

# Stress Test Facility User Guide

## Infrastructure & Adaptation

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GCA Learning from Practice

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GLOBAL  
CENTER ON  
ADAPTATION



Rijkswaterstaat  
*Ministry of Infrastructure  
and Water Management*

### Purpose



This Stress Test User Guide builds on the experiences from the Global Center on Adaptation (GCA) and the Ministry of Infrastructure and Water Management of the Netherlands (MlenW) in implementing stress tests in the Netherlands, Ghana and Bangladesh.

It is intended to provide an overview of the steps required for the development of infrastructure stress tests, supporting countries to understand the potential of this process to identify adaptation needs and prioritize investments.

### Overview



Before starting with the implementation of a stress test of infrastructure systems, it is important to understand what is the landscape of adaptation investments for resilient infrastructure in the country. This requires mapping the stakeholders, policies and plans, and pipelines of projects in place to identify how the stress test can contribute to these ongoing initiatives. Furthermore, it is also important to understand what are the other climate vulnerability assessment and/or infrastructure studies that were previously developed to ensure that this work builds on previous insights, rather than duplicating existing efforts.

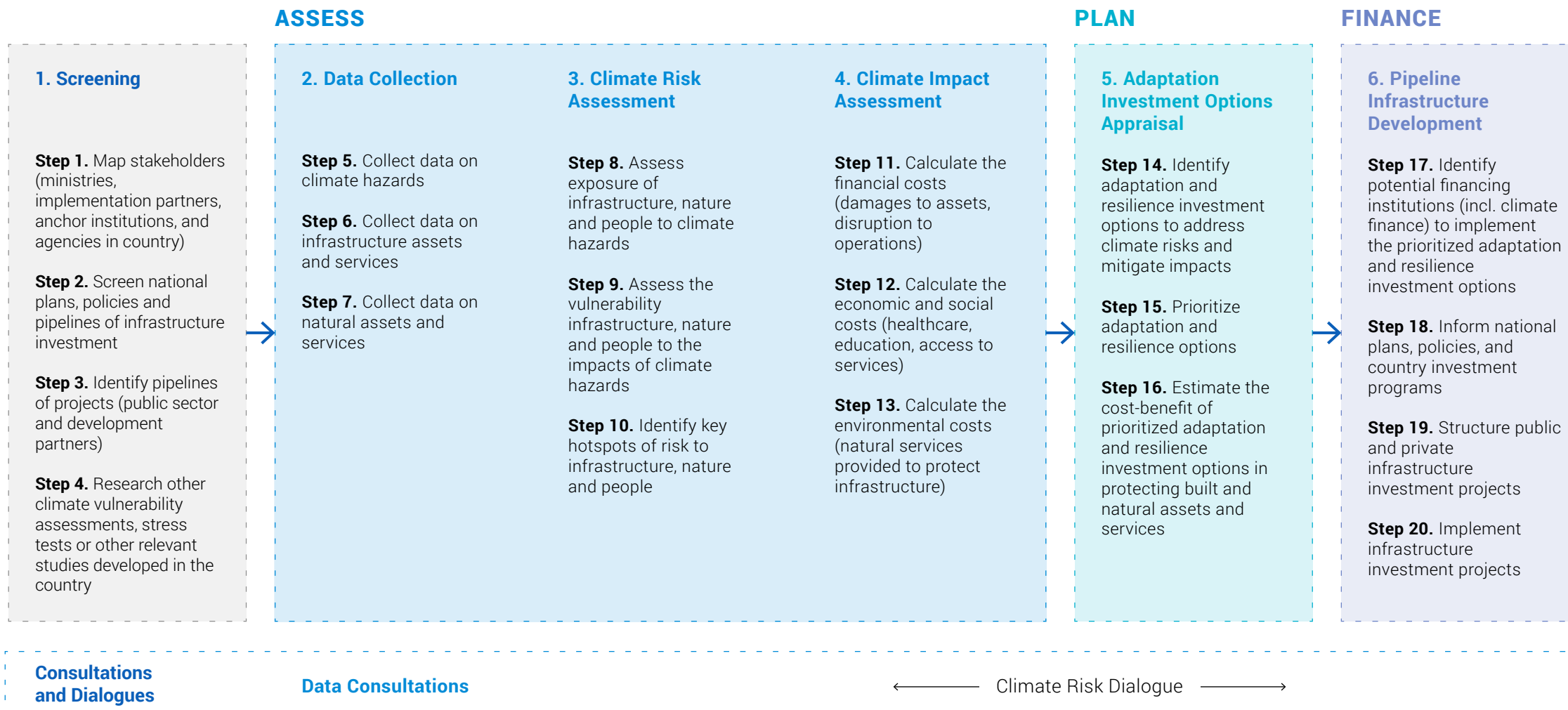
Infrastructure stress tests can be structured around:

