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OVERSIGHT HEARING ON THE 2007 IPCC ASSESSMENT WORKING GROUP II REPORT: IMPACTS, ADAPTATION AND VULNERABILITY

BEFORE THE
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Chairman Gordon, Ranking Member Hall, and other Members of the Committee, thank you for the opportunity to speak with you today on the Working Group II report of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report — 'Climate Change 2007.'

My name is Roger Pulwarty. I am a Physical Scientist in the NOAA Office of Oceanic and Atmospheric Research Climate Program Office and the program manager for the U.S. National Integrated Drought Information System. As a contributor to the Intergovernmental Panel on Climate Change Working Group II, I have had the honor of serving as a lead author on Chapter 17, *Assessment of Adaptation Practices, Options, Constraints and Capacity*, and as a contributor to the Chapter 3, *Freshwater Resources and their Management*. I am also a lead author on the forthcoming IPCC Special Report on *Climate Change and Water,* and on the author team for the U.S. Climate Change Science Program, Synthesis and Assessment Report on *Weather and Climate Extremes in a Changing Climate*. My role in the latter two reports focused on impact assessment and adaptation responses.

Working Group II was charged with assessing the scientific, technical, environmental, economic, and social aspects of vulnerability (sensitivity and adaptability) to climate change, and, the negative and positive consequences for ecological systems, socio-economic sectors, and human health. As you know, the report of Working Group I (released on February 2, 2007) covered physical climate science, while the Working Group III report will cover greenhouse gas mitigation. Chapter 17 of the Working Group II report focused on the following issues for different sectors (e.g. water, agriculture, biodiversity) and communities (coastal, island, etc.):

- The role of adaptation in reducing vulnerability and impacts,
- Assessment of adaptation capacity, options and constraints, and
- Enhancing adaptation practice and operations.

Given the expertise of my colleagues on this panel, I will focus my testimony on the results of Chapter 17, especially as they relate to water resources.

Chapter 17 sought to address the following questions in the context of climate variability and change:

- What are we adapting to?
- What are adaptation strategies?
- How can they be implemented?
- What are the benefits, costs and limits of such strategies?
- What are good adaptation practices?

The IPCC definition of climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. Climate and non-climatic factors can interact to produce opportunities or disaster. It is the goal of good adaptation practices to take advantage of such opportunities and to reduce associated risks. Climate variability and change influence events across timescales from a few hours or a season (e.g., floods and droughts) to year-to-year variability (e.g., El Nino-Southern Oscillation events). When changes in these types of events persist, decadal and longer-term trends also change. Adaptation strategies must therefore be engaged across all of these timescales.

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, take advantage of opportunities, or cope with the consequences. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, as well as the sensitivity and adaptive capacity of the system. Non-climactic factors are increasingly the most important influences on risk and thus, given a particular setting, even small climate changes can produce disproportionate impacts. It is not an either/or question as to whether the magnitude of societal impacts are a function of climate variability and change or of societal conditions alone. It is always a combination of both factors.

Adaptation to climate change occurs in the context of multiple stresses. Due to the inertia of the climate system, if emissions are reduced now, their effect in avoiding impacts by slowing the rate of temperature increase will not emerge until after several decades. Vulnerable populations, especially in the developing world and in poorer and elderly communities, have limited capacity to deal with climate shocks. Adaptation, therefore, will be important in coping with current climate vulnerabilities and early impacts in the near-term, and will help build resilient economies as our climate changes, regardless of how that change is derived. It is important to note that unmitigated climate change could, in the long term, exceed the capacity of different natural, managed and human systems to adapt.

Examples of adaptation initiatives

Early examples where climate change scenarios have already been incorporated into infrastructure design to accommodate projected sea-level rise include the Confederation

Bridge in Canada and the Deer Island sewage treatment plant in Boston harbor in the United States. The Confederation Bridge is a 13 kilometer bridge between Prince Edward Island and the Canadian mainland. The bridge provides a navigation channel for ocean-going vessels with vertical clearance of about 50 meters. Sea level rise was recognized as a principal concern during the design process and the bridge was built one meter higher than currently required to accommodate sea level rise from thermal expansion over its hundred year lifespan. In the case of the Deer Island sewage facility, the design called for raw sewage collected from communities onshore to be pumped under Boston harbor and then up to the treatment plant on Deer Island. After waste treatment, the effluent would be discharged into the harbor through a downhill pipe. Design engineers were concerned that sea level rise would necessitate the construction of a protective wall around the plant, which would then require installation of expensive pumping equipment to transport the effluent over the wall. To avoid such a future cost the designers decided to keep the treatment plant at a higher elevation, and the facility was completed in 1998. There are several other examples of designers and engineers factoring particular aspects of climate change into their plans as projects have been undertaken around the world. These examples are primarily infrastructure-based adaptations requiring major upfront investments. A more complex, but potentially dominant mode of adaptation will be the potential for shifts in land use, ecosystems and livelihoods necessary to accommodate a new climatic regime.

