strengthening regional institutions such as ASEAN, the East Asia Summit, and Asia-Pacific Economic Cooperation to reinforce shared rules and norms, forge collective responses to shared challenges, and help ensure peaceful resolution of disputes. We are also working with our Asian partners to promote more open and transparent economies and regional support for international economic norms that are vital to maintaining it as an engine for global economic growth. The TPP is central to this effort.

As we have done since World War II, the United States will continue to support the advance of security, development, and democracy in Asia and the Pacific. This is an important focus of the deepening partnerships we are building in Southeast Asia including with Vietnam, Indonesia, and Malaysia. We will uphold our treaty obligations to South Korea, Japan, the Philippines, and Thailand, while encouraging the latter to return quickly to democracy. We will support the people of Burma to deepen and sustain reforms, including democratic consolidation and national reconciliation.

The United States welcomes the rise of a stable, peaceful, and prosperous China. We seek to develop a constructive relationship with China that delivers benefits for our two peoples and promotes security and prosperity in Asia and around the world. We seek cooperation on shared regional and global challenges such as climate change, public health, economic growth, and the denuclearization of the Korean Peninsula. While there will be competition, we reject the inevitability of confrontation. At the same time, we will manage competition from a position of strength while insisting that China uphold international rules and norms on issues ranging from maritime security to trade and human rights. We will closely monitor China's military modernization and expanding presence in Asia, while seeking ways to reduce the risk of misunderstanding or miscalculation. On cybersecurity, we will take necessary actions to protect our businesses and defend our networks against cyber-theft of trade secrets for commercial gain whether by private actors or the Chinese government.

In South Asia, we continue to strengthen our strategic and economic partnership with India. As the world's largest democracies, we share inherent values and mutual interests that form the cornerstone of our cooperation, particularly in the areas of security, energy, and the environment. We support India's role as a regional provider of security and its expanded participation in critical regional institutions. We see a strategic convergence with India's Act East policy and our continued implementation of the rebalance to Asia and the Pacific. At the same time, we will continue to work with both India and Pakistan to promote strategic stability, combat terrorism, and advance regional economic integration in South and Central Asia.

Strengthen Our Enduring Alliance with Europe

The United States maintains a profound commitment to a Europe that is free, whole, and at peace. A strong Europe is our indispensable partner, including for tackling global security challenges, promoting prosperity, and upholding international norms. Our work with Europe leverages our strong and historic bilateral relationships throughout the continent. We will steadfastly support the aspirations of countries in the Balkans and Eastern Europe toward European and Euro-Atlantic integration, continue to transform our relationship with Turkey, and enhance ties with countries in the Caucasus while encouraging resolution of regional conflict.

NATO is the strongest alliance the world has ever known and is the hub of an expanding global security network. Our Article 5 commitment to the collective defense of all NATO Members is ironclad, as is our commitment to ensuring the Alliance remains ready and capable for crisis response and cooperative security. We will continue to deepen our relationship with the European Union (EU), which has helped to promote peace and prosperity across the region, and deepen NATO-EU ties to enhance transatlantic security. To build on the millions of jobs supported by transatlantic trade, we support a pro-growth agenda in Europe to strengthen and broaden the

region's recovery, and we seek an ambitious T-TIP to boost exports, support jobs, and raise global standards for trade.

Russia's aggression in Ukraine makes clear that European security and the international rules and norms against territorial aggression cannot be taken for granted. In response, we have led an international effort to support the Ukrainian people as they choose their own future and develop their democracy and economy. We are reassuring our allies by backing our security commitments and increasing responsiveness through training and exercises, as well as a dynamic presence in Central and Eastern Europe to deter further Russian aggression. This will include working with Europe to improve its energy security in both the short and long term. We will support partners such as Georgia, Moldova, and Ukraine so they can better work alongside the United States and NATO, as well as provide for their own defense.

And we will continue to impose significant costs on Russia through sanctions and other means while countering Moscow's deceptive propaganda with the unvarnished truth. We will deter Russian aggression, remain alert to its strategic capabilities, and help our allies and partners resist Russian coercion over the long term, if necessary. At the same time, we will keep the door open to greater collaboration with Russia in areas of common interests, should it choose a different path—a path of peaceful cooperation that respects the sovereignty and democratic development of neighboring states.

