USAID
FROM THE AMERICAN PEOPLE

FACT SHEET

FLOOD CONTROL STRUCTURES

ADDRESSING CLIMATE CHANGE IMPACTS ON INFRASTRUCTURE:
PREPARING FOR CHANGE

Flood control structure in Iloilo, Philippines. Photo Credit: IRG

- Changes in climate will threaten the efficacy, adequacy, and durability of flood control structures and their continued services.
- Since flood control structures provide defense against frequent, small floods in rivers and estuaries, rising sea levels, and storm surges, climate change impacts on these structures may significantly affect the communities relying on their protection. Such impacts have implications for urban stability, economic growth and trade, and food and water availability.
- These structures and their services can be protected with adaptation strategies that include fortifying existing structures and updating design standards to accommodate future climate changes.

FLOOD CONTROL STRUCTURES INCLUDE:

- Dikes
- Spurs
- Levees
- Seawalls

FLOOD CONTROL STRUCTURES SUPPORT:

- Urban programs
- Economic growth and trade
- Food and water availability

FLOOD CONTROL STRUCTURES ARE INTEGRAL TO DEVELOPMENT PRIORITIES

Flood control structures are designed to protect coastal and river-bank areas, including urban and agricultural communities, homes, and other economically valuable areas, and the people located within them. These structures are used to divert flows of water, by re-directing rivers, slowing natural changes in embankments and coastlines, or preventing inundation of vulnerable coastlines or floodplains. Dikes, spurs, levees, and seawalls often act as the first line of defense against overflowing rivers, floods, storm surges, and—in the longer term—rising seas. By keeping water out, flood control structures lessen harm to physical infrastructure and help to ensure continuation of communities' economic and social activity.

But flood control structures do not completely eliminate risk. Flooding may occur if the design water levels are exceeded. If poorly designed, constructed, operated or maintained, these structures can increase risk by providing a false sense of security and encouraging settlements or economic activity in hazard-prone areas.

Nevertheless, many development programs rely on these structures to maintain program objectives, including continued food and water supplies, economic activity, and protection from storms and floods. For example, urban initiatives (e.g., urban transport projects) in coastal cities like Dhaka, Bangladesh necessarily rely on effective flood control structures, such as pump stations and dikes, to maintain program effectiveness in the short-term. ***By supporting the climate-resilient design, construction, and maintenance of flood control structures, USAID and other development practitioners can help ensure the lasting effects of development projects and programs in vulnerable areas.***

CLIMATE STRESSORS CAN SIGNIFICANTLY IMPACT FLOOD CONTROL STRUCTURES AND THEIR SERVICES

Like many other types of infrastructure, flood control structures are often designed to last several decades. Several climate stressors affect the efficacy and durability of flood control structures, including changes in precipitation, sea levels, extreme events, and resulting storm surges. Flood control structures are unique in that they can be compromised by the same stressors they are designed to withstand. For example, increases in the intensity and frequency of floods could overwhelm these structures, causing them to fail. These stressors will grow in importance as climate change continues to alter their intensity, variability, and accompanying hazard potential.

Potential impacts will depend on a variety of factors that affect the vulnerability of these structures. For example, if sea walls are constructed in areas that are experiencing land subsidence, they will be more vulnerable to storm surges and sea level rise. Climate change risks vary in relative importance, with a range of cost implications, compounding effects, and impacts on development objectives. Failures of flood control structures can result in dire consequences for the services provided and investments made by the development community. Table 1 provides several examples of potential climate change impacts on flood control structures.

Table 1. Examples of Potential Climate Change Impacts on Flood Control Structures and Services

	Flood Control Structures and Services
Precipitation Change	• Failure of existing flood control structures due to increased flooding from increased precipitation • Weakened embankments or inefficient impervious core due to erosion and liquefaction from recurring, intense flooding
Sea Level Rise	• Overflowing of older structures built to standards that do not integrate sea level rise • Weakening of flood control structures due to land subsidence and erosion combined with sea level rise • Inundation of structures in low-lying lands due to failure of flood control structures
Storm Surge	• Overpowering of structures due to increased height of waves, tides, and surges • Weakened or damaged structures (e.g., cracks in critical junctures) due to repeated storm surge
Extreme Events	• Damage to and destruction of flood control structures due to sudden freeze-thaw cycles or the combined forces of cascading extremes such as cyclones, snowmelt, heavy precipitation • Breaches of structure leading to temporary and permanent inundation

DEVELOPMENT PROGRAMS CAN INCLUDE FLOOD CONTROL STRUCTURE-RELATED ADAPTATION

To reduce climate change impacts on flood control structures and the resulting damage and destruction to coastal and low-lying communities, development practitioners must adapt flood control structures to future climate stressors. Adapting flood control structures will protect investments in a variety of sectors, including transportation, energy, and urban programs.

The resilience of flood control structures can be increased in many ways. For example, flood control structures should be built to higher levels and with more resilient materials and designed to withstand repeated and more extreme floods. Similarly, in designing flood control structures, USAID and other development organizations should consider, where feasible, constructing back-up structures to provide services in case of failure. In addition, design standards should incorporate sea level rise projections, as well as the hydrology and physiography of the watershed to minimize or avoid unintended adverse impacts.