- Assessing climate risk to infrastructure assets and services. This should leverage the use of state-of-the-art analytical tools and the best available data on physical climate hazards to pinpoint hotspots of risk within infrastructure systems and to identify the existing adaptation needs.
- Planning adaptation investment options to address these risks. Identify and prioritize adaptation investment options to address the existing adaptation needs. This process should be participatory, promoting climate risk dialogues with key stakeholders in country.
- Financing investments in resilient infrastructure through national programs and implementation partners. Develop a pipeline of projects to be implemented by the government, IFIs and development partners.

These phases can be divided in 20 steps. Each step was summarized considering the importance of undertaking stress tests (content), what is the potential of the analysis in terms of use of data and innovative methodologies (process), and what are the challenges and opportunities to achieve the expected results (culture).

# User Guide

## Stress Test of Infrastructure Systems



# 1. Screening



## Step 1. Map stakeholders (ministries, implementation partners, anchor institutions, and agencies in country)

## Step 2. Screen national plans, policies and pipelines of infrastructure investment

	Step 1	Step 2
CONTENT	<ul style="list-style-type: none"><li>• Ensure engagement from key stakeholders in the development of the stress test</li><li>• Leverage international and local institutions in the field of climate adaptation and resilient infrastructure</li></ul>	<ul style="list-style-type: none"><li>• Identify national development priorities and how these relate to infrastructure planning</li><li>• Identify existing pipelines of infrastructure projects and investment programs</li><li>• Identify previous activities conducted in the country</li></ul>
PROCESS	<ul style="list-style-type: none"><li>• Basic: Identify main counterpart within the government and implementation partners to develop the stress test</li><li>• Sophisticated: identify key counterparts within the government (i.e., multiple line ministries and, as well as IFIs, MDBs, IOs, NGOs, research institutes that can be involved in the process.</li></ul>	<ul style="list-style-type: none"><li>• Basic: collect data on ongoing projects from government and development partners</li><li>• Sophisticated: collect data on planned infrastructure projects from government and development partners, as well as review existing infrastructure and/or climate risk assessments conducted in the country</li></ul>
CULTURE	<ul style="list-style-type: none"><li>• Ownership from the Government (i.e., line ministries) and local stakeholders is key for a successful implementation of the project and to ensure that the results of the stress test translate into actual investments</li><li>• Government agencies, MDBs and other partners should be involved early on in the development of the stress test.</li></ul>	<ul style="list-style-type: none"><li>• Infrastructure investment projects tend to be prioritized within each line ministry, without a cross-sectoral approach</li><li>• Climate risk is often not considered in (public and private) infrastructure projects</li></ul>



