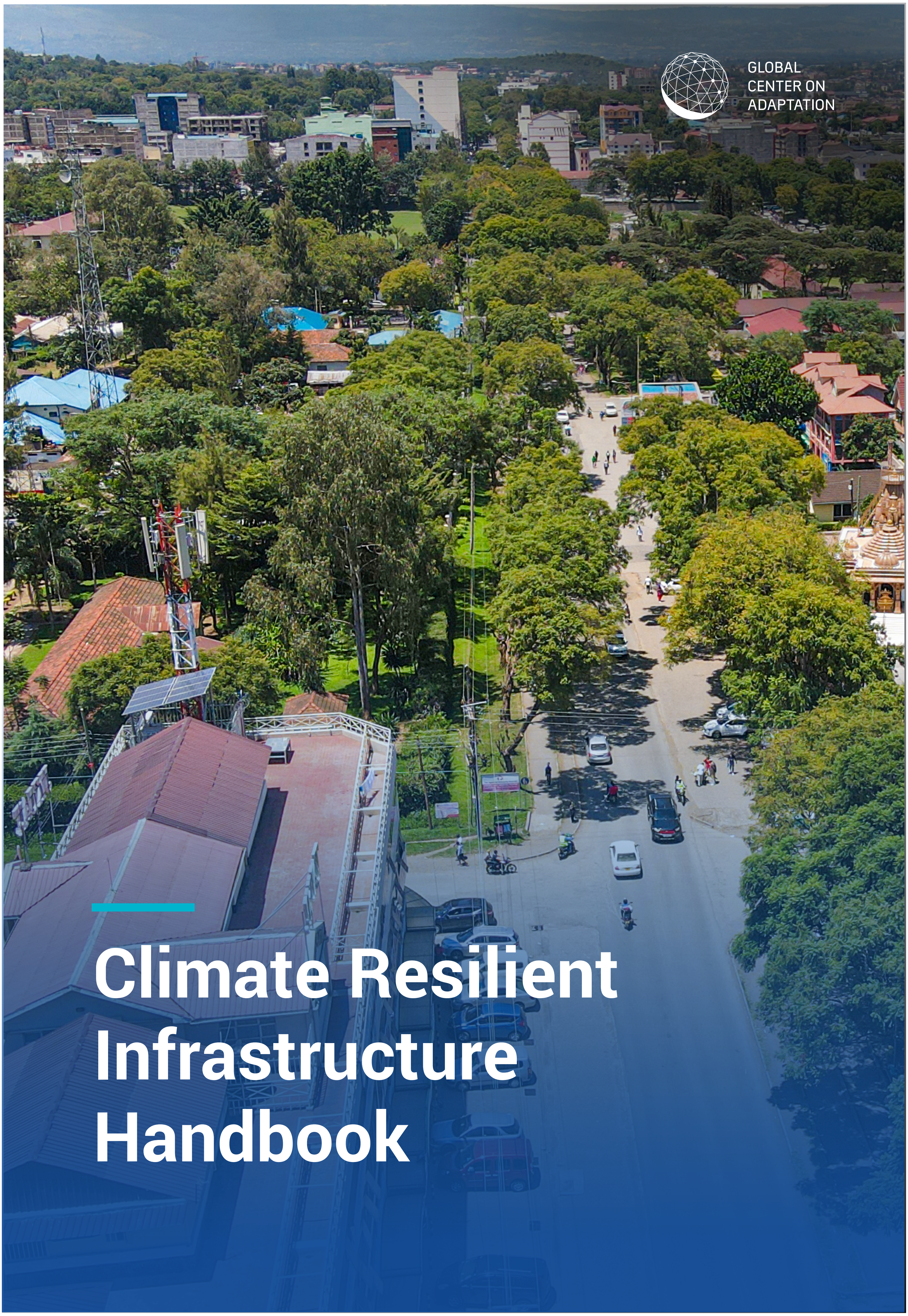

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Climate Resilient Infrastructure Handbook

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Developed by

ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Center on Adaptation (GCA) is an international organization, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

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Partnership Organizations

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Abbreviations

ADB	Asian Development Bank
AR6	Sixth Assessment Report (IPCC)
CC	Climate Change
CRA	Climate Risk Assessment
EPC	Engineering, Procurement, and Construction
GIS	Geographic Information Systems
GCA	Global Center on Adaptation
GFDRR	Global Facility for Disaster Reduction and Recovery
ICT	Information and Communication Technology
IDB	Inter-American Development Bank
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LGBT+	Lesbian, Gay, Bisexual, Transgender, and others
NBS	Nature-based Solutions
NGO	Non-Governmental Organization
OECD	Organisation for Economic Co-operation and Development
OpEx	Operational Expenditure
PPP	Public-Private Partnership
PVRA	Participatory Vulnerability and Risk Assessment
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goals
SEP	Stakeholder Engagement Plan
SPV	Special Purpose Vehicle
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
VfM	Value for Money
WBG	World Bank Group
WCRP	World Climate Research Programme

Preface

Climate change threatens critical infrastructure systems through rising temperatures, changing precipitation, extreme weather events, and sea level rise. These systems—transportation, energy, water, and telecommunications—deliver essential services and protect communities, yet face increasing vulnerability as climate disasters intensify.

The economic case for climate resilience is compelling. The World Bank reports that direct infrastructure damage in low and middle-income countries costs $18 billion annually, potentially rising to $39 billion by 2040, with indirect costs reaching $100 billion yearly. Conversely, investing in resilience yields substantial returns, with net present value exceeding $2 trillion in most scenarios analyzed.

With global urban infrastructure needs exceeding $4.5-5.4 trillion annually—including a resilience premium of 9-27%—government budgets alone cannot meet this challenge. PPPs offer a proven mechanism to leverage private capital while providing unique advantages through several interconnected features. Long-term contracts create natural incentives to address climate risks, motivating private partners to ensure assets withstand evolving climate conditions over decades of responsibility. Performance-based incentives can incorporate resilience metrics that drive forward-thinking design and maintenance practices prioritizing adaptability to changing conditions. The output-based structure encourages innovation in developing adaptive solutions, including cost-effective nature-based approaches often overlooked in traditional procurement models. A whole-of-life approach incentivizes investments in quality materials and adaptive designs that may cost more initially but deliver significant lifecycle savings by preventing costly repairs and disruptions. Additionally, private sector involvement in post-event service restoration allows public partners to focus resources on broader community recovery needs, enhancing overall resilience to climate events.

"Climate change threatens critical infrastructure systems through rising temperatures, changing precipitation, extreme weather events, and sea level rise.

To maximize these benefits, PPP contracts require careful structuring with clear resilience incentives, robust climate risk data, and thoughtful risk-sharing frameworks that align public and private interests toward sustainable, climate-resilient infrastructure.

Purpose and Audience

This handbook serves as a concise, practical reference guide for PPP and infrastructure practitioners seeking to integrate climate resilience throughout the PPP project lifecycle. It is designed for government officials, project developers, financiers, consultants, and other stakeholders involved in planning and implementing infrastructure PPPs. The content is practice-oriented, featuring real-world examples, actionable checklists, and decision-support tools that can be readily applied across diverse contexts and sectors. Crucially, this handbook does not delve into detailed project structuring. While structuring is vital for project success, it is very complex and challenging to isolate the climate component within the structuring, as it is inherently intertwined with numerous other project considerations. Furthermore, project structuring practices vary significantly across countries and legal jurisdictions, making it impractical to address them comprehensively in a generalized framework for climate resilient infrastructure.

Key Features and Content

The handbook identifies critical entry points for climate resilience and adaptation across all PPP project phases—from identification and appraisal to procurement, implementation, and asset transfer. It explains how climate risk assessment should inform project selection, design specifications, contract structuring, and operational requirements. Importantly, it demonstrates how climate considerations must be embedded in fundamental PPP processes including risk allocation, value for money assessment, and performance monitoring.

Each module provides clear guidance on responsibilities, decision points, and practical steps to enhance climate resilience. Cross-cutting themes—including decision-making under uncertainty, nature-based solutions, stakeholder engagement, gender considerations, and climate finance—are integrated throughout, reflecting their relevance across the infrastructure lifecycle.

Methodology

This handbook distills leading practices and guidance on climate resilience and adaptation in infrastructure PPPs. It has been developed through comprehensive review of existing resources and best practices, in consultation with industry experts, financial institutions, and practitioners with direct experience implementing climate-resilient infrastructure projects. The handbook reflects lessons learned from real projects across various regions and sectors, offering practical insights into both successful approaches and common challenges.

How to Use This Handbook

This resource is not intended as a textbook. Instead, it covers the key concepts focusing on practical application rather than theoretical background. Each section provides sufficient context to understand essential principles, accompanied by concise guidance on implementation steps.

For practitioners requiring deeper exploration of specific topics, the handbook links to more detailed guidance resources, tools, and case studies. This approach allows users to quickly grasp core concepts while providing pathways to additional information as needed for implementation.

By presenting climate resilience in the familiar framework of the PPP project lifecycle, the handbook enables practitioners to integrate these considerations into existing processes rather than creating parallel workflows. This integration is essential for mainstreaming climate resilience into standard practice—moving from isolated pilot projects to systematic implementation at scale.

As climate impacts continue to intensify, the resilience of our infrastructure systems will increasingly determine the resilience of our communities, economies, and ecosystems. This handbook aims to equip practitioners with the knowledge and tools needed to develop infrastructure that can withstand current climate variability while adapting to future changes—protecting investments, ensuring service continuity, and supporting sustainable development in a changing climate.

Introduction to Climate-Resilient PPPs

1. Introduction to Climate-Resilient PPPs

Description: This section provides the foundational background for the Climate Resilient Infrastructure Officer (CRIO) course and introduces the structure and cross-cutting key concepts that will be used throughout the Handbook. It also describes the current climate context, outlines existing and possible future climate risks and their impacts on infrastructure and frames the importance of climate resilience and adaptation in PPP projects. Some of the contents regarding developing pipelines are covered in the Stress Test Facility User Guide published by GCA.

Learning outcomes: At the end of this module, readers will be able to:

- Describe key concepts around climate change, climate risk and resilient infrastructure
- Explain why it is important to consider climate resilience and adaptation in PPP projects
- Describe the role of key PPP stakeholders in the context of climate resilience
- Explain how to use the PPP project lifecycle as a framework to integrate climate resilience and adaptation

1.1 Why do we need climate-resilient infrastructure

Our lives and livelihoods are built within and around systems of infrastructure. Infrastructure directly provides essential services, such as water and energy, to individuals and businesses. It also connects us to key services, such as healthcare and education, and enables us to participate in social and economic activity, by facilitating travel to work or cultural spaces. Infrastructure also protects people from climate-related hazards and helps them respond more effectively during and after crises.[1] As climate change worsens, it will exacerbate the frequency and intensity of such disasters. It is critical to consider this when planning, designing, maintaining and even retrofitting infrastructure assets.

However, infrastructure systems are increasingly stressed as a result of growing populations and the worsening impacts of climate change. In developing countries, this is compounding an existing infrastructure deficit. Natural hazards, such as flooding, extreme temperatures etc., are impacting the performance of infrastructure networks and assets across the globe. These impacts will be exacerbated over the coming decades as climate change worsens and urbanization increases. There is therefore an urgent need to invest in making existing and future infrastructure more resilient to the impacts of climate change.

Making the case for climate-resilient infrastructure

The impacts of climate change are already being felt across the world and the frequency and severity of extreme events are set to increase, damaging infrastructure systems and disrupting the provision of services to end users and communities. Key climate-related shocks and stressors that will likely impact infrastructure include flooding, erosion, sedimentation, extreme temperatures, drought, and more unpredictability in seasonal weather patterns (see **Table 1.1**). According to the Intergovernmental Panel on Climate Change (IPCC)[2], climate change increases the risk of compound and cascading impacts, and uncertainties remain around the extent and timing of such impacts due to the complexity of interconnected systems (see **Box 1.1**).

1 The Rockefeller Foundation and Arup, 2015. City Resilience Index. London.

2 Intergovernmental Panel on Climate Change (IPCC), 2023, Sixth Assessment Report.

Table 1.1 Overview of climate change impacts (non-exhaustive) on infrastructure sectors

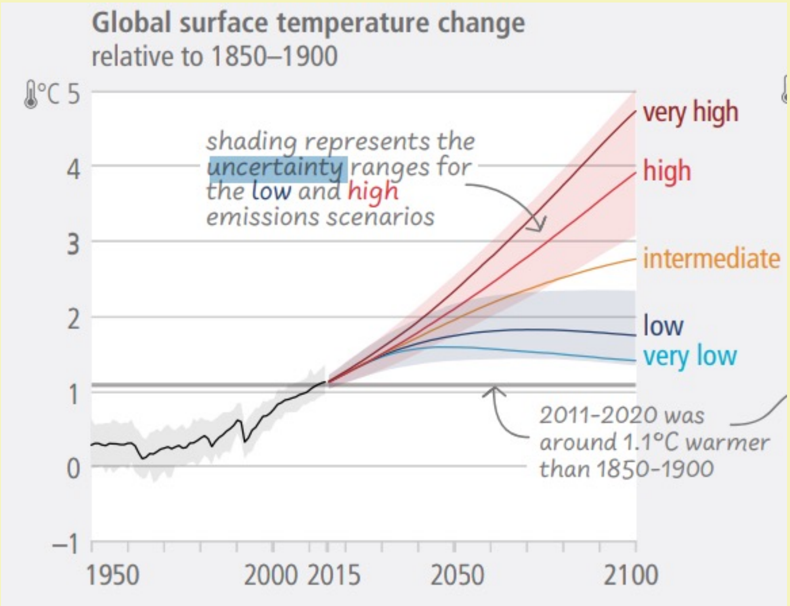
	Potential impacts per hazard type			
Sector	**Temperature changes**	**Changing patterns of precipitation**	**Sea-level rise**	**Changing patterns of storms**
Water	Need for more water treatment Higher evaporation loss, mainly on reservoirs Need for higher storage capacity Salinization of water supply Increased water demand	More risk of overtopping river embankments and flooding Overwhelming drainage systems Disruptions to the supply due to water scarcity Salinization of water supply	Physical damage to assets like water and wastewater treatment plants	Physical damage to assets like water and wastewater treatment plants
Transport	Buckle of railway lines and melting road surfaces	Shipping transport disruptions due to lower levels in waterways Damage to road asphalt Disruptions due to floods or higher water levels in waterways	Inundation and erosion of coastal infrastructure like ports, roads, and railways	Physical damage to assets like bridges and coastal transportation networks Disruption of port and airport services
Energy	Power outages or reduced output from power plants Impact on transmission lines Excess pressure and demand on networks from overheating	Physical damage to assets like energy generation, transmission and distribution networks Impact on the efficiency and operations of hydropower plants	Inundation of coastal infrastructure affecting generation, transmission, and distribution	Disruptions in the transmission and distribution of energy Downed power lines and transmission
ICT	Higher demand for cooling like data centers	Physical damage to above ground transmission (e.g., radio masts)	Inundation events of coastal infrastructure like telephone exchanges	Physical damage to above ground transmission (e.g., radio masts, telecom towers)
Urban Develop-ment	Higher demand for cooling (e.g., air conditioning)	Disruptions in distribution of basic services due to reduced water availability	Inundation events of urban infrastructure (e.g., schools, hospitals)	Physical damage to homes and commercial assets (e.g., buildings)

Source: Adapted from GCA and OECD

Box 1.1 Climate change and uncertainty

Recent climate science underscores the accelerating pace of extreme weather events and ecosystem disruptions due to rising temperatures and emphasizes the urgent need to limit warming to 1.5°C to avoid severe climate impacts. This graph, taken from the IPCC's Sixth Assessment Report (AR6), shows the global temperature rise over time, highlighting the clear upward trend. This upward trend is making the extreme weather events more frequent and intense. Furthermore, the AR6 report and subsequent studies project that even seemingly small increments of warming will lead to disproportionately larger risks, including more devastating heatwaves, intensified droughts and floods, accelerated sea-level rise, and irreversible loss of biodiversity. The shading on the graph represents the uncertainty that exists in climate projections, which depends on several factors.

Figure 1.1 Global surface temperature change relative to 1850–1900. (IPCC AR6, 2023).



Climate change uncertainty arises from three main sources: natural variability, modeling limitations, and human actions. Natural climate variability, such as chaotic system behavior and feedback mechanisms, leads to unpredictable fluctuations. Climate models, while valuable, simplify complex processes and may lack sufficient resolution or data, especially in specific regions or timeframes. Human-related uncertainties stem from future greenhouse gas emissions, socioeconomic developments, and policy actions, which are inherently unpredictable. The IPCC addresses these uncertainties using probabilistic language (e.g., 'likely') and confidence levels based on evidence and scientific consensus.

Understanding and clearly communicating these uncertainties are key to supporting informed decision-making and planning, particularly for long-term and high-stakes challenges like infrastructure development and climate adaptation strategies.

Source: IPCC. 2023. Synthesis Report for the Sixth Assessment Report.

As a result, **infrastructure needs to be prepared to cope with the impacts of existing and future climate change impacts.** Failure to address climate resilience will ultimately make infrastructure systems unsustainable and undermine their financial viability. Infrastructure assets in hazard-prone areas face disruptions by natural disasters, resulting in direct damage and indirect losses stemming from the ensuing disruption of the economic activity in the impacted communities. Low- and middle-income countries are disproportionately affected. According to the World Bank, the direct damage cost from floods, storms, earthquakes and natural hazards to power generation and transport infrastructure assets in low- and middle-income countries amounts to USD 18 billion every year.[3] As climate change increases the frequency and severity of weather-related natural hazards, direct and indirect damage losses will also be on the rise. It is estimated[4] that climate change could increase the annual global direct cost of weather-related disasters by about 20%, or $39 billion, by 2040. If indirect costs from the disruption to supply chains and economic activity in affected areas are factored in, the increase could amount to $100 billion per year.

There is an urgent need to retrofit existing infrastructure or construct new infrastructure with the specific aim of reducing hazard exposure and increasing the adaptive capacity of the asset and the community it serves. An example of this is the construction of flood protection infrastructure to protect a community and its assets against future flood hazards. Nature-based Solutions (NBS), like mangrove forests or wetlands, can serve this purpose and help increase the adaptive capacity of existing assets and communities while simultaneously providing other co-benefits.

Climate-resilient infrastructure has the potential to provide co-benefits beyond its primary role in withstanding climate impacts. It can enhance public safety, contribute to economic stability, minimize disruptions to essential services like transportation, support environmental sustainability, and even improve social equity. Before looking at the co-benefits of investing in resilient infrastructure, it is important to note the difference between resilient infrastructure (resilience *of* infrastructure) and infrastructure for resilience (resilience *through* infrastructure), see **Box 1.2**. Climate-resilient infrastructure, as referred to in this Handbook, highly focuses on resilient infrastructure but encompasses both aspects[5].

Box 1.2 Resilience of and resilience through infrastructure

- **Resilient infrastructure** – (also termed resilience *of* infrastructure) Infrastructure that is planned, designed, built, operated, and maintained in a way that anticipates, prepares for, and adapts to changing climate conditions. It can also withstand, respond to, and recover rapidly from disruptions caused by these climate conditions.[6] For example, developing drainage systems to ensure that a road network does not experience washouts

- **Infrastructure for resilience** – (also termed resilience *through* infrastructure) Infrastructure that is put in place primarily to increase the resilience of a targeted community or asset by reducing exposure and vulnerability to a climate hazard or increasing the adaptive capacity of the community or asset. For example, a sea wall to mitigate the risk of tidal/coastal flooding. Resilient infrastructure can also function as infrastructure for resilience.