Seek Stability and Peace in the Middle East and North Africa

In the Middle East, we will dismantle terrorist networks that threaten our people, confront external aggression against our allies and partners, ensure the free flow of energy from the region to the world, and prevent the development, proliferation, or use of weapons of mass destruction. At the same time, we remain committed to a vision of the Middle East that is peaceful and prosperous, where democracy takes root and human rights are upheld. Sadly, this is not the case today, and nowhere is the violence more tragic and destabilizing than in the sectarian conflict from Beirut to Baghdad, which has given rise to new terrorist groups such as ISIL.

Resolving these connected conflicts, and enabling long-term stability in the region, requires more than the use and presence of American military forces. For one, it requires partners who can defend themselves. We are therefore investing in the ability of Israel, Jordan, and our Gulf partners to deter aggression while maintaining our unwavering commitment to Israel's security, including its Qualitative Military Edge. We are working with the Iraqi government to resolve Sunni grievances through more inclusive and responsive governance. With our partners in the region and around the world, we are leading a comprehensive counterterrorism strategy to degrade and ultimately defeat ISIL. At the same time, we will continue to pursue a lasting political solution to the devastating conflict in Syria.

Stability and peace in the Middle East and North Africa also requires reducing the underlying causes of conflict. America will therefore continue to work with allies and partners toward a comprehensive agreement with Iran that resolves the world's concerns with the Iranian nuclear program. We remain committed to ending the Israeli-Palestinian conflict through a two-state solution that ensures Israel's security and Palestine's viability. We will support efforts to deescalate sectarian tensions and violence between Shi'a and Sunni communities throughout the region. We will help countries in transition make political and economic reforms and build state capacity to maintain security, law and order, and respect for universal rights. In this respect, we seek a stable Yemen that undertakes difficult structural reforms and confronts an active threat from al-Qa'ida and other rebels. We will work with Tunisia to further progress on building democratic institutions and strengthening its economy. We will work with the U.N. and our Arab and European partners in an effort to help stabilize Libya and reduce the threat posed by lawless militias and extremists. And we will maintain strategic cooperation with Egypt to enable it to respond to shared security threats, while broadening our partnership and encouraging progress toward restoration of democratic institutions.

Invest in Africa's Future

Africa is rising. Many countries in Africa are making steady progress in growing their economies, improving democratic governance and rule of law, and supporting human rights and basic freedoms. Urbanization

and a burgeoning youth population are changing the region's demographics, and young people are increasingly making their voices heard. But there are still many countries where the transition to democracy is uneven and slow with some leaders clinging to power. Corruption is endemic and public health systems are broken in too many places. And too many governments are responding to the expansion of civil society and free press by passing laws and adopting policies that erode that progress. Ongoing conflicts in Sudan, South Sudan, the Democratic Republic of the Congo, and the Central African Republic, as well as violent extremists fighting governments in Somalia, Nigeria, and across the Sahel all pose threats to innocent civilians, regional stability, and our national security.

For decades, American engagement with Africa was defined by aid to help Africans reduce insecurity, famine, and disease. In contrast, the partnerships we are forging today, and will expand in the coming years, aim to build upon the aspirations of Africans. Through our Power Africa Initiative, we aim to double access to power in sub-Saharan Africa. We will increase trade and business ties, generating export-driven growth through initiatives like Trade Africa and AGOA. We will continue to support U.S. companies to deepen investment in what can be the world's next major center of global growth, including through the Doing Business in Africa campaign. Moreover, we are investing in tomorrow's leaders—the young entrepreneurs, innovators, civic leaders, and public servants who will shape the continent's future. We are strengthening civilian and military institutions through our Security Governance Initiative, and working to advance human rights and eliminate corruption. We are deepening our security partnerships with African countries and institutions, exemplified by our partnerships with the U.N. and AU in Mali and Somalia. Such efforts will help to resolve conflicts, strengthen African peacekeeping capacity, and counter transnational security threats while respecting human rights and the rule of law.