# 2. Data Collection

## Climate Hazards

Hazard	Description	Sub-Hazards (and indicators)	Examples of scenarios to consider
Floods	Flooding poses a threat to infrastructure systems primarily in the form of inundation or destruction of energy, transport, and water infrastructure assets, or a reduction in the efficiency of dams and reservoirs through increased sediment transport. In addition, flooding can impact other sectors such as agriculture, causing destruction to crops and irrigation infrastructure.	<ul style="list-style-type: none"> <li>• Riverine flood / river runoff</li> <li>• Coastal flood</li> <li>• Sea level (mean sea level rise and extreme sea level rise)</li> <li>• Precipitation (RX – maximum precipitation accumulated within different temporal windows)</li> </ul>	<ul style="list-style-type: none"> <li>• Observational record/baseline (1980-2018/2020)</li> <li>• Current/baseline scenario (2018-2022)</li> <li>• Future scenarios (2030, 2040, 2050, 2060, 2080, 2100)</li> <li>• Future projections (RCPs 2.6, 4.5 and 8.5)</li> <li>• Return periods (2, 5, 10, 25, 50, 100, 500, 1,000 years)</li> </ul>
Drought	Droughts are predominantly caused by meteorological trends and conditions, in particular changes in precipitation patterns and rates of evapotranspiration. Reduced precipitation and river runoff are projected to decrease the availability of both surface water and groundwater, which in turn can impact hydropower potential, agricultural production, and potable water availability.	<ul style="list-style-type: none"> <li>• Meteorological drought (SPEI - Standardized Precipitation-Evapotranspiration Index)</li> <li>• Reduced river runoff</li> <li>• Groundwater level</li> </ul>	
Landslides	Heavy rainfall and flooding linked to climate change can increase landslide risk through heightened ground saturation, erosion, and the undercutting of slopes.	<ul style="list-style-type: none"> <li>• Landslide-prone areas</li> <li>• Level of susceptibility</li> </ul>	
Extreme Heat	Extreme heat can cause physical damages infrastructure assets through buckling, melting, and dilatation (expansion), and operational damages such as higher demand for cooling.	<ul style="list-style-type: none"> <li>• Extreme temperature (TXx - maximum daily temperatures within a year, such as TX35 and TX40)</li> <li>• Risk of wildfires (FWI – Fire Weather Index)</li> </ul>	
Erosion / Salinity	Soil erosion affects rural and built environments, causing physical damages to buildings, roads and utility supply networks. Furthermore, salinity intrusion will affect the supply of groundwater and operations of water treatment plants, and can also disrupt waterways.	<ul style="list-style-type: none"> <li>• Coastal erosion</li> <li>• Riverbank erosion</li> <li>• Salinity intrusion</li> </ul>	
Cyclones	Cyclones linked to climate change can also cause storm surges, extreme wind and waves, and high-tides. These hazard events can, for example, inundate coastal infrastructure (e.g., ports, roads and highways) and disrupt the supply of energy.	<ul style="list-style-type: none"> <li>• High tides</li> <li>• Storm surges</li> <li>• Extreme wind or wind damage (WX – maximum daily values of surface wind)</li> <li>• Extreme waves</li> </ul>	

# 2. Data Collection

## Infrastructure and Natural Assets

### Infrastructure Assets

Sector	Asset	Examples of attributes to consider
Energy	<ul style="list-style-type: none"> <li>• Powerplants</li> <li>• Substations</li> <li>• Distribution lines</li> <li>• Transmission lines</li> <li>• (Sub-)Grids</li> <li>• Gas fields</li> <li>• Gas lines</li> </ul>	<p>General:</p> <ul style="list-style-type: none"> <li>• Location (point or node data, geographic coordinate)</li> <li>• Size (square meters)</li> <li>• Investment value (\$)</li> <li>• Population served (# of people)</li> </ul>
Transport	<ul style="list-style-type: none"> <li>• Roads</li> <li>• Highways</li> <li>• Railways</li> <li>• Stations</li> <li>• Airports</li> <li>• Ports (sea and inland)</li> <li>• Waterways and terminals</li> </ul>	<p>Energy:</p> <ul style="list-style-type: none"> <li>• Generation capacity (GWh of m3)</li> <li>• Distribution capacity (GWh of m3)</li> </ul> <p>Transport:</p> <ul style="list-style-type: none"> <li>• Freight volume and capacity (tons)</li> </ul>
Water	<ul style="list-style-type: none"> <li>• Dams</li> <li>• Reservoirs</li> <li>• Water treatment plants</li> <li>• Surface water abstraction points</li> <li>• Water supply pipeline</li> </ul>	<p>Water:</p> <ul style="list-style-type: none"> <li>• Supply capacity (m3/s)</li> <li>• Demand consumption (m3/s)</li> </ul>
Social	<ul style="list-style-type: none"> <li>• Healthcare facilities</li> <li>• Education facilities</li> <li>• Cyclone shelters</li> <li>• Market centers</li> </ul>	<p>Social:</p> <ul style="list-style-type: none"> <li>• Business served (# of business)</li> </ul>

