Infrastructure, Construction, and Energy

Introduction

Purpose: This annex to the Climate Risk Screening and Management Tools is designed to provide you with more information on climate change[1] implications for Infrastructure. The information is grouped into the following sub-sections, with the corresponding step from the Tool shown in parentheses:

- Climate Risks to Infrastructure, Construction, and Energy (Step 2)
- Adaptive Capacity Related to Infrastructure, Construction, and Energy (Step 3)
- Assign Climate Risk Rating (Step 4)
- Opportunities Related to Infrastructure, Construction, and Energy (Step 5)
- Climate Risk Management Options for Infrastructure, Construction, and Energy (Step 6)
- Identify Next Steps (Step 7)
- Additional Key Resources Related to Infrastructure, Construction, and Energy

The questions and examples provided in this annex are illustrative and designed to stimulate thinking about climate risks, adaptive capacity, opportunities, and climate risk management options.

Important note for engineering design: *Activity*-level climate risk management (CRM) for engineering design **must** be conducted by the Engineer of Record.[2] At the strategy and project level, climate risks should be assessed and addressed as part of the overall design, but again the details of managing climate risk will need to be handled by the Engineer of Record once you get to activity design. For this reason, all construction or rehabilitation[3] interventions should be considered high risk until they are addressed by the Engineer of Record.

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[1] In this document, the term “climate change” refers to both climate variability and climate change. “Climate variability” refers to variations in climate (including the normal highs and lows, wet and dry periods, hot and cool periods and extremes) and can refer to month-to-month variability, year-to-year variability, and even decadal scale variability. In this document, “climate change” refers to those variations as well as persistent change in climate over decades or longer (USAID, 2014. *Climate-Resilient Development: A Framework for Understanding and Addressing Climate Change*).
[2] An appropriately qualified engineering firm under contract or subcontract with USAID for the purpose of completing the engineering design.
[3] USAID Implementation of Construction Activities, A Mandatory Reference for ADS Chapter 303, defines “construction” as: “construction, alteration, or repair (including dredging and excavation) of buildings, structures, or other real property and includes, without limitation, improvements, renovation, alteration, and refurbishment. The term includes, without limitation, roads, power plants, buildings, bridges, water treatment facilities, and vertical structures.” Construction at USAID almost always occurs within another primary programming area (e.g., school building for education, hospital/clinic construction for health).

Sample language for construction design: Contracts/awards that include construction design should include the following language.
Engineering analysis preceding design activities must include consideration of climate change and its potential impacts on the location (siting), functionality, and sustainability of resulting infrastructure and infrastructure services. Such analysis must include identification of relevant data sets and gaps, review of local building standards and codes for adequacy, and determination of safety factors or other measures of uncertainty that will be carried through design. The results of this analysis, including risks identified and how they are addressed, shall be documented.

Sectoral focus of the annex: This annex should be used for any design including construction or infrastructure such as energy systems, transportation, buildings, and information and communication technology. See the Water Supply and Sanitation Annex for infrastructure-related information on that topic. The material in this annex is relevant to the following Program Elements in the Standardized Program Structure: EG.7 Modern Energy Services, EG.8 Information and Communications Technology Services, EG.9 Transport Services, and EG.12: Climate Change - Clean Energy.

Tool Step 2: Climate Risks to Infrastructure, Construction, and Energy – Illustrative Examples and Questions

Once you have reviewed this section, you can navigate back to the Tool by clicking on the relevant hyperlink in the header.