3 World Bank, 2019. Lifelines: The Resilient Infrastructure Opportunity.

4 Cambridge Centre for Risk Studies, 2018; Global Risk Index 2019 Executive Summary, Cambridge Centre for Risk Studies, University of Cambridge.

5 MDBs Typology typically categorizes climate adaptation projects into 3 types:
Type 1: Adapted Projects - Equivalent to resilient infrastructure covered in this book here projects related to water and sanitation, transport, energy and education
Type 2a: Projects with shared objective of adaptation and development - Health care, social protection, Agriculture, Irrigation etc.
Type 2b: Equivalent to Infrastructure for resilience covered in this handbook e.g. flood defense walls to protect a city and businesses from increased risk of flooding

6 Organisation for Economic Co-operation and Development (OECD), 2018. Climate-resilient Infrastructure: OECD Environment Policy Paper NO.14. Paris.

It is essential that practitioners understand the need for implementing infrastructure that is resilient to the impacts of a changing climate, and this requires a shift in practice. Climate resilience should be integrated from the early stages of the infrastructure lifecycle to ensure that new and existing infrastructure is climate resilient. Several aspects need to be considered to incorporate climate resilience into infrastructure. These include the selection of adequate resilience-building actions and the application of different guiding principles such as the Principles for Quality Infrastructure Investment (QII)[7] or the UNDRR Principles for Resilient Infrastructure.[8]

Why PPPs for infrastructure development?

The World Bank estimates a global need for urban infrastructure investments that amount to over $4.5 trillion to 5.4 trillion per year, of which an estimated premium of 9-27% is required to make infrastructure low-carbon and climate-resilient.[9] This kind of funding cannot be covered by government budgets alone, hence the need for private capital to supplement public funding. In addition, there is a multi-trillion-dollar financing gap for infrastructure, coupled with ready-to-deliver infrastructure projects.[10] PPPs are one instrument that has been successfully used to bring private funding into the infrastructure lifecycle. Because of the essential services that infrastructure provide to communities, the public and private sectors need to work close together, with the public sector maintaining an appropriate level of contractual or regulatory control.

While PPPs currently comprise a limited share of total infrastructure investments, their use is accelerating[11]. Besides becoming more popular in mature economies, PPPs are also expected to play a major role in addressing the infrastructure challenges of fast-growing economies such as Africa and Asia. For example, the African Development Bank estimates that the African infrastructure financing gap ranges between $68 and $108 billion[12] and the Asian Development Bank estimates a $907 billion infrastructure financing gap[13] for Asia.

Box 1.3 What are PPPs?

Public Private Partnerships (PPPs) can be defined as a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance.

PPPs aim to deliver Value for Money (VfM) by transferring risks to the private sector, encouraging innovation, and using performance-based contracts that incentivize cost-effectiveness, innovation, and timely delivery. This approach ensures that projects are designed, financed, built, and maintained in a manner that optimizes the benefits for both the public and private sectors over the long term. PPPs can offer many benefits, including a whole-life costing approach that optimizes construction, operation, and maintenance costs, better risk management – with the private sector taking on a level of assessed risk and rewarded for the extent of risk taken on – and efficient project delivery. Well-structured PPPs can help ensure that brown and greenfield projects are delivered on time, within budget, and generate attractive risk-adjusted returns for investors.

For those who wish for a more in-depth refresher or feel the need for a more foundational understanding of PPPs, refer to the APMG PPP Certification Guide and associated training, as well as the GCA PPP Primer.

7 World Bank, 2024. QII: Advancing Green, Resilient, Inclusive Development
8 United Nations Office for Disaster Risk Reduction (UNDRR), 2023. Principles for resilient infrastructure.
9 World Bank, 2016. Investing in Urban Resilience Can Save the World's Cities Billions Each Year and Keep Millions out of Poverty.
10 Lu, J. 2020. A simple way to close the multitrillion-dollar infrastructure financing gap. World Bank Group.
11 World Bank, 2015. World Bank Group support to public-private partnerships: lessons from experience in client countries, FY2002-12. Washington, D.C.
12 African Development Bank (AfDB), 2018. Africa's Infrastructure: Great Potential but Little Impact on Inclusive Growth.
13 Asian Development Bank (ADB), 2018. Closing the Financing Gap in Asian Infrastructure.

Why climate resilience and adaptation for PPP projects?

Previous sections highlighted the urgency and importance of embedding climate resilience and adaptation in infrastructure development.

This is also true for PPP infrastructure projects. Climate change undermines the benefits that both the public and private sectors can get from PPPs. Specifically, the increased frequency and severity of extreme weather events decreases the availability of infrastructure, increases the maintenance and repair cost of critical assets, and ultimately reduces the socio-economic value of the investment. For the end users, weather-related disruptions of infrastructure systems entail loss of service and potential dangers to life and health. On the private sector side, infrastructure disruptions brought about by weather extremes come with unpredictable increases in operation and maintenance costs, reduced asset life and foregone revenues, as well as penalties.

Climate resilience and adaptation – when properly integrated into or supported through infrastructure – can add value for little additional cost, meaning less risk to continuity of service and potential value creation. The case for resilient infrastructure is clear: according to the World Bank, the net present value of integrating resilience into new infrastructure assets 'exceeds $2 trillion in 75 percent of the scenarios and $4.2 trillion in half of them.[14]

PPPs create profit-based incentives for the private sector to assume part of the risk in project delivery while generating significant benefits for society. By incorporating climate resilience and adaptation into PPPs, governments and private entities can collaboratively develop infrastructure systems better equipped to withstand climate change. This not only ensures sustainable development and long-term returns but also safeguards the VfM principle central to PPPs.

PPPs provide unique opportunities to embed climate resilience and adaptation throughout the infrastructure lifecycle:

- **Long-Term Risk Management** - PPP contracts, covering the entire lifespan of infrastructure assets and systems, inherently address long-term risks, including those posed by climate change. Furthermore, planning, design and contract preparations also take a long time, so time lags of the order of 5 to 10 years are not out of the ordinary. Risk-sharing mechanisms, such as pain-gain sharing, enable the integration of resilience into contracts, balancing downside risks (e.g., hazard impacts) with potential gains. Embedding resilience principles in project design enhances asset durability, minimizes operational disruptions, and reduces repair costs.

- **Performance-Based Incentives** - PPP remuneration, whether through user fees or availability payments, can be linked to climate-adaptive performance metrics. This motivates private partners to implement resilient solutions that meet predefined criteria, ensuring infrastructure durability and reliable service delivery.

- **Innovation and Flexibility** - Output-based PPP contracts encourage private sector innovation. Evaluation frameworks can prioritize sustainable, adaptive solutions such as NBS, which provide cost-effective climate resilience benefits while leveraging natural processes. Innovative designs can thus be promoted through evaluation frameworks that prioritize adaptive and sustainable approaches.

- **Lifecycle Cost Optimization** - The whole-of-life approach in PPPs integrates resilience planning across all phases — design, construction, operation, and maintenance. Private contractors, responsible for these stages, have vested financial interests in ensuring assets withstand climate hazards, reducing lifecycle costs while safeguarding performance and service continuity.

- **Enhanced Recovery Capacity** - PPPs strengthen recovery efforts after a climate-related disaster event. Private sector involvement in ensuring rapid restoration of services allows public partners to allocate resources more effectively toward broader recovery needs, enhancing the efficiency and effectiveness of overall disaster recovery.

14 Hallegatte, S., Rozenberg, J., Rentschler, J., Nicolas, C., Fox, C. 2019. Strengthening new infrastructure assets: a cost benefit analysis. World Bank. Washington, D.C.

- **Global Applicability and Scalability** - As a widely adopted procurement and infrastructure development tool, PPPs offer a practical pathway for embedding climate resilience without relying entirely on novel mechanisms. Existing expertise and institutional capacities can seamlessly incorporate climate adaptation principles into PPP processes.

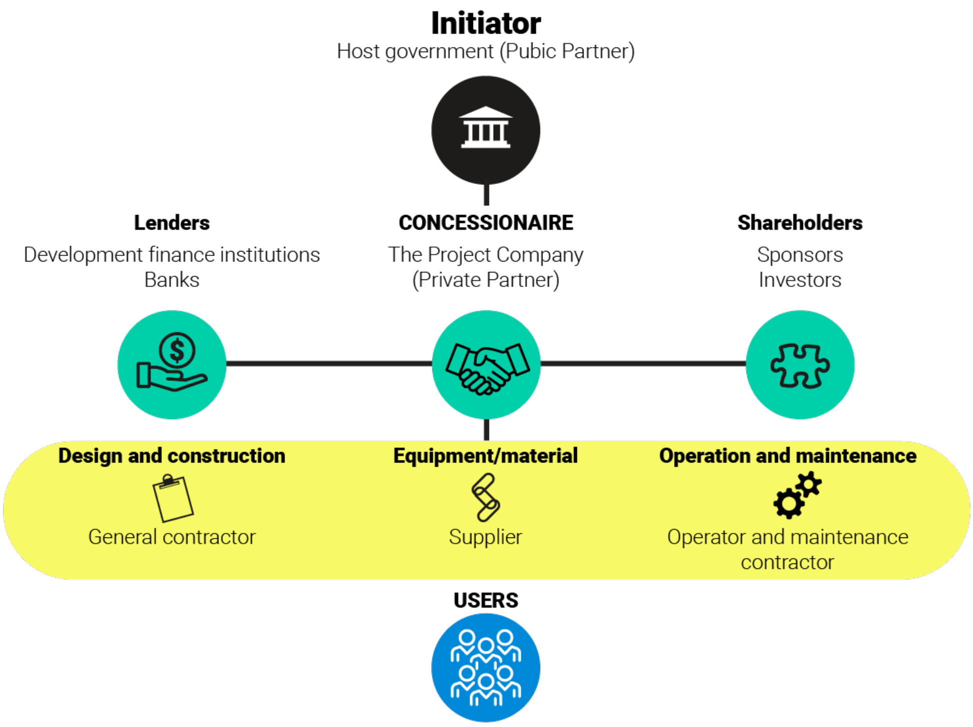
To realize these benefits, PPP contracts must be carefully structured to provide clear resilience incentives, supported by robust climate risk data and thoughtful risk-sharing frameworks. Properly designed PPPs are uniquely positioned to enhance climate resilience and adaptation in infrastructure projects while maintaining VfM and fostering sustainable development.

1.2 Key stakeholders and their role in climate-resilient PPPs

This section identifies the key stakeholders involved in PPPs and ways in which these stakeholders can evolve to better meet resilient infrastructure needs. **Stakeholders** are 'persons or groups who are directly or indirectly affected by a project, as well as those who may have interest in a project and/or the ability to influence its outcome, either positively or negatively'. It is important to consider stakeholders relevant to both climate resilience and the PPP process. This includes public and private sectors alongside civil society and non-governmental organizations, as well as those directly impacted by the project geospatially and those who may have interests in the project but are not geospatially impacted by it. Depending on their involvement in the project, the stakeholders can have different expectations (short- vs. long-term view) and their interests might not always be aligned.

Figure 1.2 illustrates the typical project structure of a PPP and identifies the key stakeholder groups that will be used throughout the Handbook. The project structure refers to the architecture of contract relationships and cash flows that govern the development and life of the project.

Figure 1.2 Typical PPP structure and key stakeholders



Source: Authors. Adapted from ADB, EBRD, IDB, IsDB, and WBG. 2016. The APMG Public-Private Partnership (PPP) Certification Guide. Washington, DC: World Bank Group. License: Creative Commons Attribution CC BY 3.0 IGO.

Different stakeholders will have different opportunities for integrating climate resilience and adaptation in PPP projects. Ultimately, the responsibility for embedding climate resilience in infrastructure PPPs will be shared between the public and private partners. The following section outlines the roles and responsibilities of key stakeholders in the context of climate-resilient PPPs.

The Public Partner

The Public Partner is responsible for identifying, screening, and appraising PPP projects with the interest of the public in mind. This can be done through effective policies, careful planning, competitive procurement, as well as compliance management and legislation. Specifically, the Public Partner should ensure adherence to relevant international agreements, such as the Paris Agreement, and incorporate policies that prioritize projects with climate-resilient infrastructure designs, promote the use of sustainable materials, and reduce greenhouse gas emissions throughout the project lifecycle.

In the context of advancing climate-resilient PPPs, the Public Partner plays a critical role by creating an enabling environment for investment. The Public Partner should:

- Support projects that work towards national or local 'climate readiness' and respond to climate shocks through programs. Readiness is enabled through programs that strengthen the technical and managerial capacities of governments, organizations and communities, e.g.climate data collection, climate risk and impact assessments, emergency preparedness plans, protocols, trainings, and early warning systems.

- Develop a clear pipeline of investment opportunities for climate-resilient projects to attract investors.

- Design financial regulations to promote economic stability and tie investments to climate risk mitigation, leveraging frameworks like the Task Force on Climate-related Financial Disclosures. If governments can demonstrate that they have invested in building resilience, long-term investments in the area become more lucrative.

- Provide technical and financial support. Government agencies in different regions and countries will likely have different skill levels around climate-resilient infrastructure. Supranational and national agencies, such as the Ministry of Environment or Ministry of Planning, can work to provide the necessary technical and financial support to increase capacity and feasibility of resilience projects across different government levels.

- Establish an enabling environment with supportive policies, standards, regulations and guidelines. One of the most important roles of the Public Partner is to make an enabling environment by mainstreaming climate resilience consideration into decision making process of infrastructure.

- Maintain the rule of law and enforce contracts that ensure transparency and trust, critical for securing private sector participation in climate-resilient PPPs.

The Public Partner would benefit from having readily available access to additional skills to support the integration of climate resilience into the PPP process. These include climate scientists, climate economists, climate policy experts, environmental economists, environmental engineers, social scientists, sector experts, and stakeholder engagement experts. Furthermore, it is important that public sector partners manage the upstream pipeline development process actively by aligning with relevant national or sub-national climate policies. National Adaptation Plans (NAPs) and other climate policies are key to creating a shared vision and long-/medium-term goals to achieve mitigation and adaptation commitments and should be associated with a pipeline of priority investments that are needed achieve these goals

The Private Partner

The Private Partner is responsible for designing and implementing the PPP project. The private sector brings innovation, new technologies, and expertise in project management, design, construction, maintenance, operations, lifecycle optimization, and financing.

In the context of climate-resilient PPPs, the Private Partner needs to:

- Have the relevant skills to understand and incorporate climate change projections and decision-making under uncertainty into their project decision processes. This includes having experience in climate risk assessment, resilient design standards and resilience options appraisal.

- Leverage the Monitoring and Evaluation (M&E) process within the Operations and Maintenance (O&M) phase to collect data on how different resilience options perform in each context. This can then inform current and future projects to maximize resilience benefits.

- Encourage collaboration or partnerships to share knowledge seeking to draw on professional practice ecosystems within the climate resilience and sustainability space to innovate on best practices.

- Set higher benchmarks for subcontractors around climate resilience by including climate-resilience aspects in the operating standards.

The Shareholders

Shareholders in PPP contracts play a vital role in providing financial resources, assuming risks, contributing expertise, and ensuring the project's success through effective governance, performance monitoring, and stakeholder engagement. Their involvement is essential for the sustainability and efficiency of PPP projects. Specific roles and responsibilities include:

Special Purpose Vehicle (SPV)

- Acts as the primary liaison between public and private partners.
- Ensures proper project execution and implementation of climate resilience measures.
- Verifies that projects meet PPP contract performance requirements.
- Holds contract obligations and delegates them to Engineering Procurement Construction (EPC) and O&M contractors through downstream agreements.
- Guarantees contractors uphold commitments related to climate resilience.

Shareholders: Industrial Sponsors

- Typically act as SPV shareholders, managing EPC and O&M contracts.
- Promote climate-resilient infrastructure by introducing innovative solutions and technologies.
- Their expertise is critical, especially for specialized projects like green or blue infrastructure.
- O&M activities maintain performance standards and integrate stakeholder feedback.
- Monitoring results contribute to improving future project designs and fostering knowledge-sharing networks.

Shareholders: Investors

- Recognize the value of climate resilience for long-term project success.
- Require tools and methods to assess the financial benefits of climate-resilient projects, including co-benefits and avoided losses.

The Lenders

The Lenders have a unique opportunity to push for climate resilience – which is likely to benefit them in the long term by planning for climate risk over the lifetime of an asset – by insisting that climate resilience be considered as a term of their loan.

At different PPP stages, lenders are responsible for engaging in dialogue with the private and public parties, ensuring climate risk assessments have been done to a high standard, and considering risk allocation.

Major concerns of PPP Lenders include:

- Certainty about the project cash flows needed to meet debt service requirements.
- Creditworthiness of the public sector (in terms of meeting its obligations) and confidence in the regulatory regime.
- Soundness and stability of the legal framework for PPPs and enforceability of the PPP contract and related agreements.
- Ability of sponsors to perform and the quality of their management.
- Creditworthiness of the sponsors and the quality of their guarantees.
- Risks must be understandable, controllable, finite, and appropriately allocated.
- Acceptability of the termination regime (providing sufficient protection to the debt).
- Reputational impact of the project (environmental and social), if funded by international financial institutions[15]

15 Farquharson, Torres de Mästle, and Yescombe, with Encinas, 2011. How to Engage with the Private Sector in Public-Private Partnerships in Emerging Markets. World Bank.

The End Users

End users play an integral role in the design and delivery of climate-resilient infrastructure because they are primary beneficiaries – they will be faced with the shocks and stresses of climate change in addition to pre-existing socio-economic circumstances. Increasing public participation in PPPs is essential to their success. Conducting public consultations is a good way to involve the local population in the process as they are the final users of the infrastructure. This can also provide an opportunity for the public to communicate their needs and visions for the area, as this may have a bearing on the type of resilience options developed or prioritized, including integrating more NBS.

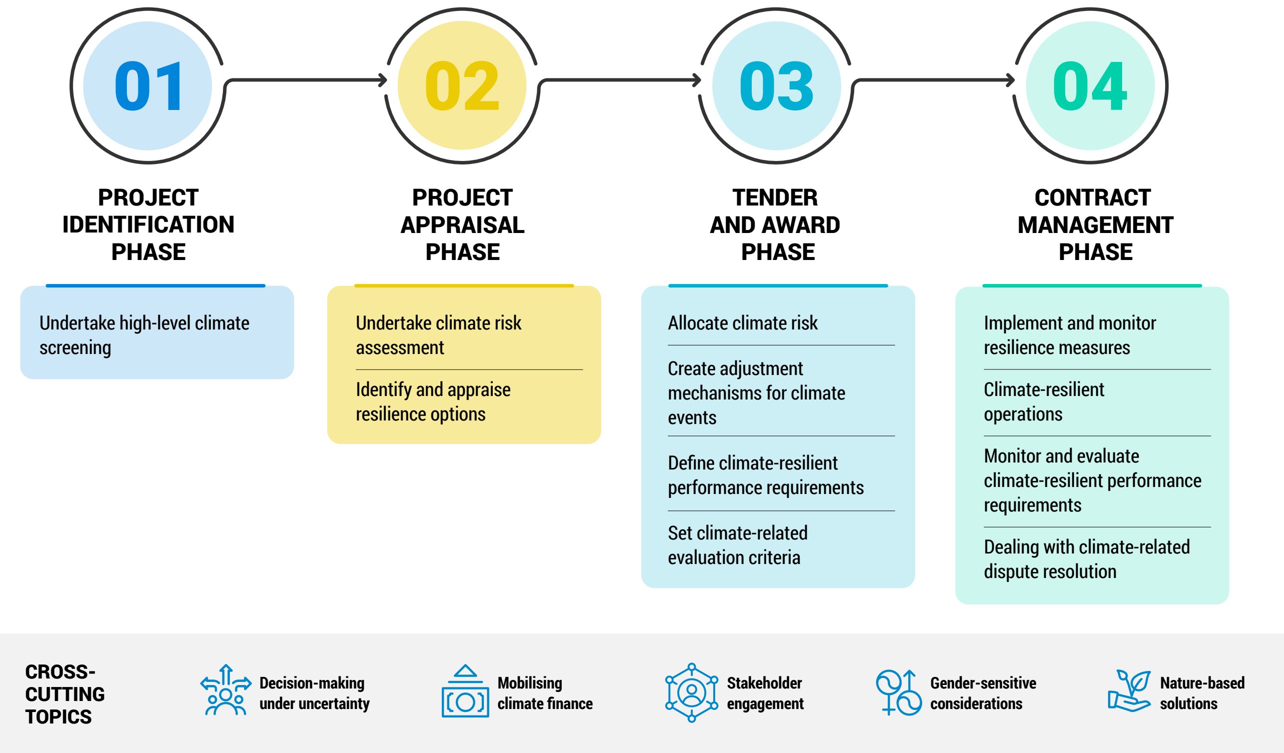
There are several benefits of community engagement, including to:

- Provide more detailed information to input into project preparation processes, such as climate risk assessments.
- Support the prioritization of resilience options and understanding of willingness to pay for resilience.
- Help to understand whether the project will deliver value for society, particularly by identifying and optimizing co-benefits that arise from different resilience options.
- Mitigate risk by engaging a range of stakeholders to better understand inter-dependencies, commonalities and trade-offs of a project, thereby potentially highlighting any issues and securing buy-in through participatory planning processes.
- Utilize the principles of Locally Led Adaptation to ensure resilience through a bottom-up approach, providing value for money and reducing long-term project risks by leveraging local knowledge and expertise to develop context-specific, cost-effective adaptation solutions.