### Natural Assets

Asset	Examples of attributes to consider
Land Use Cover	<ul style="list-style-type: none"> <li>• Types of land use</li> <li>• Area</li> <li>• Soil composition</li> </ul>
Preservation areas	<ul style="list-style-type: none"> <li>• Location and size of preservation areas</li> <li>• Deforestations Rates</li> </ul>
Wetlands / mangroves	<ul style="list-style-type: none"> <li>• Location</li> <li>• Area</li> <li>• Services provided</li> <li>• Elevation</li> </ul>
Agriculture areas	<ul style="list-style-type: none"> <li>• Crop types</li> <li>• Area</li> <li>• Production capacity</li> <li>• Connectivity to market centers</li> </ul>
Waterways	<ul style="list-style-type: none"> <li>• River discharge</li> <li>• Groundwater levels</li> <li>• Salinity levels</li> </ul>

# 3. Climate Risk Assessment



## Step 8. Assess exposure of infrastructure, nature and people to climate hazards

## Step 9. Assess the vulnerability of infrastructure, nature and people to the impacts of climate hazards

## Step 10. Identify key hotspots of risk to infrastructure, nature and people

CONTENT	<ul style="list-style-type: none"> <li>Quantify infrastructure adaptation needs through geospatial analysis at the asset scale</li> <li>Assess the exposure of infrastructure assets and services provided to people</li> </ul>	<ul style="list-style-type: none"> <li>Geospatial mapping of the level of vulnerability of infrastructure and natural assets and services</li> </ul>	<ul style="list-style-type: none"> <li>Geospatial mapping of the key climate risks to infrastructure and natural assets and services</li> </ul>
PROCESS	<ul style="list-style-type: none"> <li>Basic: overlay data on selected climate hazards and infrastructure/natural assets to identify exposure based on the location in hazard-prone area</li> <li>Sophisticated: (i) assess exposure of infrastructure/natural assets across multiple climate hazards and scenarios based on the location in hazard-prone areas and basic attributes of service provision (e.g., capacity, population support, etc.), and (ii) calculate the % of exposure of infrastructure assets to multiple climate hazards and current/future scenarios with the use of asset damage curves.</li> </ul>	<ul style="list-style-type: none"> <li>Basic: map vulnerability based on level of exposure of infrastructure/natural assets at a regional/district level</li> <li>Sophisticated: (i) measure vulnerability through indexes on adaptive capacity at asset level, and (ii) measure vulnerability through detailed socioeconomic indicators at the local/household level.</li> </ul>	<ul style="list-style-type: none"> <li>Basic: based on exposure and vulnerability to climate hazards, pinpoint the key hotspots of risk</li> <li>Sophisticated: quantify the hotspots of risk through a detailed analysis of the concentration of assets and population, for multiple future climate scenarios</li> </ul>
CULTURE	<ul style="list-style-type: none"> <li>Assess exposure through a gender lens, highlight the insights for different groups (e.g., women)</li> </ul>	<ul style="list-style-type: none"> <li>Assess vulnerability through a gender lens, highlight the insights for different groups (e.g., women)</li> </ul>	<ul style="list-style-type: none"> <li>Validate the identified hotspots of risk with relevant stakeholders through Climate Risk Dialogues</li> </ul>

