water & climate

DISCUSSION BRIEF

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Water Infrastructure Design under Climate Uncertainty

"Effective policies are possible under conditions of uncertainty, but they must take uncertainty into account..."[1]

Summary

Water and sanitation services infrastructure are designed to last a long time, up to 50 years or more. In designing them consideration has to be given to accommodating future demands and operating conditions. However, one of the basic design assumptions has been that the climate is stationary; the assumption that natural systems such as climate vary within a known and well-defined range. Climate change has challenged that assumption. While our understanding of the future climate is still evolving, the infrastructure we design today will have to cope with a changed and more variable future climate. Our designs must accommodate that uncertainty. Infrastructure should be resilient to cope with variability by adopting multiple infrastructure options at different scales; from countrywide to household-level systems that complement each other; provide greater storage capacity, promote rainwater harvesting, reuse of treated wastewater and soft solutions such as allocation rules that can respond to changing conditions such as drought, and better integration with economic development land use planning.

Key Points

- Past climate conditions are not the basis for future designs
- Long-lived water services infrastructure needs to be designed now to deal with the climate in 50 years' time
- Water systems (infrastructure and institutions) need to be more flexible to cope with greater variability by adopting multi-pronged and multi-level solutions

Water Infrastructure Design

Water infrastructure consists of all the man-made and natural features through which water is moved and treated for domestic, commercial, industrial and municipal uses, and to remove it once it has been used. Properly maintained and operated, water infrastructure supports our daily needs for safe, clean and reliable drinking water and wastewater services. Infrastructure is typically designed to last up to 50 years, and sometimes more; once built it is difficult and costly to change. So when planning them it is important to consider how future conditions might be different from present. In light of climate change, the assumption that what

Potswork Dam, Antigua. Photo: Elisabeth Gawthrop/IRI happened in the past is a good basis for designing for the future is no longer true. Designs need to adapt to take into account greater future variability.

Infrastructure Issues in the Caribbean

In many Caribbean countries the population with access to improved water supplies and sanitation exceeds 90%.[2] However, there are challenges related mainly to the quality of service and the maintenance and operation of the infrastructure. Specifically, the challenges include: inappropriate governance arrangements; inadequate tariff structures and level; ageing infrastructure; high levels of water unaccounted for; and poor infrastructure management.[3]

In many Caribbean countries efforts are directed to keep existing infrastructure running and extend the existing supplies to new customers. Investment in mains replacement and leakage management has not been adequate. Not enough is being done to upgrade the infrastructure to meet future needs and conditions. These challenges to water infrastructure are very important given the expected climate change impacts.

Climate Change and Variability

Projected climate change for the Caribbean suggests a 1.5°C to 2°C mean annual air temperature increase, leading to:

- A decrease in the length of the rainy season and increase in the length of the dry season;
- An increase in the frequency of intense rainfall events as basic physics indicates that a warming atmosphere with higher humidity leads to more intense precipitation;
- An increased frequency of the strongest hurricanes;
- A sea level rise of 30 to 50 cm by 2080.

The potential impacts from climate change and variability, are summarised in Table 1.

Adaptation Responses under Climate Uncertainty

According to Brown (2010)[6], a new design approach is needed under climate uncertainty. This new paradigm for responding to the uncertainty of climate variability anticipates a range of future climates as part of water infrastructure decision making. It includes no regret strategies, reversible strategies, safety margin strategies, soft strategies as well as strategies that reduce decision-making time horizons. Some of these strategies are listed in Table 2.

Other measures that can be explored for managing the impacts on water supply include capturing and

Table 1. Potential impacts to water structure.

WATER INFRASTRUCTURE COMPONENT	POTENTIAL IMPACTS FROM CLIMATE CHANGE AND VARIABILITY
Water supply sources	• Lengthened dry periods will decrease water storage and potentially increase water demand; • Less water inflow or recharge to rivers and aquifers due to droughts; • Increased water source impairment due to increased pollutant load from increased occurrence of floods and more intense precipitation and biological activity; • Reduced security of water supplies from changing rainfall • Salinization of aquifers due to sea-level rise.
Physical infrastructure	• Increased corrosion rates and leakage (associated with water table fluctuations and increased bacteriological activity); • Increased storm-related effects from more intense surge activity, wind effects, and flooding, especially to aging systems; • Sea level rise effects if located near the coast, potentially combined with hurricanes.

controlling stream and river flows. Dams can be constructed or expanded to retain and store peak flows that are more than user requirements and then released during periods when low flows are not sufficient to meet user needs.

Groundwater systems offer potential for water reserves, including use for aquifer storage and recovery (ASR) systems. Rainwater can be caught and stored in cisterns. Desalinised water, already used by some countries, is becoming feasible as costs come down. Reclaimed water also offers potential for use in dual systems and for appropriate direct reuse. Each of these has to be looked at and considered within the context of each Caribbean state and its particular circumstances.

Design and management of water infrastructure under climate uncertainty should not be restricted to the physical infrastructure. Equally important are the institutional structures that help to manage water resources under climate variability. A clear example is rules on water allocation that prioritize different uses of water at different times. From this point of view, organized drought restrictions should not be considered supply failures but, rather, be seen as institutional mechanisms to manage variability by prioritizing different water uses during times of supply stress. Other institutional measures such as land use planning can substantially reduce the vulnerability of communities to water-based natural disasters if they are supported by reliable flood data and use of various climate scenarios.

Priority areas in water management for investment that will boost the Caribbean's resilience to climate risks include:

- *Augmenting/identifying alternative water resources*
- *Treating and using wastewater as a resource*
- *Protecting and restoring watersheds*
- *Flood risk management*
- *Strengthening water infrastructure and networks*
- *Improving water use efficiency*

Given that uncertainties about the expense of adaptation and the potential cost of taking no action may be barriers to investment in water infrastructure it is very important that cost benefit analyses are also carried out. These analyses can be used to compare various management options from an economic point and risk-based approach.

Manmade reservoir in Antigua. Photo: Elisabeth Gawthrop/IRI

Table 2: Adaptation responses to climate change and climate variability for water infrastructure.[7]

INFRASTRUCTURE TYPE	ADAPTATION DECISION FOR EXISTING STRUCTURE	ADAPTATION DECISION FOR NEW STRUCTURE
Long life span (20 years and over) e.g water storage and distribution structures	Identify risks from climate change and best responses. Incorporate adaptation measures into maintenance regime	Identify risks from climate change and best responses. Incorporate adaptation into investment decisions; Adaptation measures identified and developed as part of planning application process.
Short or medium life span	Identify risks from climate change and best responses. Incorporate adaptation measures into maintenance regime	Identify risks from climate change and best responses. Incorporate adaptation into investment decision; Adaptation measures identified and developed as part of planning application process.
Both short or medium and long life span	Improvement to infrastructure and assess impacts of failure; Loss reduction (such as leakage control) and increase efficiency; Climate and flood proofing of infrastructure	Climate and flood proofing of infrastructure; Capacity increase

Conclusions

Adapting to climate change and variability has to start now in the provision of water services infrastructure. Adopting no regret strategies which include provision of greater storage to cope with variability is a key adaptation strategy. Dual systems that can utilize reclaimed water for non-potable uses would increase resources and flexibility. Soft solutions such as water allocation measures are as important in meeting future needs as hard infrastructure capacity. Whatever approaches are adopted, the risk and cost of inaction when making infrastructure investments need to be explicitly part of decision-making.

References

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