1.3 Embedding climate resilience and adaptation in the PPP project lifecycle

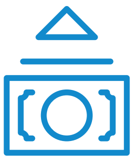
The PPP project lifecycle framework will be used to guide project development to ensure that projects are designed, operated and managed in ways that optimize climate resilience and adaptation and provide co-benefits where possible. The next modules will cover the key intervention points to integrate climate resilience and adaptation in the PPP project lifecycle, which are summarized in **Figure 1.3**.

Figure 1.3 PPP project cycle and key intervention points for climate resilience

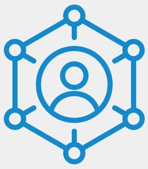


Cross-cutting topics

Five cross-cutting topics will be referenced throughout the Handbook giving examples of how they support/ can be integrated in climate-resilient PPPs. These topics are listed in the table below. Keep an eye out for the topic icons in each Module of the Handbook.

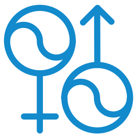
Cross-cutting topic	Relevance to climate-resilient PPPs
Decision-making Under Uncertainty 	*Uncertainty is inherent in making climate-informed decisions across the PPP lifecycle.* Integrating climate change into infrastructure decision-making requires navigating uncertainty, as the timing, magnitude, and local impacts of climate change are often unpredictable. Delaying action increases risks, as infrastructure lifecycles span decades, locking in vulnerabilities. Decision-makers must balance this uncertainty with urgent needs for resilience, using adaptive management and scenario planning to account for a range of possible futures. Flexible, nature-based, and robust solutions can ensure functionality under varying conditions. Incorporating uncertainty fosters innovation, avoids costly retrofits, and enhances long-term sustainability. Proactive planning under uncertainty safeguards communities, economies, and ecosystems, ensuring infrastructure remains resilient in a rapidly changing climate.
Mobilizing Climate Finance 	*Climate finance mechanisms and approaches should be considered to support the integration of climate resilience and adaptation in PPP projects.* Mobilizing climate finance is crucial for integrating climate resilience and adaptation measures into PPP infrastructure projects. Traditional financing often overlooks the higher upfront costs of climate-proofing infrastructure, creating a gap that climate finance instruments can fill. Funds from sources like green bonds, national / international climate funds or carbon pricing help address these costs, making projects more viable while enhancing resilience. By bridging financial gaps, climate finance enables the integration of adaptive measures, ensuring PPP projects withstand climate impacts while delivering long-term social, economic, and environmental benefits. It's important to note that climate finance does not always reduce the cost or adaptation as it mainly enables local capital market engagements to address liquidity barriers. The mobilization of climate finance funds may take a long time, especially in developing countries where institutional frameworks and financial infrastructure might be less developed. The process may also be quite demanding as it typically involves significant managerial and reporting requirements, which in turn increase the administrative costs of handling them. It is advised to ensure the suitability of climate funds early on in the PPP development cycle before embarking on the relevant process.

Stakeholder Engagement



Stakeholder engagement is a crucial component of any project planning process. Engaging stakeholders ensures the process is participatory, transparent, and incorporates a breadth of knowledge and practice. Establishing and implementing robust stakeholder consultation processes throughout all phases of the PPP project cycle is the responsibility of the public and private partners. Climate-resilient infrastructure is context-specific and this calls for interaction with local financial institutions and intermediaries. In addition, PPPs aim to deliver public services and end-beneficiaries should be duly considered to ensure that climate-resilient PPPs address 'on-the-ground' needs effectively.

Integrating Gender Considerations



Infrastructure is inherently gendered, with distinct demands from men, women, and LGBT+ communities often overlooked. Historically, women's needs, such as safety, sanitation, and clean water, have been neglected. Climate change worsens these disparities, disproportionately affecting women and girls in sectors like transport, energy, and water. Addressing gender equity in infrastructure empowers women, reduces poverty, and supports sustainable development. Gender mainstreaming ensures inclusivity, while PPPs provide a platform for embedding gender inclusion. Gender-responsive infrastructure prioritizes women and girls, and inclusive approaches ensure no group is excluded, driving societal and economic benefits.

Nature-based Solutions

Integrating NBS into infrastructure development enhances climate resilience and supports adaptation by leveraging ecosystems to mitigate risks. NBS, such as wetlands for flood management or mangroves for coastal protection, reduce exposure to climate-related hazards while delivering co-benefits like biodiversity conservation and improved air quality. These solutions are cost-effective, adaptable, and can evolve with changing environmental conditions. Incorporating NBS fosters synergies between infrastructure and natural systems, addressing vulnerabilities in sectors like transport, energy, and water management. By embedding NBS into planning and design, infrastructure projects can achieve greater sustainability, resilience, and social equity while supporting global climate adaptation goals.

Recap

- In the context of a changing climate, there is an urgent need and a compelling financial case for embedding climate resilience and adaptation in infrastructure development.
- PPP projects would greatly benefit from integrating climate resilience and adaptation and they offer significant opportunities to do so within their project lifecycle.
- Different stakeholders have a role to play in ensuring climate resilience and adaptation are included in PPPs.
- Using the PPP project lifecycle provides a useful framework for this, supported by a range of cross-cutting topics.

Project Identification Phase

2. Project Identification Phase

Description: This module outlines activities for the Project Identification Phase and discusses steps for conducting climate risk screening. It will outline how to assess the impact of climate risks and scenarios on the VfM proposition. It also introduces the cross-cutting topics of NBS, stakeholder engagement and gender and it outlines how considerations of these topics should be included at this early stage of project development. Crucially, this module will not delve into detailed project structuring. While structuring is vital for project success, it is very complex and challenging to isolate the climate component within the structuring, as it is inherently intertwined with numerous other project considerations. Furthermore, project structuring practices vary significantly across countries and legal jurisdictions, making it impractical to address them comprehensively in a generalized framework for climate resilient infrastructure.

Learning outcomes: By the end of this module, learners will be able to:

- Explain the importance of building and prioritizing a pipeline of climate-resilient projects
- Identify the objectives, steps and outputs of a climate risk screening
- Use the outputs of a climate risk screening to inform decision-making
- Discuss the benefits and challenges of NBS and how PPPs can support them
- Understand the importance of including gender-sensitive considerations in infrastructure projects

The key objectives of the Project Identification Phase are to assess the need for the project, its overall feasibility, whether procurement through PPP is suitable and to ensure VfM for the public sector vs traditional procurement.

Climate risks are attracting growing attention from all stakeholders and should be properly understood, assessed and shared between the public and private parties throughout the lifecycle of the PPP project. Given the long duration of PPP contracts, it is likely that climate change impacts will manifest themselves during the contracts or several years after the financial close of the project bringing unforeseen harm to the contract.[16]

Consideration of climate risk and resilience should therefore become part of the assessment at this stage because of their potential impact on the project's risk allocation and bankability (e.g. too expensive to future-proof the project to future climate risks, too risky for a Private Partner to invest in and insufficient returns).

Identifying climate risks early allows us to answer some crucial questions about the project:

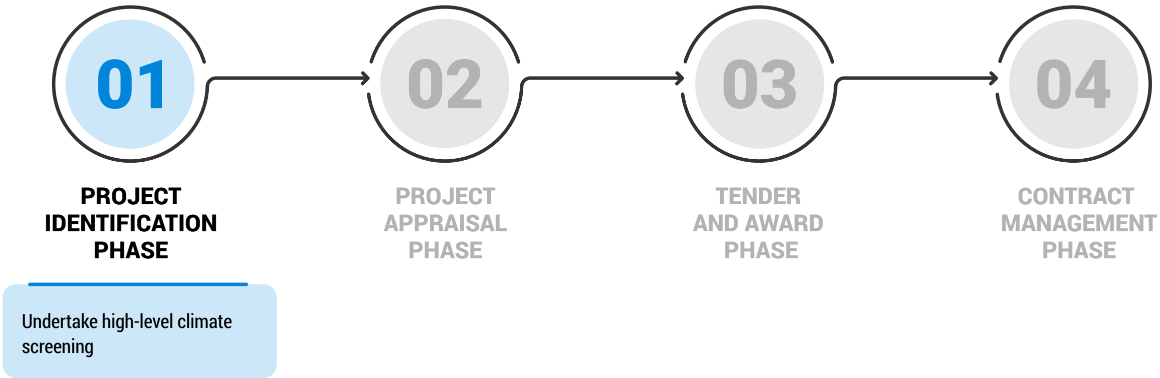
- Do we want to proceed with the PPP project despite the exposure to climate hazards?
- Does the project location and/or scope need to be changed to minimize risk?
- Do climate risks impact the decision to pursue the project?
- What is the VfM of the project with appropriate climate resilience measures?

Figure 2.1 below identifies entry points for integrating climate resilience at this stage.

While a portfolio-level identification and prioritization of climate-resilient infrastructure projects is beyond the scope of this Handbook, it is important to recognize that it is the Public Partner's responsibility to identify and bring forward projects within the pipeline that enhance resilience through infrastructure, as adding this to the project scope later becomes more difficult, see **Box 2.1**.

16 World Bank/PPIAF, 2022. Climate toolkits for infrastructure PPPs. Washington D.C.

Figure 2.1 Key entry point for climate resilience in the Project Identification Phase



Box 2.1 Identifying and prioritizing a pipeline of climate-resilient projects

As the Public Partner typically initiates the project, they also have the leverage in promoting resilience *of* and *through* infrastructure, through the Project Identification phase. No single climate-resilient infrastructure project is ever done in isolation, but rather as part of a country's much broader portfolio of projects across climate, development, energy, environmental, healthcare, education and other policies and initiatives. At this early stage, the Public Partner has the opportunity to broaden the aims of infrastructure development and think innovatively about potential projects that include climate resilience and adaptation as a core tenet and can be developed to maximize the co-benefits delivered by resilient infrastructure.

Critically, in order to identify and prioritize projects, the Public Partner requires an understanding of the key climate risks as well as a bird's eye view of the other ongoing planning processes within different government departments. In practical terms for PPP projects, this implies a portfolio view of a VfM approach, with climate screening being one of the pass/fail criteria.

Case study: Ghana Roadmap for Infrastructure Resilience

Climate-resilient infrastructure projects are not designed and implemented in isolation. They affect and are affected by existing infrastructure systems and climate resilience actions undertaken around other infrastructure sectors, systems and assets. Ghana's Roadmap for Infrastructure Resilience in a Changing Climate showcases how infrastructure climate resilience initiatives should - and in fact can - be designed and implemented as a coherent whole, leveraging co-benefits across multiple infrastructure sectors.

Ghana is confronting significant climate change challenges, including increased flooding and more frequent droughts, which threaten its socio-economic development and progress toward national goals like the Paris Agreement and the Sustainable Development Goals (SDGs). These impacts also risk hindering social outcomes, such as gender equality.

To tackle these issues, a comprehensive study led by Ghana's Ministry of Environment, Science, Technology and Innovation (MESTI), alongside international partners, has assessed the country's climate adaptation needs in the energy, water, and transport sectors. Utilizing advanced methodologies that combined local datasets with downscaled climate modelling, the study identified major climate risks and involved extensive stakeholder engagement to ensure broad ownership of the proposed solutions.

A total of 35 prioritized adaptation options were developed, focusing on safeguarding critical infrastructure and enhancing institutional capacity. The study also identified potential financing sources, revealing that the Government of Ghana has access to various infrastructure-related funds. This roadmap aims to mobilize resources for climate resilience, supporting the government's integrated approach to addressing climate vulnerabilities. Project partners continue to collaborate on implementing the adaptation options identified.

Source: GCA. 2022. Ghana's Roadmap for Infrastructure Resilience in a Changing Climate.
(Accessed November 2024).

2.1 Undertake a climate risk screening

Climate risk assessments in the context of PPP projects are undertaken in stages with increasing levels of detail and resources required to inform decision-making as the project develops. These stages usually comprise:

1. **Climate risk screening:** this high-level assessment or screening of the risks related to climate change is undertaken at the Project Identification Phase. It is a preliminary analysis that provides a general understanding of the key climate hazards, the project's exposure and how severely the hazards might impact the project. It also serves to determine whether a detailed climate risk assessment is required.

2. **Detailed climate risk assessment** (if required - covered in the next module): this is a more detailed assessment focused on the key climate risks identified in the high-level climate risk screening and it is carried out at the Project Appraisal Phase.

Box 2.2 Defining Risk

The IPCC[17], [18] considers risk as a function of three components: hazards, exposure, and vulnerability.
Risk = f (hazard, exposure, vulnerability)

Figure 2.1. Risk as a function of hazard, exposure and vulnerability

Risk: The potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.

Hazard: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Exposure: The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

17 The Intergovernmental Panel on Climate Change. IPCC Glossary.

18 Reisinger, A., Howden, M., Vera, C. et al., 2020. The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

The steps for undertaking a climate risk screening might vary slightly according to published guidelines and nomenclature, but they typically comprise[19]:

1. Identifying climate hazards that could affect the proposed project

2. Assessing the exposure of the project and end users to the identified climate hazards at the project's location

3. Estimating the impact of hazards on the project and its components.

The Public Partner is responsible for conducting a climate risk screening during the Project Identification Phase. Input information should be readily available and include e.g., project location, description and preliminary layout (if available), data and geospatial information on climate and other existing geophysical hazards and risks. This activity requires technical expertise e.g. to specify the level and resolution of data required to analyze the issues sufficiently or to provide a realistic assessment of impact levels.

1 **Identify climate hazards that could affect the proposed project.** As part of this activity, potential climate hazards are identified based on the proposed project location. Climate hazards might result in rapid onset events (e.g., storms, floods) or slow onset events (e.g., sea-level rise, temperature increases), see **Table 2.1**. This step comprises collating existing geo-climatic hazards and climate data, both historical and projections for future climate scenarios relevant to the project's location. Natural hazards not related to climate change (e.g., earthquakes) have been included for completeness and because their potential impacts can be exacerbated by concurrent climatic events. Climate models are used to project future climate conditions and the likely **frequency and intensity** of identified hazards over the project's lifespan.These hazards can impact infrastructure sectors differently.

Table 2.1 Indicative list of hazards that can impact projects, their end-users and communities, hazards with strong links to climate change are marked bold

Environmental hazards	Geological hazards	Hydrometeorological hazards	Other hazards
Air pollution **Water pollution** **Soil degradation and pollution** **Deforestation and loss of biodiversity** **Wildfires** **Salinization**	Earthquakes Volcanic activity and emissions **Landslides/ other surface collapses** Liquefaction Sinkholes **Tsunamis**	**Storms/strong winds** **Pluvial (rainfall) and fluvial (riverine) floods** **Coastal storm surges/ floods** **Sea-level rise** **Droughts** **Heatwaves** **Cold spells** **Snowfall, hail, avalanches**	Technological hazards (e.g. industrial pollution, toxic wastes, accidents, explosions, fires, chemical spills) Biological hazards (e.g. bacteria, viruses, parasites, disease-causing agents)

19 European Commission, 2021. EC Technical Guidance on Climate Proofing of Infrastructure.

Publicly available regional or national climate models and open-source databases are commonly used. There is no hard and fast rule on what climate models/databases to use, some examples of key sources are given in **Table 2.2** below.

Table 2.2 Examples of key sources of climate data and information to support climate risk screenings and subsequent detailed assessments

Resource	Provider
Climate Change Knowledge Portal	The World Bank
Think Hazard	Global Facility for Disaster Reduction and Recovery
Climate Impact Explorer	Climate Analytics
Climate Change Data Platform	UNEP
Risk Data Hub	European Commission Joint Research Center
CHC datasets	Climate Hazard Center
Climate Data Store (CDS)	European Union
CORDEX	World Climate Research Programme (WCRP)

2

Assess the exposure of the project and end users to the identified climate hazards. The purpose of this step is to gain an initial understanding of how the project and its end users may be exposed to the identified hazards. Based on the project's location and historical climate hazards, list the key hazards that are relevant to the project location.

The exposure assessment should determine which elements of the PPP project (e.g., infrastructure, operations, supply chains) and the end users/communities are exposed to identified climate hazards.

The following guiding questions are used to assess exposure[20]:

- Has the location experienced climate-related events such as strong winds, sea level rise, storm surge or geophysical hazards that might be triggered by climate events in the past that may occur again in the future?
- Are there any design considerations or supply chain vulnerabilities, such as reliance on river water, that could be affected by climate change?

Decision-making Under Uncertainty

Qualitative probabilistic considerations that reflect climate uncertainty start at this early stage. The high-level hazard exposure and severity assessment done as part of the climate risk screening include consideration of how the frequency of climate-triggered events and climate hazards are projected to change in the future.

20 World Bank. Rapid Assessment Tool.

The exposure analysis is conducted by overlaying assets and hazards. This is usually done with maps and GIS software. An exposure level is assigned to each of the identified climate hazards. Below is an example of a simple scoring method.

Table 2.3 Assigning an exposure level

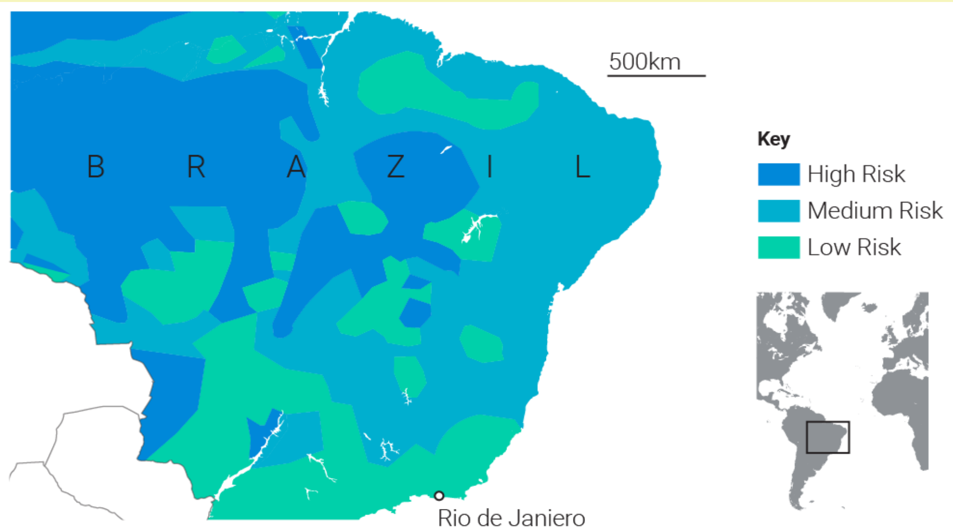
Impact level	Definition	Exposure rating
High	Hazard is very likely to occur during construction and operational phases of the project	3
Moderate	Hazard is somewhat likely to occur during construction and operational phases of the project	2
Low	Hazard is unlikely to occur during construction and operational phases of the project	1

An example of climate hazard and exposure considerations for the developed Belo Monte – Rio de Janeiro UHVDC Transmission Project is provided in **Box 2.3** below.