# 4. Climate Impact Assessment



## Step 11. Calculate the financial costs (damages to assets, disruption to operations)

## Step 12. Calculate the economic and social costs (healthcare, education, access to services)

## Step 13. Calculate the environmental costs (natural services provided to protect infrastructure)

CONTENT	<ul style="list-style-type: none"> <li>• Price the impacts of physical climate risks</li> <li>• Quantifying the financial damages to infrastructure assets and disruption of services</li> </ul>	<ul style="list-style-type: none"> <li>• Price the impacts of physical climate risks</li> <li>• Quantifying the economic and social costs of disruption of services</li> </ul>	<ul style="list-style-type: none"> <li>• Price the impacts of physical climate risks</li> <li>• Quantifying the environment cost to damages of natural assets and disruption of ecosystem services</li> </ul>
PROCESS	<ul style="list-style-type: none"> <li>• Basic: calculate the financial cost based on % of assets exposed (e.g., km of roads, number of power plants) and the investment value of these assets across multiple climate hazard scenarios.</li> <li>• Sophisticated: (i) use of local data/validation with local experts to quantify costs of repair/reconstruction, demand capacity of assets, and disruption to operations (e.g., downtime), (ii) apply probabilistic analysis of the exposure to multiple hazards and scenarios combined with integrated asset damage and economic loss risk curves.</li> </ul>	<ul style="list-style-type: none"> <li>• Basic: calculate the economic and social costs based on the % of social infrastructure exposed, the investment value of these assets, and the number of people serviced by infrastructure assets at risk across multiple climate hazard scenarios.</li> <li>• Sophisticated: (i) use of local data/validation with local experts to quantify the impact of disruption in the provision of services in terms of trade, access to basic services, and population affected; and (ii) use of household level data to determine the socio-economic impacts of physical climate hazards to household</li> </ul>	<ul style="list-style-type: none"> <li>• Basic: calculate the environmental cost based on % of natural assets exposed (e.g., km<sup>2</sup> of wetlands) and the number of people serviced by these natural assets across multiple climate hazard scenarios.</li> <li>• Sophisticated: (i) use of local data/validation with local experts to quantify the impacts to ecosystem services provided by natural assets and benefits in protecting infrastructure; and (ii) apply ecosystem/natural capital valuation methods to quantify the costs of climate change impact to natural services and assets.</li> </ul>
CULTURE	<ul style="list-style-type: none"> <li>• The financial cost of damages to infrastructure assets depend on the availability of data on the investment value of the asset and knowledge on reconstruction/repair cost.</li> <li>• Having registered/calculated the damages in previous climate hazard events and understanding of impacts to operations can also help to estimate future costs.</li> <li>• There is often not asset damage and economic loss risk curves for all climate hazards (even if at a global scale), and those estimates have to be adjusted to the local context.</li> </ul>	<ul style="list-style-type: none"> <li>• Quantifying the economic costs in the provision of services can help to understand the cascading impact of climate change to infrastructure systems.</li> <li>• There is often not enough information on the access of households to infrastructure services (i.e., # and % of population served) and other social characteristics (e.g., income level, literacy, housing type, employment, gender) that help to understand how the most vulnerable groups are affected.</li> <li>• Assess the impacts and risks through (i) a gender lens, providing insights for different groups (e.g., women); and (ii) achievement of the SDGs.</li> </ul>	<ul style="list-style-type: none"> <li>• The benefits of natural assets and ecosystem services can be measures in a qualitative or quantitative way.</li> <li>• There is often not enough information on the economic/financial costs of services provided through natural assets and in the development of investment cases to integrate natural solutions into infrastructure investments.</li> </ul>