Energy and Power Generation	Transportation	Buildings
• Increased burden on electricity infrastructure due to increasing demand for air conditioning and cooling caused by heat stress. • Decreased amount of water available for hydropower generation due increases in reservoir evaporation and evapotranspiration in watersheds caused by higher temperatures. • Reduced water levels available for hydropower generation due to prolonged drought. • Generation efficiency of thermal power generation may be affected by reduced thermal gradient caused by warmer intake temperatures of cooling water. • Decreased generated wind power due to increases in air temperature. • Decreased solar power cell efficiency and energy output due to temperature increase.	• Premature deterioration of structures/equipment from thermal stress, including pavement materials and rail tracks, due to increased temperatures. • Foundation failure for roads, rail lines, and structures due to permafrost thaw from increased temperatures. • Increased incidence of transportation service disruption, including loss of access to critical destinations and services, and impeded restoration efforts of energy, water supply and sanitation, and communication services due to increases in heavy precipitation and inland flooding. • Higher levels of structural damage due to flooding caused by increases in heavy precipitation and inland flooding.	• Increased demand, and costs, of building cooling due to increased temperatures. • Premature deterioration of structures/equipment from thermal stress, including building materials, due to increased temperatures. • Building systems, including water and waste services, may be disrupted by changes in precipitation rates and levels. • Water damage to buildings and equipment, disruption of businesses and services, evacuation of occupants, and increase in maintenance and repair costs may be caused by increases in heavy precipitation and flooding. • Damage to building foundations and structures due to increased soil cracking and subsidence in areas with clay soils caused by increased drought.

Energy and Power Generation	Transportation	Buildings
● Decreased generation and transmission efficiency, increased stress to substations, and increased difficulty of meeting environmental constraints for cooling water effluent due to heat stress. ● Foundation failure for pipelines, transmission lines, and generation facilities due to increased permafrost thaw from heat stress. ● Increased generation capacity and replenished reservoirs due to increased precipitation. ● Damaged infrastructure, inhibited facility access, and creation of high repair costs due to flooding from increased precipitation. ● Scouring of transmission tower bases, water damage to underground substations and lines, and increased corrosion of electrical components due to increased salt water exposure caused by sea level rise and increased storm surge.[4] ● Physical damage to generation facilities and transmission lines due to increased intensity of storm surge. ● Power outages due to tree falls caused by structural damage to transmission lines from increased velocity and duration of high winds.	● Long-term material damage due to increased moisture levels caused by longer periods of inundation from increased duration or severity of precipitation ● Disruption of inland shipping channels due to increased silt deposition from increased heavy precipitation and flooding. ● Reduced shipping navigability due to lower water levels in navigable rivers from drought. ● Increased risk of wildfire damage to infrastructure due to drought. ● Disruption of transport and increased repair and maintenance costs from damage of roads, railroads, airports, and port infrastructure due to sea level rise and increased intensity of storm surge. ● Closure and/or diminished access to low-lying coastal transportation routes (roads, rail) due to permanent inundation or temporary flooding caused by sea level rise and increased intensity of storm surge. ● Shipping lanes and port services may be affected by sea level rise and increased storm surge.	● Increased incidence of building flooding and damage to building foundations and HVAC systems due to sea level rise. ● Increased corrosion and physical damage to coastal buildings due to increased intensity of storm surge. ● Reduced durability of buildings and structures due to increased erosion and weathering of exterior surfaces from dust storm and debris, caused by structural damage from increased high winds.

[4] A temporary sea level rise associated with a storm.

