Water Security: Climate change and the great unknowns

By Peter Goodwin and David Wagner

We are on a fast track to climate disaster. Major cities under water. Unprecedented heatwaves. Terrifying storms. Widespread water shortages. The extinction of a million species of plants and animals. This is not fiction or exaggeration. It is what science tells us will result from our current energy policies.

António Guterres
UN Secretary-General
April 4, 2022

This compelling comment was part of a recent statement accompanying the release of the Intergovernmental Panel on Climate Change (IPCC) on the release of the Working Group Reports for the 2022 Sixth Assessment (AR6). The final report AR6 *Climate Change 2022: Synthesis Report* is expected to be released in September 2022.

Climate change is increasing the risk and challenges of designing, operating, and managing water infrastructure. No one in the global community is immune from the potential impacts. Costs, both financial and human, are projected to increase as extreme weather events become more frequent and intense due to climate-related events.

According to the U.S. General Accounting Office, calendar year 2021 was the seventh consecutive year in which the United States experienced 10 or more weather and climate disaster events that cost more than $1 billion each in overall damages. Over the past 5 years, the cost of these disasters has averaged approximately $150 billion each year.

Figure 1 illustrates the rapid increase of such events since 1980. The trends found in the United States are reflective globally. Of importance, the IPCC estimate that about 40% of the world's population is highly vulnerable to the changing climate.

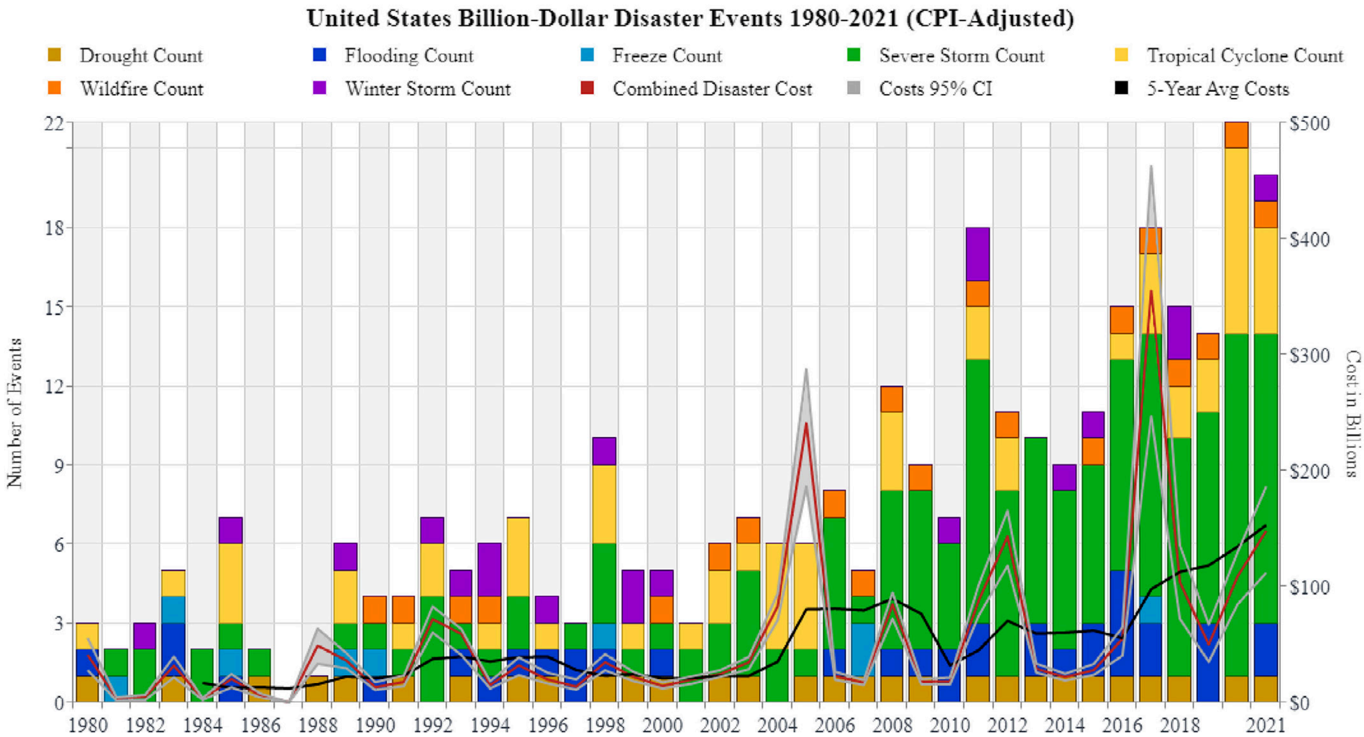


Figure 1 | Increase in climate and weather-related disasters in the United States (1980-2021). The bars indicate the annual number of events (left vertical axis) and the curves the cost in billion US dollars (right vertical axis). CPI stands for Consumer Price Index.

Source: NOAA National Centers for Environmental Information (https://www.ncei.noaa.gov/access/monitoring/billions/).

Water Security and Climate Change

Water security has emerged as a talking point for many decision-makers and politicians around the globe but what is "water security"? We all can agree that implementing decisions and building/operating water infrastructure should embrace a risk reduced approach. Reducing climate-driven risk will increase global, national, regional, and local stability, enhance public safety resulting in maintaining the capacity for transportation, food production, economic capacity, public safety, and ecosystem services.