# 5. Adaptation Investment Options Appraisal



## Step 14. Identify adaptation and resilience investment options to address climate risks and mitigate impacts

## Step 15. Prioritize adaptation and resilience options

## Step 16. Estimate the cost-benefit of prioritized adaptation and resilience options

CONTENT	<ul style="list-style-type: none"> <li>Identify and appraise adaptation and resilience options to address physical climate risks</li> </ul>	<ul style="list-style-type: none"> <li>Develop a roadmap of prioritized adaptation investment options</li> </ul>	<ul style="list-style-type: none"> <li>Quantifying the cost-benefit of these solutions in protecting built and natural assets and services</li> </ul>
PROCESS	<ul style="list-style-type: none"> <li>Basic: develop a long list of physical (hard infrastructure and soft/natural solutions), social (operations, education, behavioural) and institutions (governance, economic, regulation, policy and programme) measures to address each climate risk and the adaptation and resilience benefits they can provide to the infrastructure asset and services.</li> <li>Sophisticated: shortlist measures according to the key climate risks they should address to assets and services, based on international best practice and local knowledge, as well as determining a set of "no-regret" adaptation options that address multiple climate risks.</li> </ul>	<ul style="list-style-type: none"> <li>Basic: prioritize adaptation and resilience options based on the level of severity of the climate risks identified (e.g., negligible, medium, high, very high)</li> <li>Sophisticated: in addition to the level of severity of the climate risks identified, prioritize the adaptation and resilience options based on the impact (of no adaptation measures)</li> </ul>	<ul style="list-style-type: none"> <li>Basic: evaluate adaptation and resilience options based on a high-level estimate of cost and implementation time</li> <li>Sophisticated: quantify costs based on damage and economic risk curves and operational revenues, as well as investment value, and benefits based on the potential for risk reduction.</li> </ul>
CULTURE	<ul style="list-style-type: none"> <li>Engagement with stakeholders can help to identify adaptation and resilience options that are feasible within the local context</li> </ul>	<ul style="list-style-type: none"> <li>Develop a roadmap of prioritized adaptation investment options in consultations with stakeholders in country</li> <li>Address adaptation needs and contribute to national development priorities (SDGs, NDCs, NAPs, gender impact)</li> <li>Different priorities between ministries and agencies in country need to be balanced to ensure that the national development goals are achieved</li> </ul>	<ul style="list-style-type: none"> <li>Support the development of a climate adaptation rationale to influence investments from downstream partners</li> <li>Cost-benefit assessment depends on availability of technical specifications of assets and operations</li> </ul>