Water Supply and Sanitation Infrastructure (see separate annex for further detail)	Information and Communication Technology	Cross-Cutting
• Increased demands for potable water and other uses of water due to higher temperatures, which add stress to existing water storage and distribution systems. • Reduced surface water availability and groundwater recharge due to prolonged drought, which increases pressure on existing water storage and distribution. • Reduced water quality and increased demand on water treatment infrastructure due to increased pathogens and lower dissolved oxygen caused by higher temperatures. • Reduced efficiency of sanitation systems and treatment performance due to prolonged drought. • Borehole failures due to prolonged drought and declining groundwater levels. • Contaminated groundwater through boreholes and unprotected wells due to flooding. • Increased damage to water supply, treatment, and distribution systems due to increased intensity of precipitation and flooding. • Damage to storm water drainage and sanitation infrastructure due to flooding. • High levels of suspended sediments, potentially exceeding water treatment capacity, due to flood waters. • Increased public health risks due to inundation and overflow of latrines and septic systems caused by increased precipitation and storm events. • Accelerated salinization of coastal aquifers due to sea level rise, storm surge, and/or reduced rainfall.	• Decreased range of wireless signal transmission due to heat stress; disruptions in wireless signals from changes in vegetation growth due to shifting ecosystems. • Flooding of low-lying/ underground infrastructure and access points, particularly in coastal areas, flood plains, and cities, may be caused by increased precipitation. • Flooding, structural damage, and salt water corrosion of communications infrastructure in low-lying/coastal areas may be caused by sea level rise and increased intensity of storm surge. • Cell towers or telephone poles may fall or be damaged by fallen trees or debris due to increased wind severity.	• Changes in the timing or length of construction shifts and work seasons or changes in ongoing staff management may be required due to health impacts to construction crews and permanent staff from heat stress. • Failure of flood control structures due to increases in heavy precipitation and flooding. • Damage to infrastructure, including transportation systems, buildings, and sanitation infrastructure can disproportionately impact marginalized populations by reducing access to services for people with disabilities and people who depend on public infrastructure to access basic services (health care, shelter, etc.).

Water Supply and Sanitation Infrastructure (see separate annex for further detail)	Information and Communication Technology	Cross-Cutting
• Damaged pumps and inundation of low-lying latrines and septic systems due to sea level rise and saltwater intrusion. • Back up of discharge and spread of waterborne-diseases due to flooded coastal outfalls caused by sea level rise and storm surge. • Disruption to supply chains for construction of water and sanitation infrastructure due to flooding and severe events. • Initial heavy surface flows, floods, sediment load, damage to infrastructure, and eventual diminished water supply due to melting glaciers and Glacial Lake Outburst Floods (GLOFs).		

Because much of infrastructure is interdependent, these risks should not be considered in isolation. For example, power stations provide energy to help telecommunications systems function, which in turn can be essential to the operation of water management systems. Because of this, a disruption in electrical power can have cascading impacts that ultimately affect multiple services throughout a region. Additionally all risks and impacts in infrastructure should be examined through a gender lens due to the different ways these risks will likely impact men and women, and may disproportionately impact marginalized populations.[5]

Illustrative questions by climate stressor:

Temperature:

- Are higher temperatures likely to contribute to changes in the volume or quality of water needed for the infrastructure services?
- Are higher temperatures likely to cause damage to the structural components of the infrastructure?
- Are higher temperatures likely to affect the labor force on which the infrastructure construction or operation will depend?

[5] Marginalized populations are groups of people who are excluded, based on their identity, from political, social, and economic power and participation. Often they include women and girls, at-risk youth, the elderly, LGBTI individuals, persons with disabilities, people in linguistic minorities, indigenous people, and/or a combination of any of these identities. (LGBTI individuals refers to lesbian, gay, bisexual, transgender, or intersex individuals. Further information can be found in the LGBT Vision for Action, https://www.usaid.gov/sites/default/files/documents/1874/LGBT%20Vision.pdf.)

Flooding:

- Are changes in flooding likely to damage the infrastructure assets or disrupt the services it provides?
- Will changes in the intensity of rainfall events damage the infrastructure assets or disrupt the services it provides?

Drought:

- Are droughts likely to reduce the volume or quality of water required for the infrastructure facility to operate and meet service demand?
- Will drought contribute to increased incidence of fire that may affect the infrastructure assets or service?
- Will drought contribute to changes in landscape that, interacting with precipitation events, may cause greater erosion that will impact the infrastructure assets or service?

Sea level rise and storm surge:

- Will sea level rise damage coastal infrastructure?
- Will increasing intense storm surge damage infrastructure assets or disrupt services?
- Will sea level rise inundate areas in which the infrastructure is sited, or inundate access roads and services on which the infrastructure depends?

Illustrative questions by programming or system element:

Exposure/Siting:

- To what extent is the planned infrastructure likely to be affected by climate change due to its location? For example, is the infrastructure system located in a flood plain, and therefore subject to potential increases in flooding, sea level, or storm surge?

