



# TRANSPORTATION

## ADDRESSING CLIMATE CHANGE IMPACTS ON INFRASTRUCTURE: PREPARING FOR CHANGE

Washed-out bridge. Photo Credit: IRG



- ▶ Climate change impacts on transportation infrastructure may include temporary or permanent flooding of roads, bridges, and ports; increased maintenance costs due to damage or increased wear and tear; and service disruption.
- ▶ Since reliable transportation is essential to strong communities and economic development, climate change impacts on transportation infrastructure could have far-reaching implications for development programs, especially those that rely on transportation to gain access to the populations they serve.
- ▶ Transportation-related adaptation options include designing back-up services, constructing storm surge barriers, and elevating roadways. In some instances, infrastructure may need to be relocated.

### TRANSPORTATION IS INTEGRAL TO DEVELOPMENT PRIORITIES

Transportation infrastructure often forms the critical backbone of local, regional, national, and international economic and community activities. It enables the distribution of goods and services within and between countries and eases access to schools, markets, and health services. As such, transportation infrastructure is critical to development programs around the world.

In order to implement food security programs, for example, USAID and other development practitioners have to support the development and operation of roads and rails, as well as access to ports and airports, to allow the movement of critical food supplies to and from markets. **By supporting reliable and climate-resilient transportation, USAID and other development practitioners can ensure lasting program effects.**

### CLIMATE STRESSORS CAN SIGNIFICANTLY IMPACT TRANSPORTATION SYSTEMS

Changes in the variability and magnitude of temperature, precipitation, rising sea levels, and extreme weather events can affect transportation infrastructure. For example, rising sea levels can permanently inundate coastal transportation networks, rendering roads, airports, and ports unusable; increased storm surge due to rising sea levels and more intense

#### TRANSPORTATION INCLUDES:

- Roads (including bridges, tunnels, and bicycle/ pedestrian paths)
- Railways
- Ports and waterways
- Airports

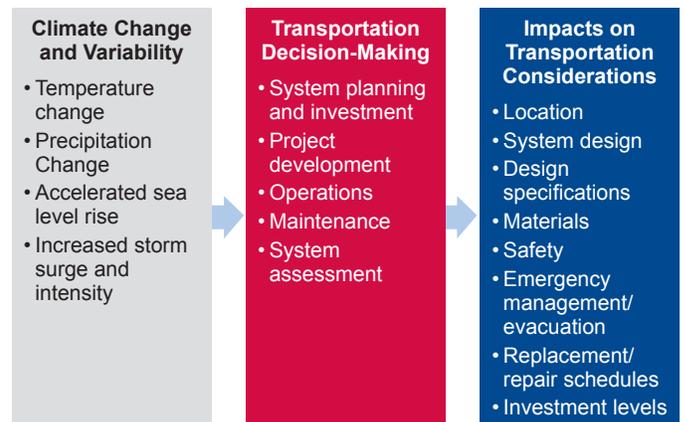
#### TRANSPORTATION SUPPORTS:

- Food security programs
- Humanitarian assistance
- Urban programs
- Economic growth and trade

storms can significantly damage infrastructure; and areas that endure prolonged high temperatures may experience road deterioration or rail buckling that can disrupt transportation and trade routes. These impacts affect access to markets, schools, and health centers.

Climate change risks vary in relative importance, with a range of cost implications, compounding effects, and impacts on development objectives. Figure 1 provides further information on how climate change and variability can affect transportation decision-making and what factors may have to be considered. Please see Table 1 for additional examples of climate change impacts on transportation, many of which are already being experienced.

**Figure 1.** Climate Change Impacts Can Affect a Range of Transportation-Related Decisions<sup>1</sup>



<sup>1</sup> Figure adapted from CCSP, 2008. Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I. Savonis, M.J., V.R. Burkett, and J.R. Potter (eds). Department of Transportation, Washington, D.C.

**Table I.** Examples of Potential Climate Change Impacts on Transportation Infrastructure and Services

	Roads	Railways	Ports and Waterways	Airports
<b>Temperature Change</b>	<ul style="list-style-type: none"> <li>• More rapid road asphalt deterioration due to prolonged heat</li> <li>• Substructure damage and buckling due to permafrost thaw</li> <li>• Increased maintenance and construction costs</li> </ul>	<ul style="list-style-type: none"> <li>• Expansion and buckling of railway tracks, joints</li> <li>• Overheating of rail electrical systems and communications equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Thermal expansion of bridge joints, paved surfaces</li> <li>• Higher land-side electricity consumption to meet increased refrigeration needs</li> </ul>	<ul style="list-style-type: none"> <li>• Asphalt deterioration on runways</li> <li>• Length of runways inadequate due to decreasing air density</li> </ul>
<b>Precipitation Change</b>	<ul style="list-style-type: none"> <li>• Increased flooding of roadways</li> <li>• Increased soil erosion and washout of road- and tunnel-supporting culverts during flash floods</li> </ul>	<ul style="list-style-type: none"> <li>• Increased flooding of tracks and stations</li> <li>• Washout of track supports (ballast)</li> </ul>	<ul style="list-style-type: none"> <li>• Changes in scour rates in response to increased peak stream flow</li> <li>• Channel closures due to increased silt deposition from flooding</li> <li>• Reduced navigability due to low water levels</li> </ul>	<ul style="list-style-type: none"> <li>• Travel disruptions due to storms and runway closures due to flooding</li> <li>• Damage to airport infrastructure due to inundation</li> </ul>
<b>Sea Level Rise</b>	<ul style="list-style-type: none"> <li>• Erosion of roadbase</li> </ul>	<ul style="list-style-type: none"> <li>• Flooding of underground pathways and tunnels</li> </ul>	<ul style="list-style-type: none"> <li>• Diminished access due to rising sea levels</li> </ul>	<ul style="list-style-type: none"> <li>• Erosion of coastal airport runways</li> </ul>
	<ul style="list-style-type: none"> <li>• Permanent inundation of road, rail, port, and airport infrastructure</li> </ul>			
<b>Storm Surge</b>	<ul style="list-style-type: none"> <li>• Temporary inundation of and diminished access to roadways, rails, ports, and airport facilities</li> <li>• Closure of facilities due to debris (e.g., cranes) and damage to infrastructure (e.g., clogging of drainage systems)</li> </ul>			