Box 2.3 Case study - Belo Monte-Rio de Janeiro UHVDC Transmission Project

Project overview: The UHVDC Transmission Project aimed to transmit power from the Belo Monte Hydroelectric plant via Xingu converter station, to a terminal converted station in Paracambi, in the state of Rio de Janeiro.104. The infrastructure of transmission networks should be made resilient but note that transmission networks are also a vehicle of community resilience, as they are an essential service that facilitates access to other essential services. Transmission lines are exposed to heavy precipitation events and associated with riverine, urban and coastal flooding, extreme heat, landslides, and wildfires. **Figure 2.2** shows a multi-layer map of Brazil, which shows the economic stock exposure, multi-hazard mortality risk) and the multi-hazard average annual losses of $600 – 6,000 million across Brazil.

Figure 2.2 Multi-layer map of Brazil, including exposed economic stock, urban assets, and multi-hazard mortality risk



Source. Adapted from UNEP. 2021. Global Risk Data Platform. Available from: https://preview.grid.unep.ch/index.php?preview=map&lang=eng [Accessed 15 February 2021].

Climate hazard overview: The key data sources used for the high-level risk screening are the World Bank's Climate Change Knowledge Portal, GFDRR's ThinkHazard platform and USAID Climate Risk Profile for Brazil. It is critical that the authority use up-to-date and well-informed information to ensure that the assessment is robust. Most countries will also have national databases of key hazards, which should be sought out where possible.

Using USAID's fact sheet, key climate projections for Brazil are:

- 1.7 – 5.3°C increase in average temperature by 2085
- Increased length of the dry period and increased Amazonian drought
- 0.2 to 2 meters rise in sea levels by 2100
- These climate projections will have significant impacts on ecosystems, agriculture, tourism, and health.

Figure 2.3 details a rough map of the Belo Monte transmission project. It runs nearly the length of the country and passes through elevations between 43 and 1350 meters. This span of the project along with the changes in topography indicates that it is exposed to several hazards, including wildfires, extreme heat, landslides, and riverine flooding. Based on this data, the key hazards that could impact the transmission networks can be identified.

Figure 2.3 Map of the Belo Monte transmission project

Source: Leal, M. 2016. Belo Monte power line passes through Brazil's Amazon and Cerrado Savannah. ChinaDialogue. [Accessed 15 January 2021].

3 **Estimate the impact of hazards on the project and its components.** This step assesses the current and future potential impacts of identified climate and geophysical hazards on the project's physical infrastructure assets and non-physical elements (e.g. operations and supply chains), end-users and interdependent infrastructure systems. The impact rating is based on the exposure rating and the understanding of the project's sensitivity to the identified hazards.. Although at this early stage the project information might be limited, this step is recommended to complement the result from the previous step to obtain a high-level risk classification that is representative of the proposed project rather than merely based on hazards, and it can helpfully inform initial VfM considerations (see **Box 2.4**).

The following guiding questions are used to assess potential impacts[21]

- Does the project design consider recent trends and future projected changes in identified climate and geophysical hazards?
- Does the project design consider how the structural integrity, materials, siting, longevity and overall effectiveness of health infrastructure, if applicable, may be impacted?
- Does the design 'lock in' certain decisions for the future?
- How do the project's non-physical or 'soft' components (e.g. institutional capacity, existing codes and standards, skills and capabilities of the local workforce) and the broader sector and development context influence the level of risk posed to the project? Also consider impacts on vulnerable groups.

Integrating Gender Considerations

When conducting climate risk screening and assessment, it is crucial to consider gender and other vulnerable groups. Women and children are especially susceptible to climate change due to gender norms and labor divisions. During natural disasters, women often evacuate last due to caregiving responsibilities or lack of permission from male family members. They also face greater challenges in the labor market, domestic violence, and sex trafficking in shelters. Additionally, vulnerable groups such as persons with disabilities and indigenous populations, who have inalienable land rights, must be considered, especially when changes in land use occur, such as renewable energy projects.[22]

Concrete steps that can be taken at Project Identification Stage to ensure gender mainstreaming include[23]:

1. Account for the different infrastructure needs and uses of men and women
2. Carry out gender-sensitive consultations with a balanced selection of stakeholders

Carry out a preliminary gender analysis

21 Ibid.

22 International Federation of Red Cross and Red Crescent Societies (IFRC), 2010. A practical guide to gender-sensitive approaches for disaster management.

23 The World Bank, 2024. PPP Gender Toolkit. Washington D.C.

Table 2.4 below illustrates an example of a simple scoring method. Expert judgment is required in the selection of the level of impact.

Table 2.4 Assigning an impact level

Impact level	Definition	Impact rating
High	Hazard (if it occurs) is likely to cause **major damage or disruption** during construction and operational phase of the project	3
Moderate	Hazard (if it occurs) is likely to cause **moderate damage or disruption** during construction and operational phase of the project	2
Low	Hazard (if it occurs) is likely to cause **minor or no damage or disruption** during construction and operational phase of the project	1

Methodologies and outputs of a climate risk screening might differ slightly depending on the context or institution. Available guidance[24],[25] broadly agrees that an overall climate risk category is the primary output of the screening process, derived from hazard information, subject matter expertise, contextual understanding of the project and modulated based on the project's 'soft' components and broader development context.

The preliminary findings from the climate risk screening will identify the key climate hazards and their potential level of impact on the project and its components and will include recommendations on whether to undertake a more detailed climate risk assessment.[26] Terms of Reference, scopes and objectives for the detailed climate risk assessment to be undertaken in the next phase are developed using the output from the climate risk screening. **Box 2.4** discusses how the output of the climate risk screening can be used to inform decision-making in the Project Identification Phase. **Box 2.5** shows a case study on how a preliminary climate risk screening for the Coastal Cities Environmental Sanitation Project in Vietnam has been used to inform subsequent phases of the project.

Stakeholder Engagement

At this early stage, stakeholder identification begins. The focus is on mapping out key stakeholders (such as government bodies, local communities, investors, contractors, and environmental groups) and understanding their interests, concerns, and potential influence on the project. This initial stakeholder mapping will feed into the development of a **Stakeholder Engagement Plan (SEP)** that will be formalized in the next phase.

In the Project Identification Phase, it is useful to map the stakeholders that need to be engaged throughout the detailed climate risk assessment process that will be developed at the next stage. For the climate risk assessment, this should certainly include climate experts, relevant governmental stakeholders, infrastructure experts, local NGOs, academia, and representatives of research organizations. End users should be engaged at the early stages of the project development to gather insights and ensure their concerns are addressed.

24 World Bank, Climate and Disaster Screening Tool.

25 IDB, 2019. Disaster and Climate Change Risk Assessment Methodology for IDB Projects.

26 European Commission, 2021. EC Technical Guidance on Climate Proofing of Infrastructure.

Box 2.4 'How to' Guidance – How to use the outputs from the climate risk screening to inform decision-making

Value for Money (VfM) assessment is the process by which the public partner assesses the value of doing a project using a traditional procurement method versus PPP procurement. VfM is achieved if the project provides greater value at the same value or provides the same value at a lower cost when delivered as a PPP versus solely by the public sector. VfM does not happen in isolation but matures as new information becomes available at different phases of the infrastructure PPP lifecycle. A preliminary VfM analysis may be conducted during the Project Identification Phase with a view to embedding climate change considerations in the assessment of the PPP suitability, as described below.

The output of the climate risk screening is used, alongside other studies and assessments undertaken at Project Identification Phase (e.g. pre-feasibility studies, environmental and social screening), to inform decision-making before progressing to the next stage. An initial VfM analysis undertaken at this stage can help determine whether the project should be structured as a PPP, based – among other factors – on consideration of current and future climate risks, and the required adaptation measures.[27] This analysis should explore how climate considerations would impact the answer to guiding questions such as:

- Is the project too complex and above the levels that justify delivery as a PPP?
- Would there be investor market appetite?
- What are the benefits of procuring the project as PPP vs. traditional procurement, in relation to climate resilience and adaptation? E.g., the innovation that the private party may introduce in this sector, the competitive tension to keep costs low and performance high, efficiency, etc.
- What are the disbenefits associated with not including climate resilience and adaptation strategies measures? E.g. increased disruptions, loss of revenue, wider socio-economic costs.
- Are there any significant climate risks within the project that are not manageable by a private partner?
- Is it possible that the project will experience a change in demand due to climate change?
- Are there any significant climate risks that may harm the availability of financing?
- Is the project aligned with national climate policies?

If the outcome of the initial VfM indicates that climate risks are too significant or can't be avoided, mitigated or minimized, it can result in a no-go decision.

Box 2.5. Improving sanitation services sustainability in Vietnam's coastal cities.

The Coastal Cities Environmental Sanitation Project is a project that will provide drainage, wastewater treatment plants as well solid waste management facilities in the cities of Dong Hoi, Quy Nhon, Nha Trang and Phan Rang Thap Cham. The project will support climate adaptation in these cities, particularly regarding flooding.

Effective and efficient city-wide sanitation services will contribute to the protection of the quality of water supply sources, which may become scarcer or degraded with climate change impacts.

The Coastal Cities Environmental Sanitation Project included a preliminary climate and disaster risk screening for the project at the concept stage. The identified climate and disaster risks include increased

27 World Bank/PPIAF, 2022. Climate toolkits for infrastructure PPPs. Washington D.C.

frequency and degree of extreme weather events: heatwaves (moderate), extreme precipitation and flooding (moderate), drought (moderate), sea level rise (moderate), storm surges (high), and strong winds (moderate). This broad range of risks was then further addressed during project preparation, in particular through the hydraulic modeling used to design the sewerage/drainage networks which included a range of climate-related scenarios. These measures will be part of the management tools and assets that would be operated by potential private operations and maintenance contractors.

Source: World Bank. Weekes, K. Diaz Fanas, G., Orekhova, S., Khamudkhanov, K. 2021. Climate adaptation in infrastructure – case study examples in the PPIAF Portfolio.

Nature-based Solutions

NBS are defined by the IUCN as 'actions to protect, sustainably manage, and restore ecosystems to address societal challenges while providing human well-being and biodiversity benefits.'[28] These solutions include managing and restoring natural or modified ecosystems to deliver multiple co-benefits[29] (see **Table 2.5**) and tackle challenges like greenhouse gas emissions, flooding, and droughts.

Although NBS are sometimes considered innovative, they draw on long-standing practices, including those of indigenous and traditional communities. NBS are increasingly recognized as tools to enhance resilience in the built environment and alternatives to traditional 'gray' infrastructure. Integrating research, policies, design guidance, and traditional knowledge is essential to implement NBS effectively, despite challenges related to their design, implementation, and long-term impact.

Key features of NBS include[30]:

1. Broad scope, addressing multiple policy goals, especially climate mitigation and adaptation.
2. Multifunctionality, adaptability, and contribution to landscape resilience, differentiating them from conventional engineering.
3. Emphasis on participatory, governance-based approaches for creation and management.
4. Action-oriented focus on implementation, requiring supportive regulatory frameworks, planning, and economic tools.

NBS overlaps with concepts like green infrastructure and ecosystem-based adaptation but emphasizes tangible, on-the-ground actions.

28 International Union for Conservation of Nature (IUCN), 2020. IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NBS. First edition.

29 European Commission. 2020. "NBS - State of the Art in EU-funded Projects".

30 Pauleit, Zölch, Hansen, Randrup, & van den Bosch, 2017. NBS and climate change-Four shades of green. In NBS to climate change adaptation in urban areas. Page 29-49. Springer Nature Link.

Table 2.5 Co-benefits of NBS

Co-benefits of NBS	Description
Climate Change Adaptation and Resilience	• NBS reduce natural hazards like flooding and storm surges, enhancing community resilience. • Solutions range from small-scale urban measures (green roofs, porous pavements) to large-scale rural or coastal measures (wetlands, mangroves).
Climate Change Mitigation[31]	• NBS support carbon storage and sequestration via the conservation, restoration, or enhancement of ecosystems like forests, wetlands, and agricultural lands. • In urban areas, they reduce energy demand by regulating microclimates and promoting active transport (walking, cycling) over car use.
Net Biodiversity Gains	• NBS are rooted in healthy, biodiverse ecosystems, focusing on biodiversity conservation. • They enhance ecosystem restoration, urban biodiversity, agrobiodiversity, and ecosystem resilience.
Water Quality and Waterbody Conditions	• NBS address water quality issues, such as point source pollution, urban drainage, agricultural pollution, and soil erosion. • They help restore waterbodies' hydro-morphology and improve social cohesion and health.
Health and Well-being	• NBS improve quality of life, health, and well-being by providing spaces for physical activity and reducing respiratory and cardiovascular diseases. • Access to green spaces also promotes mental health and social cohesion.

WNBS and PPPs

NBS require a systematic approach to assess project impacts and design solutions aligned with project goals, fostering broader thinking and enhancing infrastructure resilience, especially for vulnerable communities. Despite a funding gap of $330–$400 billion annually for ecosystem conservation, private investment could fill half, though challenges like low returns, long timeframes, and unclear risks deter interest. However, business cases demonstrating returns and cost savings can attract private sector involvement, see **Box 3.15**.

PPPs and climate finance (including carbon markets) can help in scaling up NBS adoption by addressing climate risks and improving infrastructure resilience. Challenges such as limited financial returns, lengthy payback periods, and regulatory hurdles can be mitigated through public co-financing to encourage private sector buy-in.[32] Integrating NBS solutions into the structuring of PPPs can help build resilience and potentially add to overall savings from CapEx to OpEx over the life of the project.

NBS must be part of a broader sustainability strategy, addressing land access and permitting challenges while complementing other resilience-building actions. Resilience should extend beyond physical systems to include social and institutional elements, ensuring the built environment can withstand climate change impacts.[33]

31 It may seem counterintuitive to discuss mitigation in a resilience handbook, but the reality is that these two approaches should go hand in hand and are often mutually reinforcing, with mitigation co-benefits frequently contribute positively to the VfM of the project.

32 World Bank, 2017. Implementing Nature-Based Flood Protection: Principles and Implementation Guidance.

33 Stafford, R., Chamberlain, B., Clavey, L., Gillingham, P.K., McKain, S., Morecroft, M.D., Morrison-Bell, C. and Watts, O. (Eds.), 2021. Nature-based Solutions for Climate Change in the UK: A Report by the British Ecological Society.

Integrating Gender Considerations

Infrastructure is not gender neutral – the demand for and use-patterns of infrastructure by men, women, and LGBT+ communities differ significantly due to the 'gendered realities of their lives'.[34] Traditionally, infrastructure design has failed to account for the distinct needs of women such as the need for safety in public spaces, sanitation and hygiene facilities, and better accessibility of clean water and public services.[35] The effects of climate change are already exacerbating these disparities and disproportionately impacting women and girls.[36] Exposure to climate-related hazards within the context of critical infrastructure, namely transport, energy, water, and ICT, can have distinct gender dimensions that impact individuals and communities differently.

Gender-responsive infrastructure is infrastructure that has been systematically planned, designed, financed, constructed and operated in such a way that prioritizes and assures the participation, enablement and empowerment of women and girls and considers their needs and demands throughout the infrastructure lifecycle.[37]

Inclusive infrastructure is infrastructure development that enhances positive outcomes in social inclusivity and ensures no individual, community, or social group is left behind or prevented from benefiting from improved infrastructure.[38]

Gender equity is a core development objective in its own right[39] – it enhances productivity, improves other development outcomes, builds more prospects for the next generation and boosts the quality of societal policies and institutions. Gender mainstreaming (working in an environment that prioritizes gender equality and social inclusion both in practice and outcome) can promote more equitable access to social, economic and political opportunities, reduce poverty, increase women's empowerment and catalyze social inclusion.[40] This can increase the effectiveness, efficiency and sustainability of infrastructure projects. The knock-on real-world effects of such prioritization can be immense – adequate provision for women-specific needs, better levels of education leading to a more productive labor force and ultimately, economic growth and development.

PPPs are largely established in large-scale government-led infrastructure projects and can be instrumental in providing a foundation in which gender inclusion, female empowerment and diversity can flourish. Integrating gender into a PPP infrastructure project requires an active, concerted effort to review subconscious biases, stereotypes and gender-blind business practices across all phases of a project's lifecycle. Implementing gender inclusivity requires a transformation of the structure of the PPP itself – with gender gaps being identified and rectified not only in the outcome of the project for stakeholders but in the operational procurement, construction, management and maintenance of the project. Gender sensitivity comes not only from inclusivity awareness, but through a shift in management, attitude, design and practice.

34 The Solutions Lab, 2020. Gender-Responsive Infrastructure.
35 Chengchen Qian, 2023. Lifting barriers to gender-responsive infrastructure. Green Policy Platform.
36 Global Center on Adaptation (GCA), 2024. Building Gender-Inclusive Infrastructure Strategies for Climate Resilience in Africa.
37 UNOPS, 2020. Infrastructure for gender equality and the empowerment of women.
38 World Bank and PPIAF, 2019. Global Infrastructure Hub. Inclusive Infrastructure and Social Equity.
39 World Bank, 2012. World Development Report 2012: Gender Equality and Development.
40 UN Women and UNOPS, 2019. Guide on Integrating Gender Throughout Infrastructure Projects Phases in Asia and the Pacific.

Strategies for Integrating Gender Considerations in Climate Adaptation include:

- Gender-Responsive Stakeholder Engagement that promotes participation of both women and men so that their voices and priorities are considered
- Gender-Analysis that provides information through gender-disaggregated data to integrate a gender perspective into policies, programs and projects
- Inclusive Decision-Making as a process that involves diverse perspectives, values and experiences in making choices for an organization
- Mainstreaming Gender into policies and programs as a strategy towards realizing gender equality.

Integrating gender mainstreaming into the first phase of a PPP project can come seamlessly by using a more inclusive lens when it comes to business plans, impact and risk analysis and practice. Carrying out a stakeholder needs assessment is standard practice; doing so including gender-disaggregated data and gender-balanced stakeholder consult data provides managers and planners with an understanding of the gender-specific needs of stakeholders, the potential uses of infrastructure and even highlights the gaps in knowledge and standards which can be acknowledged and rectified. It is in these preliminary phases of the project where gender considerations can be mainstreamed into different aspects of the proposal, ensuring that 'gender roles and differences in access and control' are minimized, men and women are afforded the same capacities, and the project will yield gender-disaggregated results.[41]

Recap

- **An initial, high-level screening for climate risks should be undertaken during the Project Identification Phase with the aim to provide an understanding of what climate hazards the project and its end users might be exposed to, their likelihood and potential impacts.**
- **The output of the climate risk screening determines the necessity and scope of a detailed climate risk assessment to be undertaken, and it is used to support early decision-making before progressing to the next stage.**
- **NBS, stakeholder engagement and gender-responsive considerations should initiate the early stages of the project development and carry forward to subsequent phases.**

41 City Alliance, 2020. Gender Mainstreaming in Projects.

Project Appraisal Phase

3. Project Appraisal Phase

Description: This module illustrates how to integrate climate resilience and adaptation into the Project Appraisal Phase. Climate resilience considerations can be included through undertaking a detailed climate risks assessment (including future scenarios), identifying and appraising resilience options and feeding the outcomes of these analyses in the VfM and project structuring processes.