Sensitivity:

- What is the susceptibility of the infrastructure to more frequent or intense weather events (floods, droughts, and tropical cyclones) because of its age, condition, maintenance levels, or operational protocols?
- Are design standards sufficient to withstand extreme weather events?
- Are there the capability and data to develop design codes and standards that are updated to include climate change scenarios?

Redundancy:

- Are there back-up systems or alternative services available to reduce the effects of damages and disruption in service? Are safety margins adequate to address increased frequencies of extreme weather events in the location?

Safety:

- Are there likely to be specific safety hazards associated with locating infrastructure in particular geographies due to expected climate variability and change?
- Will climate change affect worker’s health or ability to safely access the infrastructure?

Operational considerations:

- Will climate change affect the functionality or operational efficiency of the infrastructure (e.g., supply of water required, load on critical cooling systems, material transformation/degradation, levels or schedule of maintenance required, availability of labor force, etc.)?

Robustness:

- Is the infrastructure design robust enough to meet increased service demand that may result from a range of plausible climate change and non-climate scenarios (energy/water demand, urbanization/migration, increased peak demand for cooling, etc.)?
- What design standards are being used? Are these standards internationally recognized for their robustness under different climate scenarios?

Tool Step 3: Adaptive Capacity Related to Infrastructure, Construction, and Energy – Illustrative Questions

Once you have reviewed this section, you can navigate back to the Tool by clicking on the relevant hyperlink in the header.

Physical Capacity

- What is the level of capacity of the infrastructure system to retain or restore service?
- To what extent is there redundancy in the infrastructure system?

Information Capacity

- What is the level of capacity to collect and use information related to climate impacts on infrastructure and infrastructure services?
    - To what extent are effective systems in place to monitor and identify damages to infrastructure and disruptions to infrastructure services from extreme weather and climate variability?
    - How well are data used to inform infrastructure design and service management? What is the level of capacity to use and apply these data?
    - To what extent is climate change information incorporated into strategic planning of resources (e.g., maintenance and operations, infrastructure improvements, personnel, and training) for infrastructure services?

Social and Institutional Capacity

- What is the capacity of institutions and civil society to take action and to adjust to climate impacts on infrastructure and infrastructure services?
    - How effective are institutions, systems, and processes for managing infrastructure and infrastructure services?
    - To what extent do national or sub-national infrastructure guidelines and standards take account of climate change?
    - How flexible and robust are national and local planning, budgeting and emergency response capabilities and systems? Are they able to accommodate additional stresses on infrastructure from a changing climate?

Human Capacity

- How well equipped are the technical and research organizations to train and support communities to adjust to climate impacts to infrastructure services?
- How well trained are the staff of infrastructure management organizations to address climate risks?

Financial Capacity

- How adequate are the financial resources to support the infrastructure sector in preparing for and responding to climate impacts?
  - How adequate are the investments that are being made to reduce climate risks to infrastructure assets and services?
  - Are funding sources to address climate risks to infrastructure assets and services available? How sufficient are the systems through which governments can access these resources?

Tool Step 4: Assign Climate Risk Rating

All interventions related to construction should be categorized as high risk and will be assessed and addressed by the Engineer of Record.[6]

Tool Step 5: Opportunities Related to Climate Risk Management for Infrastructure, Construction, and Energy – Illustrative Examples

The need to address climate risks related to infrastructure, construction, and energy may provide a range of additional opportunities. For moderate/high risk strategic elements, projects, and activities, the important types of opportunities to discuss are climate change mitigation,[7] potential co-benefits for non-climate development objectives, leveraging political will, and other development issues. For Washington-based and low-risk strategic elements, projects, and activities, opportunities should focus more on how to support resilience more broadly.

Once you have reviewed this section, you can navigate back to the Tool by clicking on the relevant hyperlink in the header.

Build institutional capacity in local governments

- Training and capacity building for local government staff on conducting climate vulnerability assessments and adaptation planning can be used to build technical skills in applying and accessing climate data, using geospatial platforms, and writing effective proposals.
- Training and capacity building for local government staff can also be used to create new and more effective working relationships among ‘stove-piped’ offices (e.g., ties between planners, economists, engineers, and civil defense/emergency response) within local government, and between government offices and local experts (e.g., from universities and the private sector).