Water security is characterized through two components, water risk and the stress. *Water risk* is defined as the possibility of experiencing a water-related challenge such as water scarcity from drought, damaging floods, infrastructure decay or trans-boundary disputes. The extent of water risk is a function of the likelihood of a specific challenge occurring and the severity of the impact. *Water stress* refers to the ability to meet human and ecological demand for fresh water. Water stress includes the physical aspects of water availability, quality, and access. Water stress can occur when the demand for water exceeds the supply of water in either the spatial or temporal context.

Why is Global Water Security Important?

The global water supply varies in terms of spatial distribution, availability and quality. The global hydrologic cycle is composed of both surface and ground water connected by infiltration, precipitation, evaporation, and sublimation. Over 90% of the water in circulation is associated with the constant interchange of water between the oceans, seas, lakes, rivers, and streams. Most of the remaining 10% of water in circulation takes the form of water vapor from plant transpiration, evaporation from surface water and sublimation from mountain snowpacks.

While the Earth has a significant amount of water, not all of it is readily available for human consumption. Water is critical for supporting people and the environment, yet fresh water comprises less than three percent of the total global water supply. The remaining 97% is salt water. The majority of the remaining 3% of freshwater is contained either in ice in the polar regions, in glaciers or confined in the underlying geology as groundwater. What remains in the form of freshwater available for humans and ecosystems is being impacted by climate change and is the focus of maintaining global water security.

Available fresh water resources are under constant threat from overuse, pollution, and waste. Protecting the functional capacity of fresh water for public and ecosystems services is critical to the global community. Not having adequate supply of clean water will result in water poverty.

How will Climate Change impact Global Water Security?

Climate change is impacting global water security at multiple levels including infrastructure, decision-making, governance, and water justice.

Infrastructure. The climate and its associated cycles are evident in increased variability and intensity of the global hydrologic cycle. We can see and measure increasing sea levels, extreme rainfall events, drought, and enhanced numbers of coastal storms with resulting surges that move further inland, all of which call for new or upgraded infrastructure. The science is clear – the impacts are increasing at alarming rates and the costs measured in terms of human life and financial impacts.

Decision-making. Determining and funding the construction of water infrastructure has been the responsibility of politicians, agency leaders and local water utilities and public safety offices. Decision makers based their actions on benefit-cost ratios, public safety, and often political support. To the decision-maker water security takes the form of reducing risk.

Governance. Water security for water infrastructure managers has to do with maintaining the capacity to ensure the operations and management of water infrastructure and systems while reducing risk to service disruption and public safety. Managing risk and maintaining infrastructure function is the major driving forces for governance water security.

Water Justice. Historically water infrastructure development occurred at the confluence of political support, financial capacity, and opportunity. Increasingly the global community has become aware that water infrastructure development often left out communities of lower economic standing, indigenous cultures and disenfranchised communities. Whether based on economic standing or ethnic background, some lower income groups are more vulnerable to the immediate impacts of climate change. Water security to these communities means being safe and having access to clean water for survival and, for some communities, ensuring cultural resources dependent on water are sustained.

How can we Address Water Security in a Changing Climate?

Water security is how nations, regions, communities, and individuals need to approach their water future under climate change. Water security is vested in developing and implementing actions that will result in increased climate resilience and reduce the risk to water poverty. There are three areas where the engineering and science communities' expertise and capacity can be applied: adaptation, mitigation, and governance. These actions and the framework that emerges from them need to be built around three guiding principles: information, integration, and incentives.

Adaptation. The initial step in developing a climate resilient –water secure path forward needs to identify and implement actions that provide guidance to develop procedures that allow us to locally adapt to changing climate conditions. Some examples include:

- Land Use and Urban Planning. Identify and protect/restore areas that can serve as buffers from storm induced impacts. This includes restricting and protecting critical coastline areas that can help in buffering storm surges. Approximately 54% of the global population live in cities which is expected to increase to 2/3rds in the next 20 years.

- Protocols on the use of freshwater systems. Include developing conjunctive use programs for managing ground and surface water systems.

Mitigation. Mitigating for future water security requires understanding the global future scenarios for climate change and developing policies and actions that can increase resilience. Examples include:

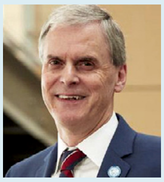
- Develop and improve models and observations to implement policies to address the global impacts on water security
- Develop information distribution systems to provide knowledge and approaches on climate and water security to the global community

Governance. Water security based on useful adaptation and mitigation methods can only succeed if the decision-makers and policy developers implement and support decision making that is based on information, integration of actions, incentives and monitoring. An example is:

- Implementing an adaptive management approach that ensures that new information, whether for science or lessons learned, is rolled back into the decision framework.

Global Water Security and IAHR

Globally the costs in human safety and impacts to infrastructure are increasing. Implementing actions to reduce impacts and institute science and engineering-based climate resilience protocols requires coordination and an understanding of the risk associated with following the traditional approaches to the design, construction, and operation of infrastructure. IAHR and its knowledge base can provide the global community important resources to approach maintaining water security to the climate challenges ahead.



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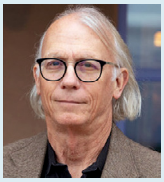

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