To date, most adaptation practices have been observed in the insurance sector and have focused on property damage. Financial markets can internalize information on climate risks and help transfer adaptation and risk reduction incentives to communities and individuals while capital markets and transfer mechanisms can alleviate financial constraints to the implementation of adaptation measures. As a result of climate change, demand for insurance products is expected to increase, while at the same time climate change impacts could reduce insurability and threaten insurance schemes, possibly resulting in States being the insurer of last resort. While these market signals can play a role in transferring adaptation incentives to individuals, reduced insurance coverage can, at the same time, impose significant economic and social costs. Market signals have also fostered risk prevention through: (i) implementing and strengthening building standards; (ii) planning risk prevention measures and developing best practices, and (iii) raising awareness of policyholders and public authorities. In the longer term, climate change may also induce insurers to adopt forward-looking pricing methods in order to maintain insurability.

Water availability and water demand in North America: What are the adaptation options?

Projected warming in the western mountains of North America is very likely to cause decreased snowpack, more winter flooding due to earlier runoff, and reduced summer flows, exacerbating competition for over-allocated water resources. In the case of the Sacramento-Joaquin River and the Colorado River basins in the Western United States, for example, streamflow changes projected beyond 2020 indicate that it may not be possible to fulfill all of the present-day water demands (including environmental targets), even with adapted reservoir management. By 2050 the Sacramento and Colorado River deltas could experience dramatic increases in salinity and subsequent ecosystem disruption.

If climate change results in greater water scarcity relative to demands, future adaptations may include technical changes that improve water use efficiency, demand management (e.g. through metering and pricing), and institutional changes that improve the tradability of water rights. If climate change affects water quality, adaptive strategies will have to be developed to protect the ensuing human uses, ecosystems and aquatic life uses. It takes time to fully implement such changes, so they are likely to become more effective as time passes. The availability of water for each type of use may be affected by other competing uses of the resource. Consequently a complete analysis of the effects of climate change on human water uses should consider cross-sector interactions, including the impacts of changes in water use efficiency and intentional transfers of the use of water from one sector to another. For example, voluntary water transfers (including short-term water leasing and permanent sales of water rights) from agricultural to urban or environmental uses are becoming increasingly common in the Western United States.

Increases in consumptive water use can reduce downstream areas of water supply that would have re-entered the stream as return flow. Such upstream uses could make irrigation infeasible in the lower reaches of basins that experience reduced streamflow. Thus the costs and consequences of adaptive mechanisms are as important as the adaptations themselves. It is important to ensure that emergency adjustments to events such as hurricanes, heat waves, and droughts do not increase vulnerability to longer term changes. Thus increasing adaptive capacity in the near-term to manage climate changes as they occur becomes important.

Ensuring that present adaptation strategies also decrease long-term vulnerability by enhancing adaptation practice and operations under uncertainty:

Climate change poses a major conceptual challenge to resource managers, in addition to the challenges caused by population and land use change. For example it is no longer appropriate to assume that past hydrological conditions will continue into the future (the traditional assumption). Due to the uncertainty associated with climate change, managers cannot place confidence in single projections of the future. It will be difficult to detect a clear climate change effect within the next couple of decades, even with an underlying trend. The vast majority of published impact assessments have used only a small number of scenarios of the future. These have demonstrated that impacts vary among scenarios, although temperature-based impacts, such as changing in the timing of streamflows, tend to be more robust. The use of a scenarios-based approach to water management in the face of climate change is recommended, but poses two problems. First, the large range for different climate model-based temperature scenarios suggests that adaptive planning should not be based on only a few scenarios; there is no guarantee that the range simulated by the models represents the full range of temperatures that could be experienced. Second, it is difficult to evaluate the credibility of individual scenarios, and uncertainty injects additional complications. Based on the studies done so far, it is difficult to reliably predict the water-related consequences of climate policies and emission pathways. Adaptation procedures that do not rely on precise projections of changes in river discharge, groundwater, and other variables need to be developed. Consequently, research on methods of adaptation in the face of these uncertainties is needed. Whereas it is difficult to make concrete projections, it is known that hydrological characteristics will change in the future. Early warnings of changes in the physical system and of thresholds or critical points that affect management priorities become important. Water managers in some countries are already considering explicitly how to incorporate the potential effects of climate change into specific designs and multi-stakeholder settings. Integrated water resources and coastal zone management, are based around the concepts of flexibility and adaptability, using measures which can be easily altered or are robust to changing conditions. For example, in California adaptive management measures (including water conservation, reclamation, conjunctive use of surface and groundwater and desalination of brackish water) have been advocated as means of proactively responding to climate change threats on water supply. Similarly, resilient strategies for flood management and environmental restoration, such as allowing rivers to temporarily flood and reducing exposure to flood damage, might be preferable to or combined with traditional "resistance" (protection) strategies, such as in the Confederation Bridge case discussed above.