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[6] An appropriately qualified engineering firm under contract or subcontract with USAID for the purpose of completing the engineering design.
[7] In this document “climate change mitigation” refers to efforts to reduce greenhouse gas emissions.

- The need to collect climate projections and observational data for infrastructure planning could also support information and data needs for early warning and emergency response.

Engage national government in development objectives that have not been priorities for them in the past

- The need to protect water supplies for hydropower generation from climate change-driven water deficits through investments in green infrastructure and watershed restoration in rural communities could encourage a national government to direct public funds to rural development and employment projects.
- Addressing risks to public transportation from climate change could open the door to simultaneously addressing broader social justice and governance issues related to under-served and marginalized populations as well as co-benefits associated with climate resilient and low emission transportation infrastructure design.
- Establishing or strengthening building codes to codify more sustainable elements in new or existing buildings will improve building performance. According to the International Energy Agency, buildings account for over one-third of total final energy consumption and are an equally important source of carbon dioxide emissions, indicating the potential of sustainable buildings to mitigate climate change.

Support countries in achieving low emission development or climate change mitigation efforts

- The need to invest in more climate-resilient energy generation networks could encourage national governments to invest in sustainable renewable energy sources and distributed networks (e.g., small-scale solar, wind, small-scale run-of-river hydro). This also creates opportunities to engage the private sector.
- Investments in climate-resilient energy could support a national government in meeting national NDC commitments.
- Meet energy demand while avoiding or minimizing the need to invest in new power generation infrastructure through peak load management and energy conservation, which can be measured in “megawatt-hours” of energy saved. Saving energy reduces greenhouse gas emissions.
- Develop green building codes and provide training to building owners and managers to incorporate energy and water saving in the design of new buildings and the retrofit of existing buildings through measures such as water catchment, grey water recycling, green/living roofs, use of solar water heating, use of less carbon-intensive building materials, open floor plans, passive heating and cooling, anticipation of electric vehicle charging, and other measures. Deployment of measures such as these would reduce energy use and greenhouse gas emissions.

Attract new funding, donor participation, or private sector financing to expand the pot for development investments

- Projects to reduce energy system black-outs during extreme weather events through investments in more resilient generation and transmission systems and back-up generation could attract support from local businesses dependent on electricity supply.
- Investments in infrastructure resilience could also increase the willingness of foreign corporations to invest in the region or community.

Engage stakeholders that have been hard to reach

- Projects to address local flooding “hotspots” can be used to engage women and girls, or at-risk youth, in community-level initiatives regarding solid waste, sanitation and public health, or erosion control.

Create new coalitions or better working relationships between stakeholder groups that have not been aligned or have been in competition

- The risk of increased drought conditions, affecting water supply for small farmers, area industry, and power generation (hydro), could provide a platform for joint problem-solving to reduce water loss, improve water conservation (e.g., improved irrigation, water capture, and recycling), and obtain funding for infrastructure improvements.

Improve infrastructure services for underserved communities and marginalized populations

- The need for investments in new or renovated infrastructure could provide opportunities to expand services to rural communities and provide jobs to women and other under-employed groups.
- When rebuilding, consider adopting the most progressive accessibility standards and rebuild in a way that improves access for marginalized populations, including persons with disabilities and people of low socioeconomic status (e.g., wheelchair accessible buses, buildings with ramps and elevators, affordable and accessible medical services in neighborhoods where many people use public transportation and might be isolated in an emergency).

Invest in infrastructure services that will support other development objectives

- The need to rebuild infrastructure after extreme events could provide an opportunity to relocate communities from high-risk locations and convert those areas to ecosystem/biodiversity restoration zones.