Learning outcomes: After completing this module, you will be able to:

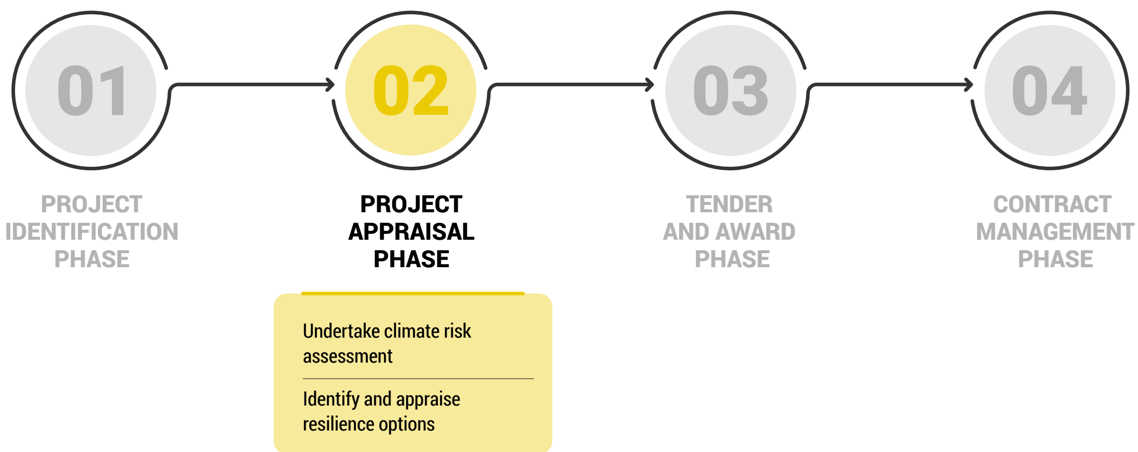
- Identify the objectives, steps and outputs of a climate risk assessment
- Describe different types of resilience options and associated co-benefits
- Describe how to undertake the economic feasibility and prioritize resilience options accounting for uncertainty in decision-making
- Explain the differences and synergies between gray, green and blue infrastructure
- Explain the potential co-benefits and added value of incorporating NBS as resilience and adaptation options
- Discuss the role and different types of climate finance.

The aim of the Project Appraisal Phase is to conduct a thorough and systematic evaluation of the project's feasibility, VfM, risk management, affordability, legal compliance, strategic alignment, and stakeholder considerations. This ensures that only well-conceived, viable, and beneficial projects proceed to the procurement phase, thereby increasing the likelihood of successful implementation and operation.

In the Project Identification Phase, the Public Partner conducted a climate risk screening to inform the initial VfM proposition, and provided a high-level analysis of the project's feasibility, risks, and potential mitigation measures.

During the Project Appraisal Phase, key interventions aimed at integrating climate resilience and adaptation are shown in **Figure 3.1**. These include: (1) building on the outputs of the climate risk screening, a detailed climate risk assessment is conducted to focus on the identified climate risks, evaluated across a range of future scenarios; and (2) resilience options to mitigate these risks are identified and appraised.

Figure 3.1 Key entry points for climate resilience and adaptation in the Project Appraisal Phase



3.1 Undertake a detailed climate risk assessment

The climate risk assessment (CRA) builds on the findings of the high-level climate risk screening developed during the Project Identification Phase. This step will help the Public Partner obtain a comprehensive understanding of a project's climate risks and how they might change in the future. The key steps of the assessment are:

1. Collate data required for the climate risk assessment

2. Analyze the hazards to which the project and its end users are exposed, for a range of scenarios

3. Assess the vulnerability of the project and its end users for each scenario.

The Public Partner is responsible for undertaking the CRA and prioritizing resilience options at the Project Appraisal Phase. This is because to effectively score bids received from private parties, the Public Partner needs to have a clear understanding of the risks and potential ways to mitigate those risks. The Public Partner should seek access to the right expertise to undertake a detailed CRA. However, it is important that the team involved in Project Appraisal have some in-house expertise to understand and evaluate the results of the CRA to ensure the prioritized resilience option is sound and provides VfM to the Public Partner.

1

Collect data required for the CRA. Readily available baseline information has already been collected as part of the climate risk screening during the Project Identification Phase. However, in this step, further information needed to undertake a detailed CRA should be identified, collated and catalogued in a data register. This includes identifying relevant project documents (e.g., project proposal, project map, preliminary design documents, baseline economic, technical and financial assessments) and existing studies (e.g., geological and hydrogeological surveys, zoning plans, protocol documents etc.) that have been conducted on similar project types and locations or with exposure to similar hazards. This step may also include developing memoranda of understanding with different governmental departments or data owners to access datasets, including geospatial data if undertaking a GIS-based CRA.

Integrating Gender Considerations

When conducting a CRA, it is crucial to consider gender and other vulnerable groups. Women and children are especially susceptible to climate change due to gender norms and labor divisions. During climate-induced or climate-exacerbated disasters, women often evacuate last due to caregiving responsibilities or lack of permission from male family members. They also face greater challenges in the labor market, domestic violence, and sex trafficking in shelters. Additionally, vulnerable groups such as persons with disabilities and indigenous populations, who have inalienable land rights, must be considered, especially when changes in land use occur, such as renewable energy projects.

Source: World Bank. 2023. Placing gender equality at the center of climate action.

2

Analyze the hazards to which the project and its end users are exposed for a range of scenarios. In the climate risk screening, hazards to which the project and its end users would be exposed were identified. High-level information was used to analyze the frequency and intensity of exposure and to determine a final exposure score. A similar analysis is undertaken at this stage using detailed information and stakeholder input.

Stakeholder Engagement

Stakeholders play a pivotal role in supporting CRAs and resilience options evaluation in PPP projects. Their engagement is critical for ensuring that the planning and decision-making processes are participatory, transparent, and informed by a diverse range of knowledge and practices, see **Table 3.1**. Stakeholder engagement can support the integration of climate resilience and adaptation at the Project Appraisal stage in the following ways:

Enhanced Data and Information – Stakeholder engagement provides detailed, locally relevant information for CRAs, offering a comprehensive understanding of risks and specific climate challenges that may not be captured through traditional methods.

Prioritization and Feasibility of Resilience Options – Stakeholders play a key role in prioritizing resilience measures and assessing their feasibility. Their input helps identify the most relevant and sustainable options, ensuring resilience investments are both effective and economically viable.

Maximizing Co-Benefits – Engaging stakeholders ensures the project maximizes value for society. Dialogue helps identify co-benefits, such as social, economic, or environmental gains, that may otherwise be overlooked, optimizing the project's overall impact on communities and the environment.

Risk Mitigation through Comprehensive Stakeholder Interaction – Engaging a diverse range of stakeholders helps identify interdependencies and trade-offs across project components. This collaboration fosters early issue detection and solution development, securing buy-in and ensuring successful implementation and sustainability.

Table 3.1 Stakeholder contributions to the climate risk assessment process

Stakeholder Group	Contribution to the Climate Risk Assessment
Local Communities	• Provide local knowledge on environmental and social conditions, past climate events, and impacts on livelihoods. • Share gendered perspectives on how climate impacts affect women, children, and vulnerable groups. • Offer insights into existing coping mechanisms and resilience strategies.
Project Developers	• Identify potential climate risks during project feasibility and design. • Engage with stakeholders to ensure gender inclusivity and diversity are incorporated into project goals and objectives.
Government Authorities and Regulators	• Set regulatory standards requiring gender mainstreaming in CRAs. • Enforce the inclusion of gender-responsive indicators to track socio-economic impacts on diverse groups. • Establish resilience standards for infrastructure and establish enabling environments.
Civil Society Organizations	• Advocate for the inclusion of vulnerable groups in consultations and decision-making. • Conduct research on gendered and socio-economic impacts of climate change, informing the risk assessment.
Private Sector and Industry Experts	• Provide technical expertise on climate risk modeling and mitigation strategies. • Assess financial risks from climate impacts, considering intersections with gender and socio-economic factors.
Academia and Research Institutions	• Contribute research and data on climate projections and differential impacts of climate risks on gender. • Offer tools and methodologies for conducting gender-sensitive CRAs.

Sources: OECD. 2015. Private sector partnerships for sustainable development.

EPEC Guide to Public-Private Partnerships.

Box 3.1 'How to' Guidance – How to ensure robust and inclusive stakeholder engagement

Practical steps that the Public Partner can take to ensure robust and inclusive stakeholder engagement include:

1. Develop a Stakeholder Engagement Plan (SEP) – Building on the initial stakeholder mapping undertaken at the Project Identification stage, a clear plan should be developed as part of the Project Appraisal Phase. The SEP will formalize which stakeholders, for what purpose and how they will be engaged in the climate resilience aspects throughout the project development. The purpose of the SEP is to involve stakeholders in climate resilience by gathering tailored insights on local climate risks, community values, and adaptive capacities, which can inform PPP project screening and the development of safeguards. The plan should map relevant stakeholders, define their roles in the climate resilience process, and outline the degree of engagement. Proposed engagement activities, such as focus groups and workshops, should align with key project milestones and address specific issues like transport challenges or government capacity gaps. A clear communication strategy should ensure continuous engagement and a monitoring plan should track the success of activities through key performance indicators, such as attendance rates.

2. Undertake participatory vulnerability and risk assessments (PVRA) – PVRA are used as a method to engage communities in the pre-implementation stage of a project. PVRA incorporates a range of strategies to understand local experiences of risk and vulnerability. This can engage the community through a wide variety of activities such as weather timelines, calendars, focus groups, mental models, mapping and scenario planning, town hall meetings, and institutional mapping. These strategies can be used to gain a deep understanding of the community perspective when implementing resilience options and informing decision-making.

3. Implement Capacity Building Initiatives - To ensure the long-term sustainability of Locally Led Adaptation, the Public Partner should invest in capacity building initiatives for local communities and stakeholders. This could include training on climate change adaptation, risk assessment, project management, and monitoring and evaluation. These initiatives should be co-designed with local communities to ensure they are relevant and effective, building local ownership and expertise to manage climate risks beyond the project lifecycle.

Sources:

UNESCAP. 2018. Effective Stakeholder Engagement for the 2030 Agenda. Bangkok.

Collins, K. and Ison, R., (2009). Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation. Environmental policy and governance, 19(6), pp.358-373.

Thi Hong Phuong, L., Biesbroek, G. R., & Wals, A. E. J. (2017). The interplay between social learning and adaptive capacity in climate change adaptation: A systematic review. NJAS: Wageningen Journal of Life Sciences, 82(1), 1–9.

This enhanced understanding of climate hazards and their potential impacts will help inform resilience options to mitigate the hazards. A hazard profile will be built by addressing the following information for each hazard[42], [43] to:

- Define the location and boundaries of hazardous areas, the magnitude of potential hazards, and the probability or likelihood of occurrence of hazardous events;
- Describe and analyze the characteristics of each potential hazard for a range of scenarios (see text box below).

Making Decisions Under Uncertainty

Climate projections are model simulations that provide an estimation of the average future climate for a certain period, typically between 20 - 30 years. The climate simulated by the numerical models during the baseline period is compared with the projected climate for selected future periods to assess the future change in the occurrence of different climate hazards. The following scenarios are often considered and compared to assess the impacts of the different possible futures:

- The observational baseline refers to the historical climate data used as a reference to assess climate change. It typically represents past climate conditions over a defined period (often 30 years or more).
- The very high-emissions scenario (RCP8.5) represents the upper end of the possible future scenarios with no climate policies implemented worldwide due to enhanced greenhouse gas emissions.
- The intermediate scenario (RCP4.5) considers significant mitigation efforts within a future world with a notable but irregular reduction in the use of resources and energy, together with moderate total population growth.

It should be noted that no model or risk assessment approach can capture all uncertainties inherent to climate change data and/or complexities associated with multiple or interconnected physical climate risks, see **Box 3.2**.

3 Assess the vulnerability of the project and its end users for each scenario. This step will assess the project's vulnerability to the identified hazards and quantify direct and indirect losses for the considered scenarios. The key impacts on the physical features of the project (e.g. damages to structures, temporary disruptions, knock-on effects on the service to be provided by the project, its staff and end users) and the root causes of hazard impact (i.e. the features of the hazard event that are causing the impact on the infrastructure) are identified, as well as the ability of the system or its features to resist impacts, cope with losses, or recover following impacts. Specifically, vulnerability can be analyzed by looking into the following items:[44], [45]

42 Godshalk, D.R., Beatley, T., Berke, P., Brower, D.J., Kaiser, E.J., Bohl, C.C. and Goebel, R.M., 1999. Natural Hazard Mitigation: Recasting Disaster Policy and Planning. Washington, D.C. Island Press.

43 Sandler, D. and Schwab, A.K., 2021. Hazard Mitigation and Preparedness: An Introductory Text for Emergency Management and Planning Professionals, 3rd Edition. New York: Routledge.

44 Karagiannis, G.M., Turksezer, Z.I., Alfieri, L., Feyen, L. and Krausmann, E., 2019. Climate change and critical infrastructure – floods. Luxembourg: Publications Office of the European Union, 39 pp., ISBN: 978-92-76-09552-1.

45 Karagiannis, G.M., Cardarilli, M., Turksezer, Z.I., Spinoni, J., Mentaschi, L., Feyen, L. and Krausmann, E., 2019. Climate change and critical infrastructure – storms. Luxembourg: Publications Office of the European Union, 40 pp., ISBN: 978-92-79-96403-9.

- Estimate the expected damage to assets or components which may result from the occurrence of the hazard.
- Assess the danger from secondary hazards which may result from the failure of the infrastructure asset or component.
- Assess the potential impact of the failure of the asset or component on the services, end users and other infrastructure systems in the area.

Each scenario identified in Step 2 is analyzed to determine the consequences of the hazard occurrence on the physical asset and affected communities as a function of the intensity of the hazard and the exposure of people and assets to that hazard. Geospatial data and analysis methods are used to determine the intensity of the hazard that assets are exposed to. For example, flood hazard maps may be combined with geospatial data layers of infrastructure assets to derive the assets located in the inundation zone and determine the water depth at each location for flood scenarios.

A key part of the vulnerability assessment is the evaluation of potential losses caused by climate-related events on the physical assets, the services that will be provided by the project, and its end users and communities. Calculating direct and indirect losses is a crucial component of the assessment, as it provides a comprehensive picture of the potential consequences of climate hazards (when they occur).

- **Direct losses:** These refer to the immediate, measurable damage caused by a climate hazard to physical assets and infrastructure, as well as the cost of any temporary solution. Lost revenues suffered by the Private Partner because of damage or disruption to the physical infrastructure or operational capability of the PPP asset are classified as direct losses. For instance, a toll road damaged by a flood cannot collect tolls until repairs are made, or a port incapacitated by a hurricane cannot facilitate cargo handling or generate associated revenues. Damages are commonly estimated using vulnerability functions or fragility curves that relate the intensity of the hazard (e.g., flood depth, wind speed) to the percentage of damage or repair cost for each asset type.

- **Indirect losses** are secondary impacts caused by disruptions to services, supply chains, or economic activity resulting from a climate event. These losses are harder to quantify due to challenges in establishing direct causal links. Disasters often trigger cascading effects, creating complex and interconnected impacts (see **Box 3.2**). Examples of indirect losses include economic impacts from service disruptions, such as lost productivity or business revenue (e.g., factories unable to operate due to damaged transport links), increased costs for alternative arrangements (e.g., rerouting cargo), and broader effects like reduced consumer spending or GDP contributions. Lost revenues may be considered indirect losses when stemming from secondary effects rather than direct damage to infrastructure. To estimate the extent and duration of service interruptions, operational data or scenario analysis is used to assess downtime and reduced capacity. Input-output models can simulate how disruptions in one sector affect others, such as a closed port impacting manufacturing, retail, and exports.

Combining direct and indirect losses provides a full picture of vulnerability, see example in **Box 3.3**. The Public Partner is primarily concerned about the socio-economic costs stemming from potential climate-related events. Disruptions to infrastructure can negatively impact critical services, local businesses, and employment, potentially leading to economic stagnation and hardship for communities. These failures can also strain essential services like emergency response and healthcare while increasing public spending on recovery and social support systems. For the Private Partner, lost revenues from climate-related disruptions are critical as they impact cash flow, jeopardize financial sustainability, and hinder the ability to service debts and provide investor returns.

Box 3.2 Accounting for wider dependencies with the supply chains and other infrastructure networks

Where possible, CRAs should account for vulnerabilities stemming from interdependencies between the project, supply chains, and other infrastructure networks, as these can trigger cascading failures during adverse events.

Severe storms may close major ports, disrupting imports and exports and impacting global supply chains. Globalization and climate change are reshaping infrastructure resilience, with increasing extreme weather events placing long-term pressures on operators and managers. At the project level, for instance, a hydropower plant reliant on water systems for generation would be affected by climate-induced disruptions to water supply. At the sector level, extreme flooding can damage rail networks, halting cargo shipments and delaying the delivery of essential goods like fuel or manufacturing components.

Tools like interdependencies' mapping and input-output models can identify vulnerabilities and assess potential impacts. For example, mapping air freight operations with ground transportation can highlight chokepoints, such as a single route to a major airport. Stress-testing these systems helps uncover risks and inform resilience strategies.

Source: Knapp, E. D., & Rajagopal, R. (2012). Critical Infrastructure Protection and Risk Management. Syngress.

Box 3.3 Case Study – Climate Risk Assessment for the Kampala-Malaba Meter-Gauge Railway (MGR)

The climate risk assessment for the Kampala-Malaba MGR evaluates the vulnerability of the railway to key climate hazards through a comprehensive stress test. Risks are quantified as Expected Annual Damage (EAD), considering both direct damages — physical harm to assets — and indirect damages, which include economic losses from disruptions. Indirect impacts are assessed in terms of passenger journey delays and cargo losses due to inventory costs and deterioration. Four climate hazards — extreme temperatures, extreme precipitation (pluvial flooding), fluvial flooding, and high-water levels at Lake Victoria — were identified as having significant impacts on the railway and incorporated into the assessment.

The analysis began with a structured screening to identify risks by comparing hazards with baseline elements and infrastructure characteristics. A matrix highlighted hazards likely to affect assets or traffic flow. To refine the analysis, the railway was segmented based on traffic demand, natural hazards, topography, and critical assets like bridges. Direct damages were calculated using vulnerability curves, representing the fraction of damage for varying hazard thresholds. Indirect damage was derived from railway downtimes and their knock-on economic effects, including costs associated with journey delays and canceled trips.

Uncertainty was addressed by applying two climate scenarios (RCP4.5 and RCP8.5) and using confidence intervals (10th, 50th, and 90th percentiles). The dominant risk driver was pluvial flooding, accounting for 99% of total climate risk. This hazard significantly affects culverts, embankments, and railway tracks, with projections under RCP8.5 indicating a 30–40% increase in precipitation by 2050. Under RCP4.5, risks stabilize by 2050 (see **Table 3.2**)

Stakeholders were engaged in a climate risk dialogue to validate findings and refine the methodology. The insights from this assessment, supported by detailed hazard-damage-downtime relationships, provide critical data for resilience planning, highlighting the importance of mitigating both direct and indirect risks to safeguard the MGR's operations and economic viability.

