Society Benefits From Adaptation to Water-Related Risks Posed by Climate Change

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Abstract:

Observed and projected climate change impacts affect water availability, water demand, water quality, and other factors influencing public health and safety, economic growth, and social stability. Though hydrology has always considered natural variability, there is evidence now that climate change has altered or enhanced that variability in ways that may affect water resources infrastructure – structural and nonstructural – that supports societal needs. The US Army Corps of Engineers (Corps) recognizes that the entire portfolio of our structural and nonstructural water resources projects will be affected by climate change, necessitating not only mitigation to climate change, but adaptation as well. This paper discusses why the performance and reliability of water investments matters, especially with respect to climate change. The paper also presents how Corps is responding to water-related risks posed by climate change to water resources infrastructure, including risk and vulnerability assessments, identification of potential adaptation strategies, and collaborative efforts supporting climate change adaptation.

Table of Contents

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Introduction

Estimating variability, risk, changes in climate and natural water flows has been central to the mission of the US Army Corps of Engineers (Corps) mission for over 100 years. As the major water resources operating agency in the United States, the Corps has been at the forefront of developing the analytical tools to establish "natural" baselines as the key to probabilistic management of our national water resources. All developed nations have invested in water infrastructure, which brings average annual damages due to impacts from climate variability to around 5% of GDP. Developing society continues to be held hostage to changes in climate, with the result that damages can be as high as 25% -30% of GDP. This level of damage thus relegating less-developed societies to continued fatalism and inability to break cycles of poverty. In this sense, the US investment in water infrastructure has created platforms for growth that lead to transformation of major regions of North America in powerful social economic engines of human productivity.

This statement discusses why the performance and resilience of regional water infrastructure matters, especially with respect to water-related risks posed by climate change, and presents information on the commitment of the Corps to the continued performance of water investments despite the challenges of climate and other global changes.

The Importance of Water Resources Infrastructure to Society

There is no doubt that water is absolutely necessary to sustain human and ecological populations. As the Ministers' Forum on Infrastructure Development in the Asia-Pacific Region has previously noted, water resources infrastructure plays a critical role in assuring sufficient quantity and quality of water to support social, economic, and environmental development, while at the same time providing resilience to natural and technological disasters. The term water resources infrastructure as used here encompasses both structural infrastructure such as dams, dikes, and canals, as well as nonstructural infrastructure such as wetlands and floodplains, or governance and social behavior, for example, laws regulating floodplain development and organizations charged with predicting, preparing and responding to natural disasters.

The investment in developing, operating, and improving water resources infrastructure matters immensely to all nations for three primary reasons. First, by providing a foundation supporting improved expectations about clean water for drinking, sanitary, and industrial purposes, water infrastructure can

set the baseline conditions for necessary for growth, breaking the cycle of poverty and fatalism that can exist where water availability and quality is irregular or insufficient. Second, in societies with a great deal of water infrastructure, additional investments that deal explicitly with increasing concern for uncertainty and risk improve resilience to natural and technological disasters. Third, water investments can bridge the gap between reactive disaster-response aid and proactive water resources management assistance that builds resilience to disasters - in short, to engender the notion that water infrastructure are investments not simply reactive aid measures.

A fourth reason underscoring the importance of water investments is emerging: increasing recognition of the relationship between infrastructure and large scale social stability. This factor is leading to a reexamination of how building the infrastructure is directly related to maintaining the health of stable cultures that support economic development and ecologic sustainability. In fact, the idea that the civil works of engineers are directly related to the civic cultures in societies has potentially profound impacts on the way we conceive of foreign assistance and to our national security.

Climate Change Impacts to Water Resources Infrastructure

Observed and projected climate change impacts on our nations and its abilities to functions calls for us to examine the ability of current large scale water infrastructure to (or not to) be able to operate to assure water availability, water demand, water quality, storm water and wastewater infrastructure, flood and coastal storm damage reduction infrastructure, wildland fires, ecosystem functioning, coastal zone functioning, navigation, and energy production and demand – will potentially affect the entire portfolio of Asian-Pacific water resources infrastructure and programs.

Climate change and adaptation to climate change affect design and operational assumptions about resource supplies, system demands or performance requirements, and operational constraints for natural and constructed infrastructure and existing and proposed programs. Development and regulatory decisions will also potentially be affected by climate change impacts and adaptation considerations.

These changes require not only alterations to our greenhouse gas emissions that exacerbate natural climate changes – mitigation – but also that we adapt our water resources infrastructure to decrease risks and provide resilience to the adverse impacts of water-related climate change.

US Army Corps of Engineers Water Resources Infrastructure:

The US Army Corps of Engineers is the largest water resources operating agency in the United States. Since 1802, the Corps has supplied engineering solutions to changing water resources needs, including navigation, flood and coastal storm damage reduction, protection and restoration of aquatic ecosystems, hydropower, water supply, recreation, regulatory, and disaster preparedness and response.

