COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENATIVES

HEARING CHARTER

The State of Climate Change Science 2007: The Findings of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), Working Group II: Climate Change Impacts, Adaptation and Vulnerability

Tuesday, April 17, 2007
10 a.m. to 12 p.m.
2318 Rayburn House Office Building

Purpose

On April 17, 2007, the Committee on Science and Technology will hold a hearing on the second section of the 2007 Fourth Assessment Report, *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability*, prepared by Working Group II of the Intergovernmental Panel on Climate Change (IPCC). Released in Brussels, Belgium, on April 6, 2007, the summary document highlights the key findings of the comprehensive appraisal of the current state of scientific knowledge on the impacts of climate change on natural and human systems around the world. The full underlying report will be released later this year.

The Committee will hear testimony from six witnesses who were involved in the preparation of the Working Group II Report. The witnesses will discuss the findings of the report and the relationship between current findings and those of past IPCC reports on the state of the science of climate change impacts, adaptation, and vulnerability.

Key Findings of the 2007 Working Group II Report

On April 6, 2007 the Intergovernmental Panel on Climate Change (IPCC) released the second section of its Fourth Assessment Report, entitled "Climate Change Impacts, Adaptation and Vulnerability." This second section of the IPCC Fourth Assessment Report builds upon information contained in the previous reports. Working Group II was responsible for assessing the scientific, technical, environmental, economic and social aspects of the vulnerability to climate change of ecological systems, socio-economic sectors and human health. The Working Group was co-chaired by Dr. Osvaldo Canziani from Argentina and Dr. Martin Parry from the United Kingdom.

This report updates information from the Third Assessment Report based on research conducted over the past six years. Providing a comprehensive analysis of how climate change is affecting natural and human systems, Working Group II's report also projects what the impacts of climate change will be in the future and assesses the roles adaptation and mitigation can play in reducing these impacts. The report also contains chapters on specific systems, sectors and regions.

Held from April 2nd through 6th, the 8th Plenary session of Working Group II (WGII) gathered government delegates from more than one hundred countries, together with the WGII Lead Authors. The IPCC-produced documents, including this Summary for Policymakers (SPM), are consensus documents, meaning that all member governments approve the Summary documents and the underlying chapters before each document is released.

Observed Trends

The Fourth Assessment Report represents a significant expansion in our knowledge of the relationship between climate change and impacts on the planet. The number of studies of observed trends in the physical and biological environment and their relationship to regional climate changes has increased greatly since the Third Assessment Report in 2001. This is the first time that WGII has sufficient information to attribute observed changes in physical and biological systems to human-induced global warming. Despite remaining uncertainties, WGII concluded that observational evidence from all continents and most oceans demonstrates that many natural systems are being affected by regional climate change, with regard to:

- **Snow, ice and frozen ground**: There is high confidence that natural systems are being affected through the enlargement and increased number of glacial lakes, increasing ground instability, rock avalanches in mountain regions, and changes in Artic and Antarctic ecosystems.
- **Hydrological systems**: There is high confidence of increased run-off and earlier spring peak discharge in many glacier- and snow-fed rivers. In addition, studies assessed in this document show a warming of lakes and rivers in many regions, with effects on thermal structure and water quality.
- **Land biological systems**: There is very high confidence that recent warming is causing earlier timing of spring events, such as leaf-unfolding, bird migration, and egg-laying, as well as poleward shifts in ranges of plant and animal species.
- **Marine and freshwater biological systems**: There is high confidence that the impacts of climate change, including rising water temperatures, changes in ice cover, salinity, and circulation, are causing shifts in ranges and changes in algal, plankton, and fish abundance. In addition, climate change stressors are linked to increases in algal and zooplankton abundance in high-latitude and high-altitude lakes and changes in fish migration patterns in rivers.

Projections of Future Impacts

The report addresses projected future impacts in six different categories and for eight regions.

Freshwater resources are projected to increase at high latitudes and in wet tropical areas and decrease in dry areas in the mid-latitudes and in the dry tropics. This is projected to increase the extent of drought-affected areas. In other areas, heavy precipitation events are likely to increase in frequency resulting in an increase in flood risk. Water stored in glaciers and snow cover is projected to decline. This will reduce water availability to one-sixth of the world’s population that relies upon meltwater from major mountain ranges.