Table 3.2 Direct and indirect EAD for pluvial flooding for 2050 under RCP4.5 and RCP8.5, and the shares of the total annual risk (50th percentile)

Year	Direct EAD (%) [$ million]	Indirect EAD (%) [$ million]
Baseline	0.23 (20%)	0.90 (78%)
2050 RCP 4.5	0.67 (18%)	2.91(80%)
2050 RCP 8.5	0.84 (22%)	2.95 (76%)

Source: GCA. 2023. Climate Vulnerability Assessment Report - The Kampala-Malaba Meter-Gauge Railway (MGR). Unpublished.

3.2 Resilience options identification and appraisal

The CRA analyzed the project's key climate risks for a range of scenarios that show how climate will change in the future compared to the current baseline. In this stage, appropriate adaptation measures are identified and appraised with the aim to strengthen the project's climate resilience and adaptation.

It is crucial that the Public Partner understands and partakes in the decision-making process. The Public Partner may wish to leave the resilience options appraisal as a criterion within the Tender and Award Phase, where the Private Partner must propose the optimized resilience option. This is the case for circumstances where there are multiple no/low-regret or flexible options available. The Public Partner should lead the participatory processes that inform the identification of resilience options.

Resilience-building measures

Resilience measures can be divided broadly into two categories:

- Structural ('hard') measures: Any physical construction that reduces or avoids possible impacts of hazards, reduces exposure or sensitivity, or the application of engineering techniques, such as green/blue/gray infrastructure or technology to achieve hazard resistance and resilience in structures or systems. See **Box 3.4** for more details.

- Non-structural ('soft') measures: Non-physical measures to reduce climate risks and impacts, such as policies, strategies, plans and governance to enhance the enabling environment; and knowledge, practice, capacity building, and education for public awareness raising. For example, enhancing cross-sectoral communication between departments responsible for intelligent transport systems (ITS) and road maintenance.

To achieve resilient infrastructure systems, a combination of both structural and non-structural measures is required. This combination of actions will be different for each infrastructure system as they will be context-dependent.

Some key characteristics of resilience and adaptation measures include:

- Resilient options must be able to **adaptively transform Infrastructure** to overcome unexpected events and grow into unforeseen roles.
- Resilient options must be **environmentally integrated** so that they do not cause any other damage.
- Infrastructure must be **protected by design** from the hazards that could face an asset once delivered.
- Any resilience action must be aligned with **Locally Led Adaptation**. Communities should have awareness and a sense of ownership.
- Resilience must be **a shared responsibility**, with focus on collaborative data and knowledge sharing regarding an asset.
- Resilient options require **continuous learning** to optimize the ability of infrastructure to cope with what's ahead.

Box 3.4 Integrating gray, blue and green infrastructure

In the built environment, different types of infrastructure provide different services and benefits to our lives. These different types of infrastructure can be positioned in a continuum that goes from gray infrastructure to green and blue infrastructure based on their characteristics. These types of infrastructure can be connected and designed to work together in hybrid and more resilient infrastructure systems. These approaches can have a relevant role in resilience building thanks to their relative strengths and weaknesses, see **Table 3.3**.

Table 3.3 Comparison of infrastructure types

Infrastructure type	Description	Pros/Cons
Gray infrastructure	Gray infrastructure refers to built-up, engineered and physical structures, often made of concrete or other long-lasting materials. These include roads, railways, canals, energy, ports, dikes, embankments, sea walls, centers and breakwaters for riverine and coastal flood protection, piped drainage systems for stormwater management (such as storm sewers or concrete detention basins), and air conditioning or cooling centers to cope with extreme heat.	Pros • Can provide strong resilience to environmental hazards Cons • Often costly to construct and maintain; • Has low flexibility; • Can lead to system lock-ins, path dependency and even maladaptation.
Green Infrastructure	Green infrastructure involves healthy and well-functioning biophysical systems, primarily related to green spaces, that support biodiversity, natural ecological processes and to which some management and restoration may apply. Examples include healthy oyster reefs, coastal salt marshes, mangroves, coral reefs, seagrasses, sand beaches and dunes in the coastal environment mainly by forests, parks, street trees, and grasslands inland.	Pros • Greater adaptability • Can provide multiple co- benefits such as carbon sequestration, biodiversity, recreation, psychological well-being and water-control opportunities Cons • Relies on healthy, functioning ecosystems • May require large amounts of land use • Performance can be unreliable.

Blue infrastructure	Blue infrastructure can also be characterized by well-functioning biophysical systems, but primarily related to water. This includes water bodies, including ponds, wetlands, rivers, lakes, and streams, as well as estuaries, seas, and oceans.	
Hybrid infrastructure	A blend of natural and engineered structures that allows for some ecosystem functions mediated by technological solutions. NBS often fall into this category. Examples include bioswales; porous pavement; green roofs; rain gardens; constructed wetlands; Sustainable Drainage Systems (SuDS)	• Hybrid approaches that combine engineering and ecosystem functions can be the solutions that perform better when trying to create resilience in the built environment as they can combine the strengths of gray, blue and green infrastructure, while minimizing the issues associated with each.

Source: Depietri Y., McPhearson T. 2017. Integrating the Grey, Green, and Blue in Cities: NBS for Climate Change Adaptation and Risk Reduction. In: Kabisch N., Korn H., Stadler J., Bonn A. (eds) NBS to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. Springer, Cham.

Resilience options appraisal process

The appraisal process is made up of the following steps:

1. Establish objectives for climate resilience
2. Identify applicable resilience options and associated co-benefits
3. Conduct an economic analysis of applicable resilience options
4. Combine technical and economic evaluation to prioritize preferred resilience options, valuing risks and benefits.

1

Establish objectives for climate resilience. During this stage, the main climate resilience objectives for the project are identified. Integrating climate resilience and adaptation measures in the PPP project will improve the resilience of physical assets and services to end users, as well as deliver a range of socio-economic and environmental co-benefits.

In addition, it can also contribute to national and local climate goals. The Public Partner should align resilience objectives for the project with national and local climate strategies and plans, such as Nationally Determined Contribution National Adaptation Plans (see **Box 3.5**). This would provide governments with a stronger case for directing and influencing investments by the private sector and others to support the implementation of prioritized adaptation actions.

To successfully embed climate resilience objectives, climate considerations in PPP projects should be in all formal decision-making processes, including the Environmental and Social Impact Assessment (ESIA), see **Box 3.6**.

Box 3.5 Spotlight on Nationally Determined Contributions and National Adaptation Plans

Nationally Determined Contributions (NDCs). The NDCs lie at the heart of the Paris Agreement. They are each party's action plans that aim to reduce national greenhouse gas emissions and adapt to the impacts of climate change. In 2023 and then every five years, each party will undertake a stock take, assessing their performance against their NDCs, which will inform the preparation of the subsequent NDCs to align with the achievement of the Paris Agreement.

National Adaptation Plans (NAPs). The NAPs encourage adaptation efforts, with technical and financial support made available to developing countries. The two main objectives of the NAPs are to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience and to integrate adaptation into new and existing policies and programs, especially development strategies.

Understanding your country's commitments under the Paris Agreement, along with its NDCs and NAPs, will inform project development, screening, design, and implementation of PPPs. The NDCs and NAPs are tied to infrastructure development and retrofitting. If, for example, reducing a country' emissions means increasing public transport availability to reduce emissions from private vehicles, it is important that resilience and adaptation measures are considered when planning for public transport (e.g. what risks might the network face from climate change?).

Box 3.6 Incorporating climate risk considerations in the Environmental and Social Impact Assessment (ESIA).

The CRA assesses vulnerabilities to climate hazards and potential impacts on the physical or socioeconomic features of the project and its surroundings.

The structured process that is followed to develop the ESIA offers several entry points for integrating consideration of climate risks. For example, baseline data collated as part of the CRA and improved understanding of climate risks and how to mitigate them should feed into the ESIA. As discussed in the previous step, national climate adaptation plans are being developed and could be incorporated into ESIA guidelines to ensure that projects are aligned with long-term climate resilience goals. The ESIA is developed with extensive stakeholder consultations, which could include discussions about climate resilience with communities, local governments, and climate experts providing input on climate risks. ESIA processes could be used to tease out stakeholders' input and appetite for resilience and adaptation measures such as NBS.

Checklist (adapted from IDB[46]):

- ☑ Does the environmental impact assessment consider the impact of the project on the environment under current and future climate conditions?
- ☑ Are the same climate scenarios applied as those used in the technical, financial, and economic feasibility of the ESIA?
- ☑ Does the ESIA contain suggestions for mitigation measures including the respective change in impact, with and without climate change?
- ☑ Has the environmental impact assessment been reviewed by climate and natural disaster risk experts?

46 Inter-American Development Bank (IDB), 2024. Resilient public - private partnerships a regional and multi-sectoral toolkit from preparation to sustainable project financing

Integrating Gender Considerations

In addition to consideration of climate risks, a gender impact analysis should be included in the ESIA with the aim of understanding the socio-economic impact of the project on local stakeholders, integrating gender impacts as a core value.

To assess the feasibility of a project's alignment with public needs, the project should be appointed a set of strategic goals in which gender inclusivity and diversity should be included. Furthermore, there should be continuous dialogue between developers and stakeholders during consultations in which transparency is promoted and practiced. Approvals from relevant authorities should include the requirement of a standardized level of gender mainstreaming; this standard should be measured and enforced using gender-responsive indicators, such as improved access to services or increased employment opportunities.

2

Identify applicable resilience options and associated co-benefits. This stage will consider what options can be implemented to enhance the resilience of the PPP project and they will be assessed against the hazards identified in the CRA.

Identification of resilience options will consider gray, blue, green or hybrid solutions (see **Box 3.4**), sector-specific resilience policies and strategies (e.g. NAPs, design codes and guidelines etc.) and other relevant information. Adaptation co-benefits that the resilience options for the project are likely to generate will then be identified. These are additional to the project's own co-benefits, which should have been assessed as normal through the typical project appraisal phase. **Table 3.4** provides some high-level examples of resilience options for a railway project, as well as their direct benefits and co-benefits. Further guidance is available for sector-specific resilience options.[47]

Table 3.4 Examples of resilience options, direct benefits and co-benefits for a railway project

Climate hazard	Resilience option	Direct benefits	Co-benefits
Flooding	Restoring wetlands near railways to act as natural flood buffers Implementing bioswales and vegetated drainage systems along rail corridors and station areas	Reduces flood impacts on railway systems Protects against severe disruptions Prevents waterlogging Protects rail ballast integrity Controls erosion	• Support integrity of ecosystems • Maintain or enhance biodiversity, soil quality and water quality of the site area and its surroundings • Reduced cost of repair • Supports integrity of ecosystem • Maintains or enhances biodiversity, soil quality and water quality of the site area and its surroundings • Recharges groundwater in adjacent areas • Reduced cost of maintenance and repair

47 For a more comprehensive list of resilience options, the reader is referred to the World Bank's Climate Toolkits for Infrastructure PPPs

Extreme heat	Use of heat-resistant rail materials and expansion joints to accommodate thermal stress Vegetation buffers along rail corridors to provide shade and reduce heat stress	Reduces rail deformation Ensures service continuity Prevents rail track buckling Lowers maintenance and repair costs	• Increases asset lifespan, reducing the need for replacement • Enhances biodiversity along rail routes • Sequesters carbon • Improves air quality and visual aesthetics

Source: Authors.

3 **Conduct an economic analysis of applicable resilience options.** This step will use the economic feasibility of the project without any resilience options assessed in the CRA and identify the net benefits of alternative resilience options for the project. A relevant time horizon should be used, typically the full performance life of the asset, and a discount rate according to national or international standards. It is important to note that the purpose of this analysis is not to provide stakeholders with a pre-defined list of measures and packages from which to choose for implementation, but instead to give an indication of the benefits that can be obtained by implementing a program of climate resilience measures, and how these compare to the costs.

The key steps of the economic analysis are:

1. Estimate the Net Present Value (NPV) (see **Box 3.7**) of the project with no resilience measures using outputs from the CRA.

2. For each resilience option identified, identify and value:
   a. Costs, primarily CAPEx and OPEx and other additional costs for non-physical measures
   b. Benefits, both direct benefits and co-benefits (as identified in Step 2) of alternative project designs that incorporate different resilience options. These include the benefits gained by solutions to the hazards to the assets. To quantify the climate risk reduction for the climate adaptation measures grouped into a package, these vulnerability functions should be adjusted to reflect the benefits provided by integrating the proposed measures in terms of decreased repair and routine maintenance costs, increased lifespan of assets, socio-economic co-benefits (if quantifiable) etc.

3. Apply the project's discount rate to convert the cost and benefit flows into present values.

4. Calculate the net benefits by comparing the estimated incremental costs of project design with the resilience option and the benefits of integrating that resilience option.

5. Conduct a sensitivity analysis to account for uncertainties.

6. Rank the NPV of all resilience options and the no adaptation option.

Other financial metrics such as the Internal Rate of Return (IRR), External Rate of Return (ERR) and the Return on Investment (ROI) can be used to complement the NPV analysis.

Box 3.7 Calculating the Net Present Value

Net Present Value (NPV) or Net Present Worth is a method for measuring the value of all future cash flows (positive and negative) over the entire life of an investment, discounted to the present. It is widely used in capital budgeting and investment planning to analyze the profitability of an investment or project. The NPV is calculated as the difference between the present values of cash inflows and outflows over a period of time:

$$NPV = \frac{C_t}{(1+i)^t}$$

Where: NPV = net present value, Ct = net cash flow at time t, i = discount rate, t = time of the cash flow

4

Combine technical and economic evaluation to prioritize and select preferred resilience options. In this step all the options considered in the analysis are considered and prioritized. Selecting the best option will involve decision-making under uncertainty — that is, choosing actions based on often imperfect observations, with unknown outcomes. Decisions need to consider the various sources of uncertainty while balancing the multiple objectives of the infrastructure being designed. Several methods are available to support decision-making under uncertainty, see text box below as well as **Box 3.8** and **3.9** for examples of these methods in action.

Making Decisions Under Uncertainty

A list of qualitative and quantitative methods most used in infrastructure development and other fields is shown in **Table 3.5** below. These methodologies are helpful when making choices without having complete information about the potential outcomes or their probabilities. When multiple criteria or parameters are being considered, these methods are usually complemented by a sensitivity analysis.

Table 3.5 Decision-making methods

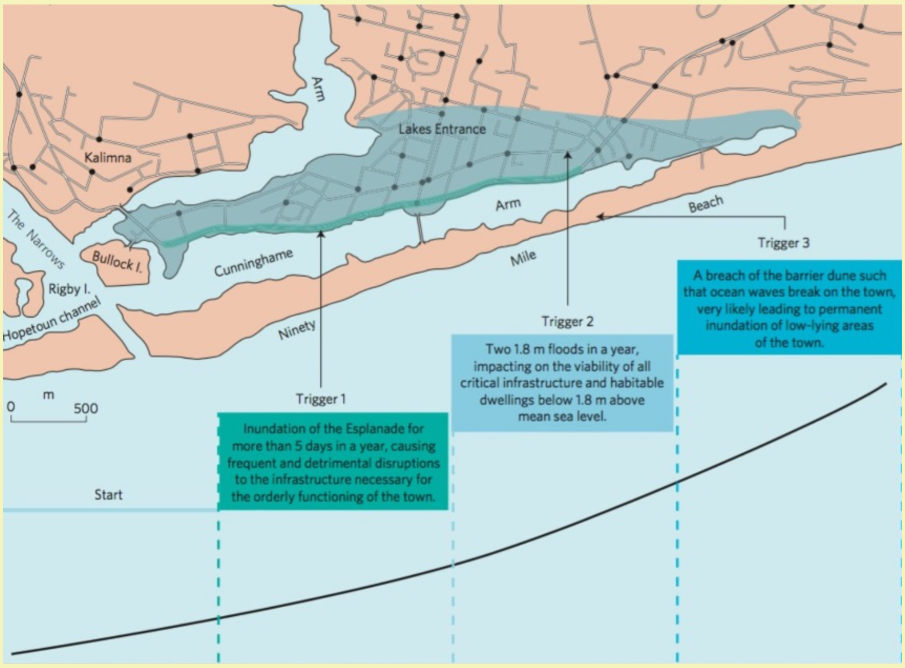
Method	Description	Applicability
Scenario Planning	Develops diverse, plausible futures to explore how different scenarios might unfold.	Useful for strategic planning and exploring a range of possible climate futures.
Adaptive Management	Involves implementing strategies incrementally, monitoring outcomes, and adjusting actions based on new information.	Effective for managing ongoing projects with flexibility to adapt as conditions change.
Real Options Analysis	Treats investments as options, allowing for adaptation or abandonment as more information becomes available.	Ideal for large infrastructure projects with significant long-term investments.
Multi-Criteria Decision Analysis (MCDA)	Evaluates and compares multiple competing criteria to balance various factors such as environmental impact, cost, and social equity.	Useful for decisions that require balancing diverse and sometimes conflicting criteria.
Cost Effectiveness Analysis (CEA)	Compares the relative costs and outcomes (effects) of two or more courses of action. Unlike Cost-benefit Analysis (CBA), which assigns monetary values to the benefits of different interventions, CEA measures outcomes in natural units (such as life years saved).	Cost-effectiveness analysis is widely used in various fields where the goal is to achieve the maximum benefit with limited resources.

Box 3.8 Implementation of an adaptive management approach at Lakes Entrance, Australia

The township of Lakes Entrance in South-Eastern Australia sits behind a barrier dune at the eastern end of the Gippsland Lakes, a large coastal lagoon system fed by six rivers. The town is located at the one permanent opening between the lakes and the sea. Lakes Entrance floods when there is a combination of high tides, low-pressure systems and strong rainfall. The main conclusions of various studies of potential climate impacts on Lakes Entrance are that climate change will cause: an increase of the 1:100 year flood level at Lakes Entrance by between 2 - 20 cm in 2030 relative to baseline flood levels, and by between 4 - 59 cm by 2070. Through a participatory approach based on focus group discussions, a climate adaptation pathway was developed as a phased approach where activities at each step are triggered by increasing coastal flooding events:

- Now – triggers negotiated and defined through consultation. This step includes low-cost and low-regrets activities that minimize present risks, prepare for future actions, and minimize the exposure of new assets to future damages.
- Step 1 – Inundation of the Esplanade for more than five days a year, causing frequent and detrimental disruptions to the infrastructure necessary for the orderly functioning of the town. This step brings stringent controls over new developments, and steps to prepare for the relocation of critical infrastructure and dwellings to more elevated parts of the town.
- Step 2 – Two 1.8-meter floods in a year, impacting the viability of all critical infrastructure and habitable dwellings below 1.8 m above mean sea level. This step entails the managed relocation of all low-lying critical infrastructure and habitable dwellings to more elevated parts of the town.
- Step 3 – A breach of the barrier dune such that ocean waves break on the town, very likely leading to permanent inundation of low-lying areas of the town. Actions in this step are to be determined by future generations through processes of review and evaluation in Steps 1 and 2.

Figure 3.2 Adaptive management approach for the coastal lagoon in Lakes Entrance.



Source: Barnett, J., Graham, S., Mortreux, C., Fincher, R., Waters, E., and Hurlimann, A., 2014. A local coastal adaptation pathway. Nature Climate Change, 4: 1103–1108.

Box 3.9 Multi-criteria decision analysis for National Adaptation Programme of Action, Ethiopia

The Ethiopian National Adaptation Programme of Action (NAPA), created under the National Meteorological Agency, used a Multi-Criteria Analysis (MCA) method to prioritize a list of urgent and immediate adaptation projects under its NAPA development process. NAPA is a mechanism within the UNFCCC, designed to help the Least Developed Countries identify their priority adaptation needs to climate change. Ethiopia used an MCA to provide a structured framework for decision makers to compare and make sense of the wide range of information that was relevant to making adaptation choices. Assessments had to be made regarding the identification of who is vulnerable and to what. Adaptation options were evaluated across five criteria, which included cost effectiveness, climate change risk (measured in economic losses avoided by poor people per year), and existing links to national and sectoral plan. By using an MCA, the project team could break down the complexity of the problem into smaller components and establish a prioritized list of projects meeting their needs. Through the NAPA process, twenty priority project ideas were identified that broadly focused on the areas of human and institutional capacity building, improving natural resource management, enhancing irrigation agriculture and water harvesting, strengthening early warning systems and awareness raising. Overall, the MCA supported the successful completion of Ethiopia's NAPA by allowing a balanced evaluation of adaptation options across a range of priorities.