It is critical that trained and registered engineers design, implement, and review new construction and improvements to ensure stability, since untested flood control structures may constitute a direct threat to human life. In addition, communities should avoid promoting an unfounded sense of security as any structure may fail in extreme circumstances.

To understand the implications for flood control structures, decision makers should identify plausible future climate scenarios to understand how relevant factors—such as sea levels and extreme event intensity—are projected to change. Using this information, decision makers can identify needed changes to the design, construction, and maintenance of structures. Development practitioners must understand the vulnerabilities of different structures, based on location, design, and construction in addition to hydrologic, environmental, and ecosystem impacts. Adaptation actions should be integrated into the overall risk management strategy for flood control structures.

Adaptation priorities should be selected based on decision-makers' assessment of the following four key factors (presented with illustrative question; refer to Overview for further guidance):

- ***Criticality*** – What is the hazard potential of failure of these structures, including population and value of assets in the area protected by the structures?
- ***Likelihood*** – Given climate projections, how likely is it that this structure will be weakened or overwhelmed by climate change?
- ***Consequences*** – Will climate changes lead to breach, overtopping, or complete failure of these structures or destabilize the embankments? If the structure fails, what damage and destruction will ensue?
- ***Resources available*** – Can the structure be fortified at low cost? Do new structures need to be built to provide adequate protection services? Are there certified specialized engineers to design, construct, inspect, and maintain these structures in the target areas?

An integrated, climate-resilient approach to flood control management will ensure that development program outcomes are durable and long-lasting. Climate change projections should be deliberately and knowledgeably included in the various project cycle stages, including the design, construction, and maintenance of flood control structures. Different options exist to mitigate the impacts of these climate stressors, including structural changes (e.g., changes to embankment slopes) and policy changes (e.g., changes to zoning codes, relocation, designing redundancy plans). Table 2 provides illustrative examples of adaptation options for flood control structures, and shows the overall approach to assessing and addressing climate risks using the Climate-Resilient Development (CRD) Framework. See the Overview for further guidance.

Table 2. Examples of Flood Control-Related Actions by Project Cycle Stage

<table>
<tr><th>Project Cycle Stage</th><th colspan="3">Project Cycle Actions</th></tr>
<tr><td>SCOPE</td><td colspan="3">• Identify flood control-related development goals important to the country, community, or sector you are working with
• Identify inputs and enabling conditions necessary to achieving those goals
• Consider the impacts of climate and non-climate stressors on those inputs</td></tr>
<tr><td>ASSESS</td><td colspan="3">• Assess climate impacts to understand how the design, construction, and maintenance of flood control structures may need to change
• Evaluate climate-related risks amidst all existing risks to flood control structures and associated services
• Evaluate social, hydrologic, environmental, and ecosystem impacts of the proposed action
• Evaluate non-climatic factors, such as land use changes, to understand how they may ameliorate or exacerbate effects from floods</td></tr>
<tr><td rowspan="3">DESIGN
Planning
Policy Changes
Project Development</td><th colspan="3">Adaptation Options (Examples)</th></tr>
<tr><td>ACCOMMODATE/MANAGE</td><td>PROTECT/HARDEN</td><td>RETREAT/RELOCATE</td></tr>
<tr><td>• Develop redundant structures or services that can be relied upon if structures fail
• Increase inspection frequency to ensure structures are enduring climate change pressures
• Design flood risk-management plans with both ecosystem- and construction-based adaptation options</td><td>• Update design standards to integrate projected sea level rise and storm surge
• Fortify embankments to counteract effects of increased coastal erosion</td><td>• Plan for community relocation
• Explore natural resource management approaches to increase storage in the watershed or break waves, such as establishment of mangroves
• Update zoning codes for coastal land to establish natural buffer zones</td></tr>
<tr><td rowspan="3">IMPLEMENT and MANAGE
Construction
Operation
Maintenance
Program Activities</td><th colspan="3">Adaptation Options (Examples)</th></tr>
<tr><td>ACCOMMODATE/MANAGE</td><td>PROTECT/HARDEN</td><td>RETREAT/RELOCATE</td></tr>
<tr><td>• Increase resources for more frequent maintenance and repairs
• Temporarily evacuate areas
• Use ecosystem options (e.g., riparian buffers) to naturally absorb excess water</td><td>• Use permeable materials in select locations to allow for better absorption of water
• Use improved asphalt/concrete mixtures</td><td>• Relocate communities further inland or away from flood basins</td></tr>
<tr><td>EVALUATE and ADJUST</td><td colspan="3">• Track performance of flood control structures and assess whether additional redundant services or other options are required
• Monitor changing environmental conditions affected by climate, including changes in storm surge levels, wind speed, and precipitation</td></tr>
</table>

FURTHER READING

British Columbia Ministry of Environment, 2011. Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Available at http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/draft_policy_rev.pdf

U.S. Army Corps of Engineers, 2011. USACE Climate Change Adaptation Plan and Report 2011. Available at http://www.corpsclimate.us/docs/usace_climate_change_adaptation_report_03_june_2011.pdf

Questions, feedback, suggestions, and requests for support should be sent to **climatechange@usaid.gov.**

Published: November 2012