Projections for **natural ecosystems** are quite negative. The report concludes that many ecosystems' capacity to adapt to climate change in combination with the other human-induced changes and natural disturbances will be overwhelmed during this century. This is projected to lead to a decline in many systems and a substantial loss of biodiversity and a reduction in ecosystem services (e.g. water and food supply). The uptake of carbon by terrestrial ecosystems is projected to peak before 2050 and then to weaken or possibly reverse. A reversal would amplify climate change by adding more greenhouse gases to the atmosphere. Ocean acidification due to absorption of carbon dioxide from the atmosphere is expected to result in declines in shell-forming organisms (e.g. corals) and the species that are dependent upon them.

Projections for **food production (agriculture and fisheries) and forestry** are mixed over time and for different regions. Global projections for crop productivity indicates that it will increase slightly where local average temperature increases are in the range of 1-3 degrees Centigrade, but will decline above this range. Commercial timber production is projected to increase slightly in the short to medium term, but regional variations around this trend are substantial. Aquaculture and fisheries are both expected to decline overall and the distributions and production of particular species will change regionally. Regional projections for crop productivity indicate increases at mid- to high latitudes for increases in the range of 1-3 degrees Centigrade. These increases are sustained in some areas and decline in others for further temperature increases. In the seasonally dry regions and the dry tropics, crop productivity is projected to decline. In areas where frequency of droughts or floods is projected to increase, local crop productivity will be lower. This is anticipated especially in areas of subsistence farming in the lower latitudes. It is anticipated that agricultural systems will be the most amenable to applying adaptive solutions to climate change through introduction of new cultivars, alteration of water, fertilizer, and land management techniques.

Coastal systems and low-lying areas are projected to be exposed to increased risks due to coastal erosion and rising sea level. The impacts will be exacerbated by increasing human-induced changes in coastal areas. Adaptation options will be variable with developing countries and small island states facing greater challenges than developed countries. Coastal ecosystems, including wetlands and mangroves will be negatively affected by sea level rise. Coral reefs are also projected to decline due to increased bleaching and other stresses due to increased ocean water temperature. Millions more people are expected to experience flooding every year due to sea level rise by late in this century. This is especially true for people living in the mega deltas of Asia and Africa and people living in small island states.

The costs and benefits to **industry, settlement and society** will be highly variable for different locations and scales, but net effects are projected to be more negative with greater changes in climate. The most vulnerable areas will be coastal and floodplain areas. Economic activities that are most closely associated with climate-sensitive resources (e.g. water, fisheries, some agriculture) will be most vulnerable to climate change. Areas where extreme weather events become more intense or more frequent will experience increased economic and social costs due to each event.

Impacts on **human health** are projected to be primarily negative. While fewer cold related deaths are projected to occur in high latitude areas, increased deaths due to heat stress, floods, fires, and droughts will offset these and exceed them especially in the long term if adaptive measures are not put into place. Malnutrition is projected to increase in areas where food production will decline and the distribution of infectious disease vectors is anticipated to change in response to changing climate (e.g. mosquitoes and ticks). The balance between positive and negative health outcomes will vary considerably with implementation of adaptive measures through public health prevention programs, infrastructure, health care, education, and economic development.

Regional Impacts

This report summarizes the impacts to specific continents and regions of the world, including Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, polar regions, and small islands. For most of the regions of the world, the projected impacts are negative.

Africa is projected to be one of the most vulnerable continents to climate variability and change. The combination of sea level rise in low-lying coastal areas, declining agricultural productivity across the region due to climate variability and change, and increasing problems of water availability all are projected to create serious constraints for African nations.

Asia is projected to have crop yield increases in some regions (East and Southeast Asia) and crop yield declines in others (Central and South Asia). Coastal areas, particularly the heavily-populated mega-deltas of South, East, and Southeast Asia will be at increased risk due to sea level rise and in some cases due to flooding from rivers. Glacier melt in the Himalayas is projected to increase flooding and risk of rock avalanches from destabilized slopes. Once the glaciers have melted, water shortages will be experienced by populations dependent upon glacier meltwater. Water availability is also projected to be an increasing problem in Central, South, East and Southeast Asia particularly in the large river basins.

Australia and New Zealand are projected to experience increasing water availability problems due to increased temperatures and reduced precipitation in many areas. Some increases in agricultural productivity and forest productivity are projected for Western and Southern New Zealand. In Eastern New Zealand and in much of Southern and Eastern Australia, agriculture and forestry production are projected to decline due to drought and fire. The unique natural systems of this region are projected to decline significantly, including the Great Barrier Reef and Queensland Wet Tropics.