Sources: USAID. 2013. Analyzing Climate Change Adaptation Options Using Multi-Criteria Analysis.

UNFCCC. 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia.

An assessment of the project's VfM with some level of confidence is needed to support the decision to move forward with a PPP at the project appraisal phase. Similar to the CRA, evaluators will need to undertake the VfM assessment under multiple scenarios, where the project has different resilience features based on the outcome of the resilience options appraisal (see **Box 3.11** and **3.12**). The Public Partner will need to assess the NPV and benefit-cost ratio under future climate scenarios that have been assigned specific probabilities. Evaluators also need to model these resilience scenarios against a PPP delivery versus a traditional delivery. The VfM assessment may be revisited at the Tender and Award phase, prior to issuing the Request for Qualification (RfQ), if the contract structure changes substantially.

Based on the outcomes of these VfM scenarios, the Public Partner can decide generally whether the project provides VfM, or whether they want to specify a resilience option in the bid because that specific option provides VfM through a PPP (see **Box 3.10**).

Box 3.10 VfM analysis in Sendai City

Sendai City, Japan leveraged PPPs to supply various types of public infrastructure, including the Aichi Toll Road. Japan faces several types of natural hazards, including earthquakes, volcanos and tsunamis. While slightly different from climate risk, disaster risk also requires decision-making under boundaries of uncertainty, which means that Sendai City had to manage these uncertainties throughout the PPP project cycle.

Sendai City explicitly integrated disaster response considerations into the VfM analysis to assess whether the project should be delivered via PPP or through a public administrator. The ultimate analysis indicated that a Build Operate Transfer model had more advantages over public delivery because the private partner would be able to respond more quickly to a disaster event, whereas Sendai City would have to go through the process of gaining a contingency budget and submitting documents to the municipal assembly to get approval for disaster recovery works.

Source: World Bank. 2017. Resilient Infrastructure Public-Private Partnerships (PPPs): Contracts and Procurement – The Case of Japan. Washington, D.C..

In this stage, the Public Partner will also undertake a financial analysis to estimate the financial viability of the project. The financial analysis provides a detailed examination of the project's costs, revenue potential, financing structure, risk management, and long-term sustainability, while also ensuring that public sector involvement aligns with fiscal policy and value-for-money principles. It will assess i) the impact of climate-related costs on the project's affordability i.e. appetite/ability to bear those costs by the Public Partner, and ii) potential commercial returns i.e. ability to take on climate-related risks by the Private Partner. The key outcome sought is for the Public Partner to identify the contingent liabilities arising from climate risk. In PPP agreements, risks such as climate-related damage may be shared between public and private partners. Implementing adaptation options can lower the contingent liabilities that the public sector must bear, influencing the financial analysis favorably. Allocation of risk and liabilities is further discussed in the Tender and Award Phase.

Box 3.11 Using the risk mitigation hierarchy to inform decision-making

The mitigation hierarchy used to support environmental impact assessments can be a useful framework to guide decision-making when applied to climate-resilient infrastructure. A robust risk mitigation and control framework enhances decision-making by providing a comprehensive understanding of potential risks and their implications. It safeguards stakeholders and assets from adverse impacts, ensuring projects comply with regulatory requirements and align with sustainability goals. Additionally, it builds trust and confidence among investors, partners, and communities by demonstrating a proactive approach to risk management and resilience building. Risk management strategies that could be deployed by the Public Partner are presented in **Figure 3.3** below.

Figure 3.3 Risk mitigation hierarchy

1. **AVOID** ▸ The risk is too high to be mitigated, and the activity should be avoided, changed or stopped. For infrastructure assets, this may entail moving the asset to a lower-risk location (for example inland for coastal infrastructures). In an extreme case, avoiding the risky activity may mean not using a PPP if the climate risk assessment indicates it is not the best available mechanism.
2. **MITIGATE** ▸ Take action to reduce the likelihood of climate-related hazards occurring or reduce the impacts to an acceptable level should they occur. This may entail a range of resilience options, such as designing the asset to withstand a higher design load, building redundant systems, using early warning systems and emergency planning.
3. **TRANSFER** ▸ A variety of widely applied techniques used to shift the financial responsibility for losses to a third party. Insurance is probably the best-known risk transfer mechanism and should be considered for all climate-resilient infrastructures. Furthermore, the PPP contract is a key mechanism for transferring some risks to the Private Partner.
4. **ACCEPT/RETAIN** ▸ This refers to residual risks that cannot be mitigated or transferred. They are either within risk tolerance thresholds, or the mitigation cost is higher than the expected damage, or – in the case of climate-resilient PPPs – this also includes contingent liabilities and risks that would be unacceptable to the Private Partner.

Sources:

Dorfman, M.S., and Cather, D.A., 2013. Introduction to Risk Management and Insurance, tenth Edition. Upper Saddle River, NY: Pearson

International Organization for Standardization (ISO). ISO/IEC 31010:2019: Risk management – Risk assessment techniques. 2nd Edition, Geneva, Switzerland: ISO, 2019.

Box 3.12 'How to' Guidance – How to prioritize resilience options and inform the VfM assessment at Project Appraisal Phase

No single methodology exists to prioritize resilience and adaptation measures. The goal is to ensure that the outcome of this process is relevant and applicable to the project's context.

Ideally, a quantitative approach should be used to prioritize and select the resilience and adaptation measures, as outlined in Step 3. However, this is challenging due to uncertainties in climate projections, variability in socio-economic scenarios, and data gaps. Difficulties arise from modeling cascading risks, interdependencies, and long timeframes, compounded by limitations in high-resolution data and methods to value indirect impacts. Confidence in results often depends on assumptions and stakeholder input.

Some practical tips to integrate uncertainty in the quantitative approach are as follows:

1. Get input and agreement from impacted stakeholders on the project's discount rate.
2. Consider the other main components that will likely be influenced by the future scenarios stress test, such as the O&M costs, the renewal and replacement costs, risk adjustments, and socio-economic consequences. The cost of climate adaptation and resilience measures should be included in the calculation.
3. Account for the benefits of a PPP procurement strategy, such as the efficiency of the private sector and cost savings stemming from competitive procurement.
4. Use statistical methods and metrics e.g. mean, percentiles and confidence levels in the sensitivity analysis to convey uncertainty, facilitate comparison and enable stakeholders to make better decisions.

When a fully quantitative approach is not possible, qualitative indicators can be incorporated into the resilience options prioritization process to complement the quantitative ones. Qualitative indicators might include social equity, scalability and innovation, stakeholder utility, national and international policy alignment, and capacity for implementation

Guiding questions for a qualitative approach should consider the following:

- Is the project itself suitable for private financing, at least in part?
- Is the private partner better able to manage some or all the climate risk? This includes addressing operational and maintenance concerns following a hazard event
- Will using a performance-based payment mechanism incentivize climate risk mitigation?
- Is there available expertise in the market to address this risk? Is the technology or sector well known and stable over the long term?
- Is there capacity in the government to manage and monitor the PPP?

Nature-based Solutions

Given their potential to enhance resilience while delivering co-benefits, it is crucial to explore opportunities to include NBS among the resilience options considered during the Project Appraisal Phase (see **Boxes 3.4, 3.13** and **3.14**).

Box 3.13 'How to' Guidance – How to embed consideration of NBS in the Project Appraisal Phase

Practical steps that the Public Partner can undertake to embed consideration of NBS in the Project Appraisal Phase include:

- Prioritize comprehensive lifecycle management to integrate NBS with or alongside traditional gray infrastructure, maximizing sustainability benefits
- Include long-term environmental benefits, such as enhanced biodiversity or ecosystem services, as part of the project's objectives
- Conduct comprehensive environmental and climate risk assessments to identify vulnerabilities and opportunities for NBS
- Engage diverse stakeholders (local communities, government agencies, private sector) to ensure NBS are contextually tailored and enhanced through collaboration

Sources:

Koppenjan, J.F. 2015. Public–Private Partnerships for Green infrastructures. Tensions and Challenges. Current Opinion in Environmental Sustainability.

European Commission. 2020. Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities: Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities.

Box 3.14 Identifying investment opportunities for NBS

To make informed investment decisions, both public and private financial institutions need information on the social and environmental benefits of NBS investments, information to assess the most suitable restoration and protection projects for a location to address drivers of loss and the costs, as well as the potential to generate financial returns and mitigate risks. Global datasets bring new opportunities for both local communities, governments and investors to identify opportunities and structure financing that can deliver major capital for implementing NBS.

For example, GCA, in partnership with The University of Oxford, has developed advanced analytical tools that can identify and map opportunities for NBS projects supporting infrastructure resilience,The Global Tool addresses data gaps by
1) assessing and pricing climate risks to infrastructure,
2) quantifying the protective value of nature-based assets, and
3) identifying NBS investment opportunities

By providing actionable data to policymakers, financial institutions, and investors, the tool supports integrating NBS into infrastructure planning, mobilizing adaptation investments, and embedding resilience globally.

For example, the Nature-Based Solutions Opportunity Scan (NBSOS) is a geospatial analysis and participatory methodology designed for World Bank operations to help engage governments and stakeholders. It can be used to inform feasibility studies, design, and implementation of NBS. The methodology comprises 4 steps:

1. Problem analysis: Assess the magnitude and spatial variation of climate resilience challenges and natural hazards.
2. Suitability mapping: Identify suitable areas for the protection and creation of NBS types.

3. Benefit modelling: Estimate the positive impact of NBS on identified challenges and hazards.
4. Decision support: Determine optimal NBS investment distribution to maximize benefits using multicriteria or cost- benefit analysis (CBA), providing crucial information to decision-makers.

The NBSOS is especially valuable for identifying areas where NBS can provide significant benefits, engaging stakeholders, and informing the design and implementation of World Bank projects. It also supports scaling up NBS investments by using Earth observation data to assess and prioritize intervention opportunities.

By providing open-access, consistent datasets, the GRI Risk Viewer supports the integration of climate resilience into project planning and investment strategies. For instance, it can help identify where NBS, such as mangrove restoration or wetland conservation, could effectively address risks like flooding or biodiversity loss while delivering co-benefits.

Sources:

World Bank. 2024 The Nature-Based Solutions Opportunity Scan: Leveraging Earth Observation Data to Identify Investment Opportunities in NBS for Climate Resilience in Cities and Coasts across the World.

Resilient Planet Data Hub. Data-Driven Investment for Nature-Based Solutions.

In the short term, engineered approaches have more immediate effects in targeted hazard risk reduction. However, NBS has shown more benefits in the long term, providing a wide range of protection from hazards, while supporting the livelihood of the local community. For example, Mangrove forests provide more than $80 billion per year in avoided losses from coastal flooding — and protect 18 million people. They also contribute almost as much ($40–50 billion per year) in non-market benefits associated with fisheries, forestry, and recreation. NBS have also been shown to be more affordable and cost-effective when compared to conventional approaches. Combined, the benefits from mangrove preservation and restoration are up to 10 times the costs.[48] Better methods and approaches to value the costs and benefits of NBS for climate resilience will enable further uptake of investments by articulating their value and their beneficiaries across sectors, see **Box 3.15**.[49]

Box 3.15 Case study - Undertaking a benefits assessment for NBS - Port of Beira, Mozambique

The Beira Coastal Development Protection Strategy is a long-term initiative aimed at enhancing local resilience against climate risks such as flooding, erosion, and cyclones through the implementation of NBS. Co-financed by the World Bank and Invest International with a commitment of $60 million, this project is part of the Cyclone Idai Kenneth Emergency Recovery and Resilience Project. It responds to the devastating impacts of Cyclones Idai and Kenneth in 2019, which caused extensive damage to infrastructure, the economy, and the environment, affecting over 1.7 million people and leading to estimated recovery costs of $3.4 billion.

48 Global Commission on Adaption, 2019. Data-Driven Investment for Nature-Based Solutions.

49 World Bank. 2023. Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers.

The project focuses on developing a coastal resilience strategy for the Port of Beira, Mozambique, by integrating a combination of gray and green infrastructure solutions. These measures aim to bolster

the resilience of upwards of 200,000 individuals and their livelihoods against the frequent threats posed by cyclones and flooding. A CBA was conducted to evaluate the feasibility of various coastal resilience options, highlighting the economic viability of combining ecological restoration with traditional engineering approaches. Outputs from the CBA were used to prioritize investments in four stretches of Beira's coastline that are mostly impacted by climate hazards (See **Figure 3.3**).

Figure 3.3 Proposed NBS along Beira's coastline.

The CBA was based on the development of full preliminary designs, which included construction material costs, estimates of the capital investments needed, the direct benefits (i.e., avoided damages), and indirect benefits (i.e., improvement of ecosystem services, health benefits, and avoided indirect flood damages) provided. The preliminary design of coastal protection measures during the feasibility studies considered not only the climate risks that the four coastal stretches were exposed to but also the physical conditions and landscape characteristics to propose adequate investment alternatives. These measures adopt a nature-based approach, where gray and green solutions are combined to achieve the greatest risk reduction and indirect risk benefits. Furthermore, they also consider the use of local materials (e.g. sand) for the implementation of measures. For each of the four coastal stretches considered, three investment scenarios were considered. **Table 3.6** shows alternatives for Coastal Stretch 4, where Alternative 1 proposes dune conservation with a sand suppletion buffer, which is required to be replenished every 10 years, Alternative 2 proposes a levee with sand suppletion buffer (also creating a beach); and Alternative 3 proposes an inland levee with a road on top. Assuming a discount rate of 6%, investment Alternative 1, which proposed dune conservation measures with a sand suppletion buffer, was the most economically viable measure, with a benefit-cost ratio (BCR) of 2.6, an estimated net present value (ENPV) of $92.5 million, and an economic internal rate of return (EIRR) of 17%.

Table 3.6 Results of the cost-benefit analysis*

Economic Indicator	Alternative 1	Alternative 2	Alternative 3
Total costs	$50.7 mil	$203.9 mil	$43.2 mil
Direct Benefits	$5.1 mil	$5.1 mil	$2.6 mil
Indirect Benefits	$126.7 mil	$133.2 mil	$0.1 mil
BCR	2.60	0.68	0.06
ENPV	$92.5 mil	($65.6 mil)	($38.1 mil)
EIRR	17.0%	3.5%	-6.7%

Source: World Bank. 2023. Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers. © World Bank.

*Presented results consider a discount rate of 6%. Source: Adapted from Van Zanten, B. T., et al., 2023

Yet, due to their complex and dynamic nature, the effectiveness and co-benefits of NBS can take years or decades to materialize. Additionally, project financers often lack experience with NBS projects and are unfamiliar with the associated approaches and risks. There is a lack of data on the benefits and trade-offs of NBS, skills and expertise shortages, and a lack of awareness among the public. Due to this uncertainty, NBS might be perceived as riskier than traditional engineering solutions, regardless of their actual risk profile.

Currently, NBS is predominantly funded by public investors. In the EU, only 3% of the identified NBS projects indicate that private sector financing exceeds 50% of the total project cost[50]. Public funding faces budgetary constraints and lacks expertise on climate resilience, while NBS requires dedicated maintenance budgets and a long-term strategy. Therefore, the involvement of private investors and partners is crucial for financial sustainability. PPP is a funding model that mirrors this principle.

Mobilizing Climate Finance

Climate finance instruments can play a pivotal role by helping assess, fund, and structure projects designed to address climate impacts. At this early stage, climate financing tools can provide additional finance to support projects that align with climate resilience, adaptation, and mitigation goals. These instruments can be particularly helpful in making projects with higher upfront costs due to climate-resilient features financially viable, making such projects more attractive to investors and ultimately more feasible to implement. Climate finance instruments include:

- **Grants** offer early-stage support without requiring repayment. This can help identify climate-vulnerable sectors or communities and create frameworks for addressing climate risks, particularly in regions lacking initial capital.
- **Concessional loans**, with lower interest rates or longer repayment terms, offer an attractive option for climate-related projects by reducing financial burdens on governments or organizations, allowing more upfront capital to be dedicated to project planning.

50 European Investment Bank/European Commission, 2023. Investing in Nature-Based Solutions: State-of-play and way forward for public and private financial measures in Europe.

- **Green bonds** are debt instruments designated to fund projects with positive environmental impacts, often issued by municipalities, corporations, or governments. Issuing green bonds early on can draw the necessary capital to finance climate-aligned planning and design stages, such as renewable energy assessments or NBS for infrastructure projects.
- **Resilience Bonds** link insurance premiums to the resilience of projects and therefore provide a way to monetize avoided losses through a rebate structure. The resulting dividends can be used for other resilience activities, such as training infrastructure operators in NBS maintenance or other capacity building. For example, the European Bank for Reconstruction and Development recently issued the first ever climate resilience bond, which raised $700 million.
- **Other blended finance** involves combining public, philanthropic, and private capital, offering a way to leverage concessional finance to attract private investment toward climate-resilient infrastructure or adaptation projects.
- **Carbon market instruments, like carbon credits**, can also mobilize an additional revenue stream to improve the viability of climate-projects at project level. To be eligible, projects need to comply with applicable carbon crediting baseline methodologies (e.g. Clean Development Mechanism, Gold Standard, Verra) that proof that the anticipated GHG emissions following implementation of the PPP design lead to net emission reduction compared to the baseline. To conceptualize, develop and register a new project can take 6 months up to several years, depending on the standard or carbon credit buyer requirements, and therefore needs to be assessed early on in the PPP design. Carbon pricing or compliance schemes (ETS, carbon tax) can also serve as domestic revenue generation mechanisms e.g. under an emission trading scheme, auctioning revenues can be redistributed into national climate funds which can then offer these resources through grants or concessional loans into climate adaptation projects.

Recap

- A CRA is undertaken at the Project Appraisal Phase to provide the Public Partner with a comprehensive understanding of climate risks, how they might change in the future, and how they will impact (quantified direct and indirect losses, when possible) the project and its end users if no climate resilience and adaptation measures are implemented.
- Resilience options, including NBS, are identified, appraised through an economic analysis and compared against the no adaptation option. A VfM assessment and a financial analysis complete the process of selection and prioritization of the resilience options that will feed into the Tender and Award Phase. A mix of quantitative and qualitative methods is used to account for uncertainty in the decision-making process.
- Stakeholder engagement plays a key role in the development of the CRA and resilience options identification and appraisal.
- Climate finance instruments can complement PPP finance to bolster the implementation of resilience and adaptation measures.

Tender and Award Phase

4. Tender and Award Phase

Description: This Module will review typical PPP contract structuring and procurement processes and identify opportunities for embedding climate resilience requirements and measures. It will provide approaches and decision-making tools that PPP project planners and teams can use during the Tender and Award Phase to ensure that climate resilience is considered. This module covers the follwoing phases of a Public-Private Partnership (PPP) project:

- Pre-Tender Phase: Activities prior to the issuance of tender documents.
- Tender Phase: The period of bid submission and evaluation.

This module does not cover Engineering, Procurement, and Construction (EPC) tendering processes, as these vary significantly based on project-specific decisions made at that stage. However, some of the concepts presented here may be applicable to EPC contracts.

Learning outcomes: After reading this module, you will be able to:

- Discuss how climate resilience measures can be embedded in PPP contracts, including output-based performance requirements, monitoring system, and payment mechanisms.
- Discuss force majeure and uninsurability in the context of PPP contracts.
- Describe how to integrate climate resilience requirements in the tendering process, including bidders qualification, tender documentation and bid evaluation.
- Identify potential sources for climate finance and describe the application process.