# Table X.

## Engineering options for infrastructure resilience in Africa



Region	Infrastructure	Hazard <sup>1</sup>	Vulnerable Component(s) <sup>2</sup>	Type of Damage <sup>3</sup>	Threshold <sup>4,5,6,7</sup>	Repair Cost <sup>8</sup>	Resilience Measure <sup>9</sup>	Improvement Type <sup>10</sup>	Improvement Cost <sup>11</sup>	Benefit-to-Cost Ratio
NORTH	Ports	Flood	Cargo buildings	Inundation	100-year flood	0.3	Living shoreline	NBS	0.05	6
			Un-embanked areas	Subgrade washout	100-year flood	0.4	Add embankment	Hard	0.1	4
		Earthquake	Cargo cranes	Crane toppling	500-year event	0.18	Add stiffness and ductility	Hard	0.025	7
			Wharf piers	Failure of deck-to-pile connections	500-year event	0.6	Strengthen pile-to-deck connections or add battered piles	Hard	0.2	3
	Wind Farms	Flood	Foundation	Erosion of soil	100-year flood	0.3	Add riprap (on-shore)	NBS	0.05	6
		Earthquake	Monopole base	Exposure of monopole piles	100-year flood	0.6	Enhance foundation design	Hard	0.3	2
Foundation	Liquefaction failure		500-year event	0.8	Ground mitigation	Hard	0.4	2		
Monopole	Failure of monopole	500-year event	0.6	Add supplementary damping	Hard	0.08	7			
WEST	Roads	Flood	Surface course	Surface washout	25-year flood	0.4	Use of concrete pavement	Hard	0.2	2
			Subgrade	Subgrade erosion	25-year flood	0.5	Enhanced subgrade and surface design	Hard	0.1	5
		Extreme heat	Surface course	Asphalt buckling	40° C sustained	0.2	Use of asphalt with high SRI	Hard	0.05	4
				Surface cracking and rutting	40° C sustained	0.2	Use of cool seal material	Hard	0.1	2
	Motorway bridges	Flood	Bridge deck	Surface overtopping	100-year flood	0.4	Design for HFL	Hard	0.05	8
			Bridge foundation	Foundation scour	100-year flood	0.8	Pile foundation below scour line	Hard	0.4	2
Extreme heat	Bridge superstructure	Failure of precast girders during erection	40° C differential temperature top & bottom	0.8	Lateral support of precast girders during construction	Hard	0.05	16		
		Expansion joint	Closure of expansion joints	10° C differential temperature	0.2	Use of wider expansion joints	Hard	0.02	10	
CENTRAL	Solar farms	Flood	Solar farm equipment	Flood water/debris impact	100-year flood	0.8	Elevate solar farm equipment	Hard	0.1	8
			Farm site	Inundation	100-year flood	0.8	Flood wall for solar farm site	Hard	0.15	5.3
		Extreme heat	PV panel	Hotspot phenomenon and potential fire	PV panel temperature 45° C	0.5	Periodic inspection, monitoring and maintenance	Hard	0.05	10
			PV panel and equipment	Lowered efficiency	PV panel temperature 45° C	1.0 <sup>12</sup>	Water cooling system	NBS	0.1	10
	Hydro-electric plants	Flood	Dam spillway	Overtopping of dam	100-year flood	0.8	Enhance spillway discharge capacity	Hard	0.1	8
			Levee and dam	Overtopping of reservoir levee	100-year flood	0.8	Higher freeboard	Hard	0.1	8
Extreme heat	Reservoir water	Lowered efficiency	Temperature rise 0.2° C per decade	1.0 <sup>13</sup>	Expand reservoir capacity	Hard	0.1	10		
		Concrete structure	Reduced concrete durability	Ambient temperature 50° C	0.6	Apply anti-carbonization coating	Hard	0.1	6	
EAST	Railway	Flood	Track and track bed	Railway track inundation	100-year flood	0.8	Install drainage and drainpipe	Hard	0.35	2.3
			Track bed	Track bed erosion and washout	100-year flood	0.8	Track bed stabilization	Hard	0.3	2.7
		Extreme heat	Rail	Rail thermal buckling (heat kink)	Rail temperature 50° C	0.5	Rail anchor and fastener	Hard	0.1	5
			Rail track	Uneven thermal expansion of rail	Differential temperature 10° C	0.2	Gap joint of rail	Hard	0.05	4
	Railway bridges	Flood	Bridge foundation	Flood scouring	100-year flood	0.2	Ground strengthening for scour	Hard	0.05	4
			Bridge pier	Flood water/debris impact	100-year flood	0.6	Pier strengthening	Hard	0.2	3
Extreme heat	Bridge connection	Excess joint thermal stress	Ambient temperature 50° C	0.4	Improve steel connection	Hard	0.15	2.7		
		Bridge and rail	Differential thermal expansion	Ambient temperature 50° C	0.2	Rail joint for bridge expansion joint	Hard	0.1	2	
SOUTH	Transmission & Distribution	Flood	Transmission tower	Foundation scour	100-year flood	0.9	Add micro piles to lattice transmission towers	Hard	0.3	3
			Distribution pole	Pole failure	100-year flood	0.6	Provide adequate embedment for distribution poles	Hard	0.1	6
		Wind	Transmission tower	Tower failure	300-year storm	0.8	Strengthen and stiffen the tower members	Hard	0.2	4
			Transformer line	Tower failure	300-year storm	0.6	Add Stockbridge dampers	Hard	0.05	12
	Solid waste plants	Flood	Plant equipment and building	Inundation and water/debris impact	100-year flood	0.8	Flood shield installation	Hard	0.1	8
			Plant site	Inundation and water/debris impact	100-year flood	0.8	Widen and deepen two-stage drain channel with bioswale	NBS	0.15	5.3
Wind	Plant building	Roof and wall damage	300-year wind velocity	0.5	Strengthen roof and wall connection	Hard	0.1	5		
		Plant equipment	External equipment overturning	300-year wind velocity	0.5	Enhance external equipment anchorage	Hard	0.15	3.3	