Europe is projected to be negatively affected in nearly all regions. Impacts of current climate changes have been documented for the first time: retreating glaciers, longer growing seasons, shift of species ranges and health impacts due to extended severe heat waves. Negative impacts are projected to include increased risk of inland flash floods, more frequent coastal flooding and increased coastal erosion, continued glacier melting, reduced snow cover and extensive species loss. Many organisms and ecosystems will exceed their capacity to adapt to climate change. Northern Europe will generally fare better than Southern Europe through benefits such as reduced heating costs, increased crop yields and increased forest growth with modest increases in average temperature. Southern Europe will become more prone to droughts and more frequent and intense heat waves. Wildfires and peat fires are projected to increase.

By 2050 **Latin America** is projected to experience replacement of tropical forest by dry savanna in eastern Amazonia and replacement of semi-arid vegetation with arid vegetation as average temperatures increase and soil moisture decreases. There is risk of substantial species loss throughout tropical Latin America. In drier areas, climate change is expected to lead to salinisation and desertification of agricultural land leading to reduced crop and livestock yields in these areas. In temperate areas, soybean yields are projected to increase. Melting of glaciers in the Andes will impact water availability for populations dependent upon meltwater. Sea level rise will increase flooding risks in low-lying coastal areas and increases in surface ocean temperatures are projected to have adverse effects on Mesoamerican coral reefs and related fisheries.

Polar regions are projected to experience reduced thickness of glaciers and extent of glaciers and ice sheets and reductions in permafrost and increases in the depth of permafrost thawing in summer months. These physical changes are projected to have negative impacts on migratory birds and mammals. The reduction in extent of sea ice and warmer temperatures provide benefits for ocean navigation and reduced heating costs. However, coastal erosion and changes in permafrost will impact infrastructure and request investments to adapt or re-locate some physical structures and communities.

Small Island states are particularly vulnerable to reductions in precipitation and sea level rise. Some of the Pacific atoll islands are only a few meters above sea level currently. Sea level risk is projected to worsen the impacts of inundation, storm surge, erosion and other coastal hazards which will put island populations at increased risk during storm events. Fisheries and tourism are projected to be negatively impacted as well. By 2050, many islands in the Pacific and Caribbean will experience water shortages during low rainfall periods.

Below are the projected impacts of climate change for **North America**.

- There is very high confidence that warming in western mountains will lead to decreased snow pack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources.
- Forests are projected to experience longer periods of high-fire risk, and greater increases in the area burned; they will also experience disturbances from pests and diseases.
- Cities currently experiencing heat waves could expect them in greater frequency, intensity and duration over the century. The potential for adverse health impacts grows, and the growing elderly population will be most at risk.
- Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. Losses are projected to increase if the intensity of tropical storms increases, as population growth and rising value of infrastructure in coastal areas increase vulnerability to climate change. Readiness for increased exposure is low.
- Aggregate yields of rain-fed agriculture could increase by five to twenty percent because of moderate climate change in the early decades of the 21st century. Major challenges are projected for crops that are near the warm end of their suitable range.

Responding to Climate Change

Since the IPCC Third Assessment there is growing evidence of human activity adapting to observed and anticipated climate change. For example, climate change is considered in the design of infrastructure projects such as coastal defense in the Maldives and the Netherlands. In Nepal, preventative measures have been undertaken to stop outburst flooding of glacial lakes, and in Australia, substantial efforts are underway to reduce water use and better manage this resource. According to the report, these adaptive measures will be necessary to address climate change impacts as a certain degree of warming is unavoidable due to past emissions.

There are wide arrays of adaptation options available to policy makers but barriers, limits and costs exist to these strategies reaching their potential. In addition, the vulnerability of certain regions to climate change can be exacerbated by the presence of other stressors such as pollution, poverty, food insecurity, conflict, and incidence of disease. In contrast, sustainable development is discussed by Working Group II as a possible way to reduce vulnerabilities to climate change.

We are committed to some change in climate over the next decade due to past emissions of greenhouse gases and their long residence time in the atmosphere. Even stringent mitigation policies enacted now will not prevent climate change impacts over the next few decades. If emissions of greenhouse gases continue unabated, mitigation policies are necessary to avoid the most severe impacts of climate change. Adaptive measures can avoid some of the most serious impacts of climate change over the next few decades. However, they will not be sufficient to overcome the more serious impacts projected if mitigation actions are not taken. This report suggests a response portfolio composed of multiple strategies including mitigation, adaptation, technological development, and research.

Many estimates of aggregate net economic costs of damages (i.e. the social cost of carbon) from climate change are now available, expressed in terms of the future net benefits and costs that are discounted to the present. Peer-reviewed estimates of the social costs of carbon for 2005 have an average value of $12 per ton of carbon dioxide with a range from $3 to $130 per ton. Furthermore, the impacts of climate change will vary regionally but net costs are very likely to impose net annual costs which will increase over time as global temperatures increase.