## DEVELOPMENT ORGANIZATIONS CAN MAINSTREAM TRANSPORTATION-RELATED ADAPTATION INTO THEIR PROGRAMS

Many options exist to adjust to or cope with the projected impacts of climate change. Despite limited resources, development practitioners and local decision-makers can use a screening process to select adaptation priorities based on their assessment of four key factors.

- **Criticality** – How important is the transportation infrastructure to the community or region? Is it required for emergency response? Are redundant services available?
- **Likelihood** – Given climate projections, is the road, bridge, port, or airport (i.e., the component in question) likely to be impacted by climate change? When are these impacts expected?
- **Consequences** – How significant is the impact? Will climate changes permanently or temporarily disrupt services?
- **Resources available** – Are both organizational capacity and financial and technical resources available to implement adaptation? Can adaptation options be integrated into existing maintenance schedules or do components have to be replaced in whole?

Adaptation priorities should be mainstreamed into existing capital improvement and maintenance programs, where possible. Adaptation options range from “hard” options (e.g., elevating bridges, changing asphalt composition) to “soft” options (e.g., increasing maintenance activities, changing land zoning practices, providing incentives for inland construction) and require differing levels of resources, depending on when they are incorporated into design and planning. Table 2 provides examples of the range of transportation-related adaptation options that may be considered.

By intentionally integrating climate information into program development and investment decisions, USAID and other development practitioners can avoid maladaptive projects such as investing in a bridge repair that is likely to be inundated by rising sea levels. While an ad-hoc approach to transportation development may result in positive short-term effects, an integrated, climate-resilient approach will maintain value in the longer term. Table 2 illustrates this approach, aligned with the Climate-Resilient Development (CRD) Framework. See the Overview for further guidance on the CRD Framework.

**Table 2.** Examples of Transportation-Related Actions by Project Cycle Stage

Project Cycle Stage	Project Cycle Actions		
	<ul style="list-style-type: none"> <li>Identify transportation-related development goals important to the country, community, or sector you are working with</li> <li>Identify inputs and enabling conditions necessary to achieving those goals</li> <li>Consider the impacts of climate and non-climate stressors on those inputs</li> </ul>		
	<ul style="list-style-type: none"> <li>Assess potential climate impacts on transportation infrastructure to understand adaptation needs and economic implications</li> <li>Evaluate climate-related risks in light of all existing risks to transportation</li> </ul>		
 Planning Policy Changes Project Development	<b>Adaptation Options (Examples)</b>		
	<b>ACCOMMODATE/MANAGE</b> <ul style="list-style-type: none"> <li>Develop redundant services to accommodate disruptions</li> <li>Shorten maintenance periods to accommodate changes in temperature and precipitation</li> <li>Plan for extreme event evacuation</li> </ul>	<b>PROTECT/HARDEN</b> <ul style="list-style-type: none"> <li>Update design standards to elevate roadways to accommodate future sea level rise and high winds</li> <li>Consider storm surge in coastal road planning</li> </ul>	<b>RETREAT/RELOCATE</b> <ul style="list-style-type: none"> <li>Plan for coastal roadway relocation</li> <li>Convert coastal land uses to establish natural buffer zones</li> </ul>
 Construction Operation Maintenance Program Activities	<b>Adaptation Options (Examples)</b>		
	<b>ACCOMMODATE/MANAGE</b> <ul style="list-style-type: none"> <li>Increase financial and technical resources for more frequent maintenance and repairs</li> <li>Temporarily close airports and ports due to extreme weather</li> </ul>	<b>PROTECT/HARDEN</b> <ul style="list-style-type: none"> <li>Update design standards to elevate Use flexible, expandable materials in railway systems</li> <li>Use improved asphalt/ concrete mixtures for roads and runways</li> </ul>	<b>RETREAT/RELOCATE</b> <ul style="list-style-type: none"> <li>Relocate roads, railways, and airport runways further inland</li> </ul>
	<ul style="list-style-type: none"> <li>Track changes in maintenance needs and schedules over time as adaptation actions are implemented</li> <li>Monitor changing environmental conditions affected by climate (e.g., land erosion patterns, frequency and severity of inundation events) to understand evolving adaptation needs</li> </ul>		

**FURTHER READING**

Transportation Research Board, 2008. Potential Impacts of Climate Change on U.S. Transportation. <http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf>

U.S. Climate Change Science Program, 2008. Synthesis and Assessment Product 4.7: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I. <http://www.climatechange.gov/Library/sap/sap4-7/final-report/sap4-7-final-all.pdf>