Our investment in nutrition and agricultural capacity will continue, reducing hunger through initiatives such as Feed the Future. We will keep working with partners to reduce deaths from Ebola, HIV/AIDS, malaria, and tuberculosis across Africa through such initiatives as the President's Emergency Plan for AIDS Relief and the Global Health Security Agenda. The Ebola epidemic in 2014 serves as a stark reminder of the threat posed by infectious disease and the imperative of global collective action to meet it. American leadership has proven essential to bringing to bear the international community to contain recent crises while building public health capacity to prevent future ones.

Deepen Economic and Security Cooperation in the Americas

We will continue to advance a Western Hemisphere that is prosperous, secure, democratic, and plays a greater global role. In the region as a whole, the number of people in the middle class has surpassed the number of people living in poverty for the first time in history, and the hemisphere is increasingly important to global energy supplies. These gains, however, are put at risk by weak institutions, high crime rates, powerful organized crime groups, an illicit drug trade, lingering economic disparity, and inadequate education and health systems.

To meet these challenges, we are working with Canada and Mexico to enhance our collective economic competitiveness while advancing prosperity in our hemisphere. With Chile, Peru, Mexico, and Canada, we are setting new global trade standards as we grow a strong contingent of countries in the Americas that favor open trading systems to include TPP. We seek to advance our economic partnership with Brazil, as it works to preserve gains in reducing poverty and deliver the higher standards of public services expected by the middle class.

We are also championing a strong and effective inter-American human rights and rule of law system. We are expanding our collaboration across the Americas to support democratic consolidation and increase public-private partnerships in education, sustainable development, access to electricity, climate resilience, and countering transnational organized crime.

Such collaboration is especially important in vulnerable countries like Guatemala, El Salvador, and Honduras, where government institutions are threatened by criminal syndicates. Migration surges involving unaccompanied children across our southern border is one major consequence of weak institutions and violence. American leadership, in partnership with these countries and with the support of their neighbors, remains essential to arresting the slide backwards and to creating steady improvements in economic growth and democratic governance. Likewise, we remain committed to helping rebuild Haiti and to put it and our other Caribbean neighbors on a path to sustainable development.

We will support the resolution of longstanding regional conflicts, particularly Colombia's conclusion of a peace accord with the Revolutionary Armed Forces of Colombia. Overall, we have deepened our strategic partnership with Colombia, which is a key contributor to international peace and security. Equally, we stand by the citizens of countries where the full exercise of democracy is at risk, such as Venezuela. Though a few countries in the region remain trapped in old ideological debates, we will keep working with all governments that are interested in cooperating with us in practical ways to reinforce the principles enumerated in the Inter-American Democratic Charter. As part of our effort to promote a fully democratic hemisphere, we will advance our new opening to Cuba in a way that most effectively promotes the ability of the Cuban people to determine their future freely.

VI. Conclusion

This National Security Strategy provides a vision for strengthening and sustaining American leadership in this still young century. It clarifies the purpose and promise of American power. It aims to advance our interests and values with initiative and from a position of strength. We will deter and defeat any adversary that threatens our national security and that of our allies. We confidently welcome the peaceful rise of other countries as partners to share the burdens for maintaining a more peaceful and prosperous world. We will continue to collaborate with established and emerging powers to promote our shared security and defend our common humanity, even as we compete with them in economic and other realms. We will uphold and refresh the international rules and norms that set the parameters for such collaboration and competition. We will do all of this and more with confidence that the international system whose creation we led in the aftermath of World War II will continue to serve America and the world well. This is an ambitious, but achievable agenda, especially if we continue to restore the bipartisan center that has been a pillar of strength for American foreign policy in decades past. America has greater capacity to adapt and recover from setbacks than any other country. A core element of our strength is our unity and our certainty that American leadership in this century, like the last, remains indispensable.

* * * * *

Editor's Note: The work of government agencies included in this compilation is not subject to copyright protection.

The contents of the documents reproduced here are solely the responsibility of the originating government agency. We make no claims, promises or guarantees about the accuracy, completeness, or adequacy of the contents, and disclaim liability for errors and omissions. No federal agency bears any responsibility for formatting or other errors contained therein, and proceeds from the sale do not go to the government. Of course, no warranty of any kind is given with respect to the contents.