Witnesses

Dr. Virginia Burkett, U.S. Geological Society (USGS) Global Change Science Coordinator

Dr. Virginia Burkett served as a Lead Author for Chapter 6 of the report entitled: *Coastal Systems and Low Lying Areas*. Currently, Dr. Burkett is serves as a USGS Global Change Science Coordinator at the National Wetlands Research Center. She completed her undergraduate and masters degrees in biology at Northwestern State University and obtained her Ph.D. in forestry in 1996 from Stephen F. Austin State University in Nacogdoches, Texas. Dr. Burkett's current research involves climate change impacts in coastal regions and bottomland hardwood regeneration in frequently flooded sites of the Mississippi River Alluvial Floodplain.

Dr. William E. Easterling, **Director of the Pennsylvania State University Institutes of the Environment**

Dr. William Easterling served as a Coordinating Lead Author for Chapter 5 of the report entitled: *Food, Fibre and Forest Products.* Currently, Dr. Easterling is the Director of the Pennsylvania State University Institutes of the Environment, as well as a professor in the Geography Department at the university. Dr. Easterling received his training as an economic geographer and climatologist at the University of North Carolina at Chapel Hill. His current research focuses on the potential for agriculture in developed and developing countries to adapt to climate variability and change. In addition, Dr. Easterling looks at issues such as the role of scale in understanding the vulnerability of complex systems, especially agro-ecosystems, to environmental change.

Dr. Roger Pulwarty, Research Associate at National Oceanic and Atmospheric Administration's (NOAA) Climate Diagnostics Center

Dr. Roger Pulwarty served as a Lead Author for Chapter 17 of the report entitled: *Assessment of Adaptation Practices, Options, Constraints and Capacity*. Dr. Pulwarty is a research scientist at the NOAA-CIRES Climate Diagnostics Center in Boulder, Colorado. Dr. Pulwarty's research interests include climate and weather, their role in society-environment interactions, and the design of effective services to address associated risks. His research and applications focus on natural resources policy, development and decision-making in the Western U.S., Latin America, and the Caribbean.

Dr. Cynthia Rosenzweig, **Senior Research Scientist at NASA Goddard Institute for Space Studies**

Dr. Cynthia Rosenzweig served as a Coordinating Lead Author for Chapter 1 of the report entitled: *Assessment of Observed Chanced and Responses in Natural and Managed Systems.* Dr. Rosenzweig is a Senior Research Scientist at NASA Goddard Institute for Space Studies where she heads the Climate Impacts Group. She has organized and led large-scale interdisciplinary regional, national, and international studies of climate change impacts and adaptation. In addition, she serves as an Adjunct Professor in the Department of Environmental Science at Barnard. A recipient of a Guggenheim Fellowship, she has joined impact models with global and regional climate models to predict future outcomes of both land-based and urban systems under altered climate conditions.

Dr. Stephen H. Schneider, Co-Director of the Center for Environmental Science and Policy (CESP) and the Interdisciplinary Program in Environment and Resources (IPER) at Stanford University

Dr. Stephen H. Schneider served as a Coordinating Lead Author for Chapter 19: *Assessing Key Vulnerabilities and the Risk from Climate Change.* Currently, Dr. Schneider is a professor in the Department of Biological Sciences and co-director of the Center for Environmental Science and Policy (CESP) and the Interdisciplinary Program in Environment and Resources (IPER) at Stanford University. His global change research interests include: climatic change; global warming; food/climate and other environmental/science public policy issues; ecological and economic implications of climatic change; integrated assessment of global change; climatic modeling of paleoclimates and of human impacts on climate, e.g., carbon dioxide "greenhouse effect" or environmental consequences of nuclear war. He is also interested in advancing public understanding of science and in improving formal environmental education in primary and secondary schools. Dr. Schneider received his Ph.D. in Mechanical Engineering and Plasma Physics from Columbia University in 1971.

Dr. Shardul Agrawala, Visiting Research Scholar in the Program in Science, Technology and Environmental Policy at Princeton University

Dr. Shardul Agrawala served as a coordinating lead author for Chapter 17 of the report: *Assessment of Adaptation Practices, Options, Constraints, and Capacity*. Dr. Agrawala is the Administrator for Climate Change, Environmental Directorate, Organization for Economic Co-operation and Development (OECD) in Paris, France. In addition, he is a Visiting Research Scholar with the Program in Science, Technology and Environmental Policy at the Woodrow Wilson School of Public and International Affairs, Princeton University. Dr. Agrawala received his Ph. D. from the Woodrow Wilson School of Public and International Affairs in 1999.