The Corps water resources infrastructure portfolio includes over 600 dams, 1,000 coastal structures, and 250 locks. Our 75 major hydropower projects, with nameplate capacity of more than 20GW, supply

more than 24% of US hydropower (about 3% of US electricity). Approximately 12 million acres of land and water resources are already under the jurisdiction of the Corps, and we continue to support additional water resources development projects each year. We also apply our expertise to support disaster preparedness and response and Military program operations that promote peace and stability around the globe.

In addition to designing, implementing and operating major water infrastructure projects, the Corps also manages the important national regulatory program on wetlands. Understating of climate variability will affect regulatory decisions made by the Corps regarding all the US wetlands. In responding to new understanding of risk and uncertainty, the Corps is examining the assumptions of traditional risk based hydrologic analysis, developing new ways o fusing a risk understanding to work comprehensively and, collaboratively with stakeholders to jointly design approaches to adaptation.

Risk-informed planning and engineering of water resources infrastructure will require development of new generation of risk-based design standards for infrastructure responding to extreme events (floods and droughts). Risk assessments of water resources climate impacts will rely on guidelines – which we are developing in collaboration with other water agencies - for producing and using climate change information appropriately to support decisions at all scales, from a reconnaissance-level planning study to a detailed structural design.

Climate Change Adaptation

It is clear that both climate change adaptation and climate change mitigation are needed to avoid unmanageable consequence to water investments that support the world's basic needs. Mitigation alone will not provide the necessary resilience or decrease vulnerabilities to the changes that are projected to occur in the future. Unfortunately, both attention and resources in the form of funding and human capital investments necessary for innovation, are currently focused largely on mitigation. We must now turn our attention and resources to help society adapt to climate change. Climate change adaptation is particularly important for water investments due to their central role in society.

Though uncertainties remain about the exact form or magnitude of climate change, hydrology has always dealt with uncertainty and variability. Sufficient information is available now to begin adaptation. Adaptive management that allows decisions to be made sequentially over time can allow for adjustments to be made as more information is known. The use of longer planning horizons, combined with updated economic analyses, will support sustainable solutions in the face of changing climate that meet the needs of the present without compromising the ability of future generations to meet their own needs. Climate change adaptation allows water resource managers to incorporate new and changing information about climate, anticipate surprise or unexpected events, reduce vulnerabilities and improve reliability of natural and constructed infrastructure.

Best Available Science as a Foundation

Climate change adaptation requires a clear understanding of how climate is changing and how these changes affect the vulnerabilities of water resources infrastructure at various scales. The Corps relies on

national and international scientific efforts describing climate change impacts at the global to regional scale, such as those provided by the Intergovernmental Panel on Climate Change (IPCC) and the US Global Change Research Program (USGCRP). US investments in climate science that develops information supporting the adaptation of water and other infrastructure investments is greater than $1B USD annually. These include general circulation models, regional circulation models, statistical and dynamical downscaling of global models, and investigations of climate changes impacting hydrology.

Decisions about climate change adaptation measures to enhance the reliability of water investment planning, design, and operation requires trustworthy information about the variability and uncertainty of probable climate change effects at the spatiotemporal scales where the decisions are taken. Increased research and development oriented toward climate change and variability is being undertaken to decrease present uncertainties. A large number of possible approaches to produce and apply climate change information for water resource issues has been developed and are in use. Each method or analytical technique brings its set of uncertainties and particular deficiencies, some of which are large or only partly characterized and poorly quantified. The Corps is working with national experts and other agencies to determine best practices and consistent approaches appropriate for decisions related to our water investments.

Corps Progress Toward Adaptation

In response to the water-related risks posed by climate change, the Corps has embarked on a comprehensive approach to climate change that requires water resources managers to move from an equilibrium – or stationary – paradigm, to one of constant evolution that recognizes the dynamic nature of physical and socio-economic processes. Climate change is but one of many challenges facing water resources managers, so that a comprehensive approach to water resources management includes all significant drivers of change. This comprehensive approach encompasses global changes, including demographic shifts, changing land use/land cover, aging infrastructure, evolving ecosystems, and changing social values and economic conditions, as well as climate change. These changes can confound each other and combine in unpredictable ways to result in potentially surprising or abrupt changes that pose a threat to water resources infrastructure which can result in sudden failure or larger than expected damages.