# 6. Infrastructure Pipeline Development



## Step 17. Identify potential financing institutions (incl. climate finance)

## Step 18. Inform national plans, policies, and country investment programs

## Step 19. Structure public and private infrastructure investment projects

## Step 20. Implement infrastructure investment projects

CONTENT	<ul style="list-style-type: none"> <li>Implementation of adaptation and resilience options and advance from concept phase to feasibility studies</li> <li>Access to climate funds and private sector, in addition to public sectors finance</li> </ul>	<ul style="list-style-type: none"> <li>Address adaptation needs and contribute to national development priorities (SDGs, NDCs, NAPs, gender impact)</li> </ul>	<ul style="list-style-type: none"> <li>Implementation of adaptation and resilience options and advance from concept phase to feasibility studies</li> <li>Access to climate funds and private sector, in addition to public sectors finance</li> </ul>	<ul style="list-style-type: none"> <li>Support the implementation of infrastructure components of national plans and policies</li> <li>Integrate adaptation and resilience into downstream investment from MDBs</li> </ul>
PROCESS	<ul style="list-style-type: none"> <li>Basic: identification of government agencies, private sector and development partners that finance infrastructure projects</li> <li>Sophisticated: application of tools to map relevant financing institutions (existing and new opportunities) across the stages of project concept, proposal and implementation, with focus on climate adaptation investments.</li> </ul>	<ul style="list-style-type: none"> <li>Basic: consultation with in-country stakeholders to identify priority areas for investments according to national priorities</li> <li>Sophisticated: development of national infrastructure programs based on the outcomes of the stress test, integration of prioritized adaptation options into NAPs, NDCs and Sector Plans, and influence of country investment programs from MDBs</li> </ul>	<ul style="list-style-type: none"> <li>Basic: development of project concepts based on infrastructure adaptation needs Nice to have: engagement with downstream development partners</li> <li>Sophisticated: engagement with downstream partners to develop (pre)feasibility studies for projects and NBS investment cases to take forward prioritized adaptation options to implementation</li> </ul>	<ul style="list-style-type: none"> <li>Basic: identify financiers for the implementation of project concepts of adaptation investment options</li> <li>Sophisticated: work with financiers and downstream partners to integrate high-resolution climate analytics and adaptation and resilience options appraisal into ESIA studies, project design, and operations and maintenance.</li> </ul>
CULTURE	<ul style="list-style-type: none"> <li>Accessing finance for adaptation requires understanding of existing funds and requirements of investments</li> <li>Public sector cannot bridge the infrastructure gap alone and therefore private sector play a key role in investing in resilient infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>There is the opportunity to align the development of the stress test with national plans and policies on infrastructure and climate change</li> </ul>	<ul style="list-style-type: none"> <li>Infrastructure investment projects tend to be prioritized within each line ministry, without a cross-sectoral approach</li> <li>Climate risk is often not considered in (public and private) infrastructure projects</li> <li>Engagement with MDBs to align with priority areas of investments</li> </ul>	<ul style="list-style-type: none"> <li>Ownership from the Government (i.e., line ministries) and local stakeholders is key for a successful implementation of the project and to ensure that the results of the stress test translate into actual investments</li> <li>Raise awareness across ministries and agencies to build in-country capacity and ambition to take over the tools developed in their processes</li> </ul>

# Conclusion

## Principles for Stress Testing of Infrastructure Systems

### Data, Methodologies and Local Capacity

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- The basic level of information is required to perform a stress test of infrastructure can already help countries to prioritize adaptation investments
- Availability of more detailed data on climate hazards and infrastructure assets will allow to provide a more robust analysis on the exposure of infrastructure and the socioeconomic impacts
- Building the capacity of local stakeholders to integrate and update data on climate hazards and infrastructure/natural assets and re-assess the impacts/risks.
- Development of geospatial tools with layers on climate hazards, infrastructure/natural assets, and toolkit guidance on the models used for simulationsholders across the country, create a shared understanding of climate hazards to assets and services, and jointly prioritize adaptation investments

### Systems and Governance

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- Ensuring high-level political support is important to mobilize the engagement of stakeholders and it also critical to ensure frequent involvement of stakeholders across ministries and agencies in country
- Climate risk dialogues are an useful process to engage relevant stakeholders across the country, create a shared understanding of climate hazards to assets and services, and jointly prioritize adaptation investments



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