Tool Step 6: Climate Risk Management Options for Infrastructure, Construction, and Energy – Illustrative Examples

For infrastructure, adaptation actions can be categorized under three main approaches: accommodate and manage, protect and harden, and relocate/retreat. While not always the case, the cost of these approaches generally increases as "hard" engineering approaches or site relocation strategies are pursued. Post-disaster recovery may present a unique avenue for transformative changes in the resilience of infrastructure. Capitalizing on this opportunity may require pre-disaster planning to identify ways to proactively address climate change risks during post-disaster reconstruction.

Once you have reviewed this section, you can navigate back to the Tool by clicking on the relevant hyperlink in the header.

Accommodate and Manage

These options are characterized by their focus on changes in management practices and programs. They consist of updating plans, management policies, regulations, and maintenance and operations activities. Appropriate use of these strategies allows decisionmakers to manage the level of risk and monitor conditions while deferring more costly construction or relocation approaches; in some instances no additional actions may be required. By adjusting existing practices, accommodation and management strategies can increase resilience, manage climate effects as part of routine activities, or prepare for emergency management if infrastructure does fail. Examples include:

- Change the frequency of repair schedules and implement changes in maintenance protocols.
- Develop contingency plans in the event of disruption and install redundant systems to back up a primary system.
- Provide education and training for staff to effectively respond to system disruptions or emergency events. These actions often can be readily redesigned, based on an evaluation of progress, changing needs, and new information.
- Establish or expand a contingency budget reserve or insurance plan to address unexpected disruptions and fund investments to restore services and facilities.

Protect and Harden

Options under this approach involve structural changes to how an infrastructure system is designed, built, renovated, or protected. These options can be resource-intensive in terms of the financing, technical, and organizational capacity required. Implementing these actions as part of scheduled plans for upgrades or infrastructure replacement can be most cost-effective. Further, these options tend to be more permanent, making them less able to respond to changing circumstances. In order to avoid maladaptation, long-lasting and expensive infrastructure needs to be particularly well-designed to ensure its resilience under a range of potential climate futures. When possible, designs should allow for flexibility to incorporate future changes or enhancements as warranted by evolving climate conditions (e.g., a seawall that allows for the height to be increased). Examples include:

- Upgrade design standards and codes (e.g., using stronger building materials) and their implementation for both new construction and renovation.
- Fortify existing structures by incorporating extra foundational supports.
- Erect protective barriers, levees or sea walls, or natural areas (i.e., green infrastructure such as wetlands or replenished barrier islands) to buffer infrastructure from climate impacts.

- Elevate roads, bridges and structures, and change the curvature of drains and roads.
- Use more resilient building materials.

Site Selection or Retreat

These strategies seek to reduce the degree of exposure by locating or relocating assets and systems away from exposed locations, such as shorelines, floodplains, and areas at risk of landslides, mudflows, floods, or fire. Examples include:

- Relocate critical public buildings, such as hospitals and schools, to higher or less vulnerable locations.
- Site emergency response infrastructure (fire stations, helipad) in secure locations.
- Locate critical infrastructure systems, such as power plants, water lines, or telephone sub-stations, in more protected areas.

Tool Step 7: Identify Next Steps

Strategies and projects that include potential construction work should identify the following next step—ensure the Engineer of Record[8] conducts climate risk management by including the following language in solicitations, contracts, and subcontracts for engineering design:

Engineering analysis preceding design activities must include consideration of climate change and its potential impacts on the location (siting), functionality, and sustainability of resulting infrastructure and infrastructure services. Such analysis must include identification of relevant data sets and gaps, review of local building standards and codes for adequacy, and determination of safety factors or other measures of uncertainty that will be carried through design. The results of this analysis, including risks identified and how they are addressed, shall be documented.

[8] An appropriately qualified engineering firm under contract or subcontract with USAID for the purpose of completing the engineering design.

Additional Key Resources Related to Infrastructure, Construction, and Energy

The following **resources** provide additional information related to climate risks to infrastructure, construction, and energy and corresponding climate risk management options.