Since 2007, the Corps has been working to develop knowledge and capabilities required to plan, design, and implement climate change adaptation measures to our water investments. There is strong evidence that cooperation in planning, operations, and decisions about water quality and quantity can provide stability and security.The Corps is actively working with its fellow water management agencies and with stakeholders and the public to build collaborative relationships that will support logical, nationally consistent, and legally justifiable adaptation. Close coordination with other agencies and stakeholders involved in monitoring, water resources management, flood and coastal storm risk reduction, and emergency response is necessary to increase public safety and reduce damages. Asia-Pacific regional approaches such as the New Zealand Ministry for the Environment and Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) can provide good models for water investment adaptation. We have taken a collaborative approach, as demonstrated by activities detailed below.

Coastal

Coastal ports and harbors are crucial to participation in the global economy. The Corps is responsible for ensuring that ships can move safely and efficiently in and out of more than 1,000 harbors. Coastal shorelines also provide environmental benefits in the form of habitat supporting ecological communities and commercial fisheries. Coastal tourism is a source of economic revenue and growth. But coastal areas in the US are threatened by development, erosion, and pollution as well as hurricanes and other major storms. Changing sea level, combined with land subsidence and other geological activity poses an added risk to our coastlines.

The Corps recognized the need for rapid and comprehensive action to support coastal adaptation. We started multiple activities related to coastlines and inland water resources changes in collaboration with other agencies. These include:

- Consistent national datum: we could not deal with changing sea levels unless all of our coastal projects were on a consistent nationwide datum. We developed new guidance in collaboration with the National Oceanic and Atmospheric Administration (NOAA) . We then conducted a comprehensive evaluation of project datums for all Corps projects, and are now bringing into compliance.
- Sea-Level Change: We updated guidance on sea-level change to reflect best available science in collaboration with NOAA's National Ocean Service and the US Geological Survey (USGS), plus numerous external reviewers. We are now working on follow-on guidance with an interagency team that includes NOAA, USGS, Navy, Federal Highway Administration, Federal Emergency Management Agency, and UK experts as well.
- Pilot tests of climate adaptation process: The US Council on Environmental Quality established in 2009 an interagency working group on climate change adaptation. The Corps has been active in this effort, and is currently pilot-testing the proposed adaptation framework for four coastal projects: ecosystem restoration (Florida), shoreline protection (North Carolina), beach protection with a sensitive resource (coral reef) (California), and a large planning study (also in California). Lessons learned from these pilots will assist in developing both national policy and Corps guidelines for coastal adaptation.

Hydrology and Water Management

Since 2007, the Corps has been involved in collaboration with the Bureau of Reclamation (Reclamation), which is the other major water resources operating agency in the US, and the two major water science agencies, NOAA and USGS). We formed the Climate Change and Water Working Group (CCAWWG) to identify and fill knowledge gaps related to water resources management challenges due to climate change and variability. To date, this collaboration has produced information of interest not only to US water resources agencies, but also to other nations facing similar issues:

- Federal water resources perspective: The initial effort culminated in the publication of a joint report (USGS Circular 1331, Climate Change and Water Resources Management: A Federal Perspective) in February 2009.

- Nonstationarity: In January 2010, the Corps hosted a CCAWWG workshop for national and international experts on "Nonstationarity, Hydrologic Frequency Analysis, and Water Management.". Discussions during the workshop addressed whether assumptions of stationarity are valid, use of different statistical models in nonstationarity conditions, trend analyses, how to use the output from global climate models (GCM), and how to treat uncertainty in planning, design, and operations.
- User needs: The user needs associated with longer term water resources time horizons have been captured in a report by the Corps and Reclamation: "Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information." Science agencies are working to develop a follow-on document detailing how the identified user needs will be met. The Corps and Reclamation are currently preparing a draft report documenting user needs associated with shorter term water resources time horizons.
- Pilot tests of climate adaptation process: the Corps is pilot testing the proposed climate change adaptation framework for three inland water resources projects. One involves an Iowa reservoir for which we are developing a method to incorporate climate change considerations into reservoir operating policies that will be robust and adaptive to potential climate changes. The second is an interagency study to develop a method to determine the effects of changing climate on reservoir sedimentation at four Corps and Bureau of Reclamation reservoirs in Montana, Wyoming, North Dakota, and New Mexico. The third is an interagency project addressing drought at a large southeastern reservoir. They are studying the information needed for monitoring and assessing drought for water management decision making and how to communicate to the public and other agencies.

Summary

Observed and projected climate change impacts affect water availability, water demand, water quality, and other factors influencing public health and safety, economic growth, and social stability. Though hydrology has always considered natural variability, there is evidence now that climate change has altered or enhanced that variability in ways that may affect water resources infrastructure – structural and nonstructural – that supports societal needs. The entire portfolio of our structural and nonstructural water resources projects can be affected by climate change. Both adaptation and mitigation are necessary to decrease the impacts of water-related climate changes to society, particularly for developing nations. This statement addresses why the performance and reliability of water investments matters to society, especially with respect to climate change. The paper also presents how the Corps is responding to water-related risks posed by climate change to water resources infrastructure, and provides details on recent progress.