Adaptation procedures and decision support tools are important both in the context of present day climatic risks and for increasing societal resilience into the future. To develop the necessary procedures and tools requires continued scientific, technical and operational efforts. The focus of such efforts is on developing research and management partnerships that provide decision makers and communities with credible, relevant information and the capacity to use such information effectively for climate risk management. Experience has shown that such knowledge and capacity is most effectively produced through:

- Enhancement of networks of systematic observations of key elements of physical, biological, managed and human systems affected by climate change particularly in regions where such networks have been identified as insufficient;
- Research into understanding and managing physical, biological and human systems where there is a risk of irreversible change due to climate and other stresses;
- Increased understanding of the potential costs and benefits of impacts due to various amounts of climate change, of damages avoided by different levels of emissions reduction, and of options for adapting to these impacts and managing the risks;
- Studies to explore how adapting to climate change and the pursuit of sustainable development can be complementary; and
- Learning-by-doing approaches, where the base of knowledge is enhanced through accumulation of practical experience.

Summary

Climate is one factor among many that produce changes in our environment. Demographic, socio-economic and technological changes may play a more important role in most time horizons and regions. In the 2050s, differences in the population projections of the four scenarios contained in the IPCC Special Report on Emission Scenarios show that population size could have a greater impact on people living in water-stressed river basins (defined as basins with per-capita water resources of less than 1000 m^3/year) than differences in emissions scenarios. As the number of people and attendant demands in already stressed river basins increase, even small changes in natural or anthropogenic climate can trigger large impacts on water resources.

Adaptation is unavoidable because climate is always varying even if changes in variability are amplified or dampened by anthropogenic warming. In the near term, adaptation will be necessary to meet the challenge of impacts to which we are already committed. There are significant barriers to implementing adaptation in complex settings. These barriers include both the inability of natural systems to adapt at the rate and magnitude of climate change, as well as technological, financial, cognitive and behavioral, social and cultural constraints. There are also significant knowledge gaps for adaptation, as well as impediments to flows of knowledge and information relevant for decision makers. In addition, the scale at which reliable information is produced (i.e. global) does not always match with what is needed for adaptation decisions (i.e. watershed and local). New planning processes are attempting to overcome these barriers at local, regional and national levels in both developing and developed countries.

The assessment in Chapter 17 leads to the following conclusions:

- **Adaptation to climate change is already taking place, but on a limited basis.[1]**
- **Adaptation measures are seldom undertaken in response to climate change alone.[1]**
- **Many adaptations can be implemented at low cost, but comprehensive estimates of adaptation costs and benefits are currently lacking.[2]**
- **Adaptive capacity is uneven across and within societies.[1]**

Adaptive capacity to manage climate changes can be increased by introducing adaptation measures into development planning and operations (sometimes termed ‘mainstreaming’). This can be achieved by including adaptation measures in land-use planning and infrastructure design, or by including measures to reduce vulnerability in existing disaster preparedness programs (such as introducing drought warning systems based on actual management needs).

[1] = Very high confidence
[2] = High confidence.
In the IPCC Summary for Policymakers, the following terms have been used to express confidence in a statement: *Very high confidence* = At least a 9 out of 10 chance of being correct, *High confidence* = About an 8 out of 10 chance, *Medium confidence* = About a 5 out of 10 chance, *Low confidence* = About a 2 out of 10 chance, *Very low confidence* = Less than a 1 out of 10 chance.

The major barriers to implementing adaptive management measures are that adaptation to climate change is not as yet a high priority, and the validity of local manifestations of global climate change remains in question. Coping with the uncertainties associated with estimates of future climate change and the impacts on economic and environmental resources means we will have to adopt management measures that are robust enough to apply to a range of potential scenarios, some as yet undefined. Empirical research carried out since the IPCC Third Assessment Report (2001) has shown that there are rarely simple cause-effect relationships between climate change risks and the capacity to adapt. Adaptive capacity can vary over time and is affected by multiple processes of environmental and societal change as societies adjust from event (drought, flood, abrupt change) to event. Greenhouse gas mitigation is not enough to reduce climatic risks, nor does identifying the need for adaptations translate into actions that reduce vulnerability. By implementing mainstreaming initiatives, adaptation to climate change will become part of, or will be consistent with, other well-established programs to increase societal resilience, particularly environmental impacts assessments, adaptive management and sustainable development.