Title	Author(s)	Organization	Date	Length	Intended Audience	Unique Value
Lifelines : The Resilient Infrastructure Opportunity	Hallegatte, Stephane; Rentschler, Jun; Rozenberg, Julie.	World Bank	2019	Overview 33 pp. Full Report 224 pp.	Governments, stakeholders, and the international community	Building on a wide range of case studies, global empirical analyses, and modeling exercises, Lifelines lays out a framework for understanding infrastructure resilience—the ability of infrastructure systems to function and meet users' needs during and after a natural shock—and it makes an economic case for building more resilient infrastructure. Offers concrete recommendations and specific actions that can be taken by to improve the quality and resilience of infrastructure services.
Resilient Energy Platform		USAID and the National Renewable Energy Laboratory (NREL)	Contin-ually up-dated	Multiple resources, publica-tions	Decision-makers in the energy sector	Developed through the USAID-NREL Partnership, the Resilient Energy Platform provides expertly curated resources, training materials, data, tools, and direct technical assistance in planning resilient, sustainable, and secure power systems.
Incorporating Climate Change Adaptation in Infrastructure Planning and Design series • Overarching Guide • Sanitation • Roads • Bridges		USAID	2015	~60 pp. each	USAID infrastructure project managers	Describes best practices to incorporate climate adaptation in the planning and engineering design of USAID infrastructure activities. For use at the project- or activity-level, after reviewing the reference *Addressing Climate Change Impacts on Infrastructure*,

Title	Author(s)	Organization	Date	Length	Intended Audience	Unique Value
• Flood Management • Potable Water • Irrigation • Green Infrastructure (forthcoming) • Vertical Structures (forthcoming)						in order to gain a more detailed understanding of risks and potential adaptation options.
Addressing Climate Change Impacts on Infrastructure		USAID	2013	52 pp.	Development practitioners including country strategy and project teams	Provides more detailed information than the Tool about climate impacts to specific infrastructure categories (e.g., cultural heritage sites, buildings). Lists potential adaptation measures that help illustrate potential ways to reduce risk.
Fast-Track Implementation of Climate Adaptation	Numerous	USAID	2015	81 pp.	Development practitioners including country strategy and project teams	Fast Track approaches can be applied as a next step after screening, to identify near-term infrastructure adaptation options that may achieve rapid incremental improvements in resilience, and incorporate these adaptation options into planning and decision-making.
Paving the Way for Climate-Resilient Infrastructure	United Nations Development Programme	United Nations Development Programme	2011	148 pp.	Development practitioners assisting government authorities in planning infrastructure investments	Provides more detailed information about key considerations for decision-making on climate-proofing infrastructure, including frameworks for detailed understanding of risks and analysis of adaptation options.
Climate Impacts on Energy Systems: Key Issues for Energy Sector Adaptation	J. Ebinger and W. Vergara	World Bank, Energy Sector Management Assistance	2011	224 pp.	USAID energy project managers	Provides an overview of how climate change might affect the energy sector and what options exist to address the impacts.

Title	Author(s)	Organization	Date	Length	Intended Audience	Unique Value
		Program (ESMAP)				
Confronting Climate Uncertainty in Water Resources Planning and Project Design: The Decision Tree Framework	P. Ray and C.M Brown	World Bank	2015	125 pp.	USAID water resource managers	Provides resource-limited project planners and program managers with a cost-effective and effort-efficient, scientifically defensible, repeatable, and clear method for demonstrating the robustness of a project to climate change.
Climate Change and the Electricity Sector: Guide for Assessing Vulnerabilities and Developing Resilience Solutions to Sea Level Rise	U.S. Department of Energy, Office of Energy Policy and Systems Analysis	U.S. DOE	2016	116 pp.	USAID energy project managers	Provides more detailed discussion of SLR and coastal climate change impacts on the power sector, with a domestic focus.
Adapting Infrastructure and Civil Engineering Practice to a Changing Climate	J. R. Olsen et. al.	American Society of Civil Engineers	2015	104 pp.	Infrastructure designers and engineers	Reviews climate science and relationship to infrastructure, and recommends engineering approaches to reduce climate risk.