The PPP Tender and Award phase involves the government selecting a private partner based on structured evaluation criteria. It includes defining project requirements, issuing tender documents, assessing bids, and finalizing contract terms. The process concludes when the government awards the contract, and the private partner secures financing to begin implementation.

Box 4.1 Private Partner vs EPC Contractor tender

A Private Partner tender differs from an EPC (Engineering, Procurement, and Construction) Contractor tender. While both tenders involve project delivery, a PPP tender focuses on selecting a private partner for the entire lifecycle of the project, from financing to operation, with an emphasis on long-term risk management and service delivery. In contrast, an EPC tender is limited to the design and construction phase, focusing more on technical specifications and timely, cost-effective delivery. Both types of tenders can include climate resilience and adaptation elements.

This phase is crucial for integrating climate resilience and adaptation, but several gaps persist. These include a lack of clear resilience criteria, inconsistent climate risk analysis, limited public sector capacity, and insufficient private sector incentives. Climate resilience is often not adequately addressed in the procurement process, leaving projects vulnerable to future climate impacts.

To bridge these gaps, both Public and Private Partners can play active roles. The Public Partner should integrate clear resilience requirements in the tender documentation, provide climate data, and balance the feasibility of resilience measures with project costs. Public Partners can also build internal capacity to evaluate climate resilience through training or hiring experts.

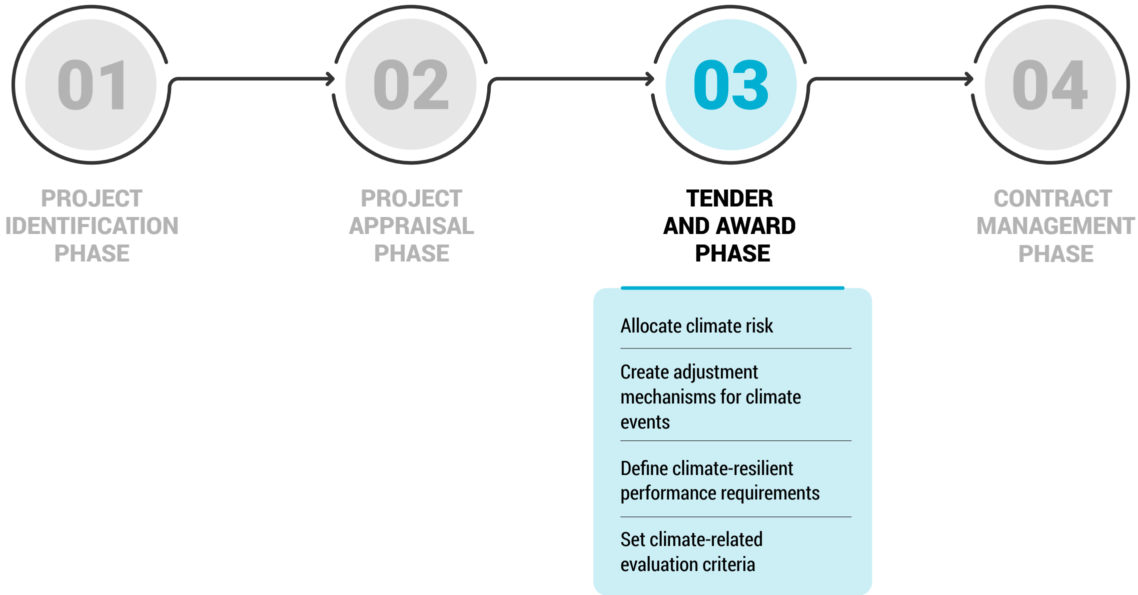
On the other hand, Private Partners have a role in proposing innovative, climate-adaptive solutions and engaging in transparent dialogue to align their proposals with public sector expectations. They can also demonstrate their commitment by showcasing past resilience projects and offering detailed climate resilience and adaptation measures in their bids.

Key entry points for integrating climate resilience include the pre-qualification stage, bid evaluation criteria, and contract design. At financial close, agreements should ensure funding for resilience throughout the asset's lifecycle. By addressing these gaps, PPP projects can deliver infrastructure that is sustainable and future-proof against climate risks.

Figure 4.1 below identifies entry points for integrating climate resilience and the stakeholders taking action at this stage.

The following sections provide several possible decision-making tools that PPP project planners and teams can use during the Tender and Award Phase to ensure that climate resilience is considered. For more details on PPP contract drafting and procurement processes, the reader is referred to documentation by the World Bank Public-Private Partnership Resource Center[51].

Figure 4.1 Key entry points for climate resilience in the Tender and Award Phase



4.1 Allocate climate risk

Risk allocation refers to deciding which party of the PPP contract will bear the cost or reap the benefits of a change in project outcomes arising from predefined risk factors. Allocating project risk efficiently is one of the main ways of achieving better VfM through PPPs. Risk allocation begins in the Project Appraisal Phase with a preliminary matrix identifying and proposing risk allocations, see **Box 4.2**. In the Tender and Award Phase, this allocation is finalized, detailing contractual instruments and agreements reached at financial closure. While CBA, VfM and risk allocation exercises during the Project Appraisal Phase aim to create a robust climate risk profile, the marketplace ultimately determines the commercial acceptability of these risks. This depends on tender requirements, as well as broader trends in policy, regulation, and consumer preferences. More on possible contractual options are included in the following sections. The business case provides the Public Partner with an informed position to present to the market, but adjustments may be needed during the Tender and Award Phase.

In PPP practice, risk allocation depends on the ability

51 World Bank, Public-Private Partnership Resource Center.

and willingness of entities to manage each risk.[52] Climate risk and associated resilience considerations present a particular nuance for risk allocation as new and more detailed information on future climate scenarios and impacts becomes available. Therefore, incorporating this uncertainty and flexibility into risk allocation in the contract is helpful to avoid activating dispute resolution mechanisms. It can be useful to distinguish between[53]:

- **Internal Climate Risks:** These are risks directly impacting on the project, such as physical damage or downtime for inspection and repairs, potentially caused by more frequent or severe climatic hazards. These risks should be allocated between public and private partners, with adaptation measures implemented to mitigate them.
- **External Climate Risks:** These risks, which may not yet be relevant, could emerge due to climate change, such as failures in interconnected infrastructure or socio-economic shifts affecting the project. External risks, including transition risks and climate-induced failures, often fall beyond the Public Partner's jurisdiction or the private partner's control, such as issues arising in a nearby catchment.

Box 4.2 Climate risk allocation matrix

Climate risks should be considered during the various phases and for different facets of the project. An example of a climate risk allocation matrix is presented in **Table 4.1**.[54]

Table 4.1 Climate risk allocation matrix examples

Risk Class	Risk Allocation	Relevant Risk Items and Rationale	Risk Mitigation Measures
Site selection	Shared	Unsuitable land	Detailed geotechnical, geological, and subsoil surveys, focused on parameters that may be affected by climate change.
Work delays	Private, Shared	Delays not caused by force majeure or non-compliance	Enforce construction deadlines, incl. extensions for specific events. Consider including a force majeure clause in the contract.
Changes in legislation	Shared	Loss or impact on the value of investments triggered by changes in policy frameworks.	Negotiate positive countermeasures to ambitious climate goals. Consider transition risk insurance.
Unavailability of insurance	Shared	Unavailability of insurance or prohibitively high premiums because of climate risk	Consider availability during the appraisal stage. If insurance is not available, the contracting authority may act as the insurer of last resort.

52 World Bank Institute/PPIAF, 2012. Public Private Partnership Reference Guide Version 1.0. Washington, DC.

53 World Bank, 2023. Climate Toolkits for Infrastructure PPPs.

54 Ibid.

Revenue risk (user-pays PPPs)	Shared	Internal climate risks caused by extreme but predictable events (exceeding the design limits of adaptation works)	The private partner needs to obtain and maintain insurance policies and consider purchasing weather derivatives.
Climate risk (government-pays PPPs)	Private	Internal climate risks caused by extreme but predictable events	Insurance coverage or guarantees from the Public Partner or MDB facilities, when insurance is not available.
Maintenance cost and standards	Private	Increased maintenance costs (beyond modeled costs), potentially exacerbated by climate change.	Output specifications described in detail in contractual provisions.
Adaptation works financing	Shared	Not meeting the financing requirements for the additional adaptation work	Include climate mitigation and resilience measures, ongoing maintenance requirements and CAPEx in design and construction. Consider climate contingency reserve.
Force majeure	Shared	Unprecedented events with potential extraordinary impacts on asset performance. Sometimes the definitions are omitted or loosely defined leading to uncertainty regarding the financial consequences for both the public and private partners	Narrow down the definition of force majeure events by specifying intensity levels and/or impact thresholds. Objective measurement of the event intensity.

4.2 Contractual options for integrating climate resilience

Even when climate risks are fully transferred to the Private Partner, the Public Partner may still bear significant risks. If the Private Partner underestimates climate risks and fails to invest adequately in resilience measures, the financial impact of extreme weather events could cripple the organization, potentially leading to operational failure or bankruptcy. In such cases, the Public Partner authority might need to provide financial relief or take over the assets. This scenario is plausible due to the inherent uncertainties of climate change. To reduce this risk, the Public Partner should require bidders to demonstrate the climate resilience of their technical proposals and thoroughly evaluate their adequacy during the Tender and Award Phase.

There are broadly two options that a public partner can take to reinforce climate resilience in infrastructure projects[55]:

Option 1: Transfer of Climate Risks to the Private Partner. This approach incentivizes private partners to invest in climate adaptation by making them responsible for associated risks. It is best suited for user-pays contracts, where the Private Partner is the economic owner, or in scenarios with low climate risk uncertainty. Proper insurance availability can support this model.

Option 2: Imposing Climate Resilience Requirements i. e. embedding climate resilience into project structure. Here, the Public Partner mandates specific climate resilience measures in design and operations, particularly in government-pays contracts or when climate risks are highly uncertain or uninsurable. This ensures that the infrastructure is built and maintained with climate resilience as a priority.

Figure 4.2 Contractual options for the reinforcement of climate resilience

Integration of climate resilience in PPP contract

1 Transfer of climate risk to contractor	**Provisions in PPP contract** • Definition and consequences of Force Majeure • Uninsurable risks • Contract variations	**Procurement process** Evaluation of climate resilience of technical proposal
2 Impose climate resilience requirements on design and performance	**Procurement process** • Minimal design specifications • Minimal performance requirements in maintenance and operations • Contract variations	**Procurement process** Evaluation of compliance of technical proposal with climate resilience requirements

These two approaches represent distinct strategies for enhancing climate resilience in PPP infrastructure projects: one indirect, the other direct. However, they are not mutually exclusive and can overlap. For example, in the first approach, the evaluation of bidders' climate adaptation plans may reference minimal specifications or requirements that proposals must meet, effectively aligning it with the direct approach. By combining these strategies, contracting authorities can promote robust climate resilience while maintaining flexibility to address evolving risks. Both options have implications for provisions in the PPP contract, as well as for the procurement process, as presented in **Table 4.2** below.

55 GCA, 2024. Reinforcing climate resilience in a PPP. Good practices and technical guidelines.

Table 4.2 Comparison of the contractual options.

Project-specific factor	Option 1 - Transfer of Climate Risks to the Private Partner	Option 2 - Imposing Climate Resilience Requirements
PPP Contract Type	User-pays contracts (e.g., toll road concessions), where private partners typically bear most force majeure risks, including climate risks are better suited to Option 1.	Option 2 is preferable for availability PPPs (e.g., DBFM contracts), where the Public Partner is the economic owner, force majeure risks are generally shared or borne by the authority. This approach provides greater assurance that that climate resilience is incorporated into the project design.
Uncertainty of Climate Risks and Adaptation Measures	Option 1 is better suited when there is uncertainty of climate risks is perceived as relatively low, or when the Private Partner is the economic owner of the asset and therefore incentivized to implement resilience and adaptation measures.	High uncertainty about climate risks or the effectiveness of adaptation measures favors Option 2. This approach ensures a baseline level of resilience, and mitigates risks for private partners, which can support financing under uncertain conditions
Contract adjustment mechanisms	Contract variations may be necessary as climate change evolves or more information about the extent of climate risks becomes available.	
Availability of insurance	If extreme weather events are adequately insurable without significant restrictions, Option 1 is more viable	If insurance options are limited, Option 2 becomes the preferable choice.
Force Majeure	Force Majeure needs to be defined, and it is informed by the level of understanding of climate risks and adaptation options examined in feasibility studies undertaken in the previous phases.	No exclusions from the standard definition of force majeure are necessary. Including all climate-related extreme weather events aligns with the direct imposition of climate resilience requirements in the project's output specifications.
Evaluation of proposals	The Public Partner should ensure the Private Partner's technical proposal is feasible and sound. The RfQ should require bidder to demonstrate experience in implementing climate resilience and adaptation in infrastructure projects and a climate resilience plan should be a requirement in the proposal.	The Public Partner must verify compliance with the minimum climate resilience requirements during the evaluation of technical proposals, similar to other technical criteria. This approach requires less climate change expertise in the evaluation team.

The following sections cover key components of the procurement process in greater detail.

4.3 Create adjustment mechanisms for climate events

Climate provisions included in payment mechanisms are an effective incentive for the Private Partner to embed climate risk management in the design, operation, and maintenance of an infrastructure project. These include:

- **Payment Adjustments:** Link payments to performance and service levels, ensuring the private partner meets climate resilience standards.
- **Penalties:** Impose consequences for failing to achieve performance targets, encouraging proper maintenance and adherence to technical designs.

The PPP contract should outline clear roles and responsibilities that will manage changes when these inevitably arise – including force majeure events. The contract should incorporate flexibility at the outset to anticipate the likely need for changes over the length of the agreement. For example, if a project team wanted to integrate adaptation pathways into the project approach, the trigger points would need to be established in the contract or be clearly stated in the contract if the trigger points are not yet known.

PPP contracts use variation and renegotiation mechanisms to manage unforeseen risks, such as pre-agreed cost adjustments or obligation changes, though these are often inadequate for long-term climate risks that arise during implementation. Regular updates to masterplans (e.g., every five years) help incorporate evolving climate scenarios and technologies, fostering resilience and influencing PPP project scopes. Change-in-law provisions protect private investors from added costs due to regulatory changes. Relief and compensation events address disruptions from pre-identified risks, offering time or financial relief to restore assets. Hand-back provisions promote whole-asset-life optimization, ensuring robust maintenance and long-term infrastructure performance.

Payment Adjustments

Climate capital expenditure should be incorporated early in the project. PPP contracts must provide clear funding and financing visibility to investors, serving as a de-risking mechanism to address climate change uncertainty. While over-investing in extreme scenarios may harm project bankability, under-investing risks undermining sustainability.

In **user-pays concessions,** users pay for access to services or infrastructure, with the government covering shortfalls up to a limit. Examples include energy and water systems, ports, and toll roads. These concessions distribute revenue and performance risks between public and private partners. Procurement contracts enable the public sector to incentivize climate risk mitigation by enhancing returns on investments. For instance, costs for mitigation measures may be deducted from the grantor's revenue share (e.g., toll payments) or included as a fixed element in the private partner's revenue, such as periodic fees or charges per user. However, these are ad hoc approaches ad the optimal solution will be project and context-specific and will need to be negotiated between the Public and Private Partner.

Penalties

Penalties are another tool for embedding climate resilience in payment mechanisms. While penalties are generally construed as punitive, they can actually benefit the private partner in several ways, such as by providing clarity and predictability on project risks, incentivizing operational efficiency, and improving reputation (for successfully avoiding penalties). Penalties also provide a framework for transferring risk to subcontractors or through insurance policies, whereas consistency in meeting performance targets (and avoiding penalties) may give the private partner goodwill in negotiations They should be included in the PPP contract to guard against insufficient maintenance or negligence to adopt relevant technical designs and maximize the environmental benefit of the project..

The following contract adjustment mechanisms are a good way to build flexibility in the contract:

Pre-specified and pre-priced contract variations for resilience measures. When a PPP feasibility study identifies resilience measures that are currently cost-inefficient but may become necessary later, these can be included as pre-defined variations in the contract. Bidders would quote a price for these measures, which would be incorporated into the contract. The contract would also outline triggers, procedures, and cost-benefit allocations for implementing the variations. This allows for faster implementation when additional resilience is needed, with updates to specifications and pricing as necessary.

Contingency Funds for Climate Risks. A climate contingency account (CCA), modeled after maintenance reserve accounts (MRA), provides funds for unexpected climate resilience investments. Like MRAs, CCAs use cash reserves or credit lines to cover climate-related costs, ensuring quick access to funding when needed. If pre-defined adaptation measures are included in the contract, their estimated costs can guide the CCA's value and funding. Maintaining a CCA incurs costs, as cash reserves increase capital requirements, and credit facilities carry fees. The benefits of having accessible funding must be weighed against these costs, but a well-structured CCA can ensure efficient climate risk management.

Define an approach to supervening events

Climate shocks and stresses have traditionally been considered force majeure events, and thus beyond the control of all PPP parties. However, infrastructure operators need to plan for these shocks and stresses and thus it is no longer acceptable for all climate shocks to be blindly characterized as force majeure. Several mechanisms have been developed to deal with these supervening events. Most jurisdictions have adopted a three-tiered approach to these events, as noted in **Table 4.3**.

Table 4.3 Three-tiered approach to supervening events

Supervening events	Description
Compensation Events	Events for which the Public Partner takes the risk. The Public Partner pays compensation to the Private Partner and gives any other form of contractual relief required to leave the private partner in the position that it was in before the relevant Compensation Event occurred ('no better, no worse').
Relief Events	Also called delay events if they occur during the construction phase. These are events for which the Private Partner is expected to take financial risk but is given relief from other consequences of non-performance that such events cause. These are, by nature, events that are either insurable or not expected to continue for many days.
Force Majeure Events	Events beyond the control of the parties that render the performance of all, or a material part, of one party's obligations impossible. The definition often focuses on events that are uninsurable, outside of the control of either party or are catastrophic in nature. Each party will typically bear its own consequences of a Force Majeure Event.

Source: IDB. 2020. Climate-resilient Public Private Partnerships: A Toolkit for Decision Makers. Washington, D.C

Force majeure

Defining force majeure events creates a risk transfer threshold. Therefore, setting the bar too high and excluding climate risks from the force majeure definition will likely result in decreased interest from prospective bidders if the increased risk ownership is too high. Force majeure expectations should be reasonable, and exclusions to the definition must strike the right balance in sharing climate risk between the Public and Private Partners.

Most, if not all extreme weather events will likely qualify as force majeure under this definition. Many PPP agreements include an open-ended catch-all definition of 'force majeure events'. If a CRA identifies climate-related risks with a high likelihood of occurrence, the project team should determine whether they can be excluded from the definition of force majeure or may only be included if qualified. Even if climate risks do qualify as force majeure, compliance with a (climate) risk mitigation plan should still be enforced in the PPP agreement, see **Box 4.3**.

A force majeure clause addresses these issues in several ways:

- It provides relief from liability to the affected party and excuses it from further performance of its obligations under the PPP contract while a force majeure event is ongoing.
- It specifies the obligations of the parties in relation to a force majeure event (typically, information and mitigation).
- It provides for termination rights if a force majeure event lasts more than a certain period of time. It specifies the allocation of costs resulting from a force majeure event and determines termination payments.

Force majeure clauses should be tailored in regions with known vulnerability to specific climate risks (e.g. prone to hurricanes) and should be more specific about hazards which may be considered force majeure according to their level of risk, see **Box 4.4.** In addition, force majeure clauses could be focused on the speed of onset and warning time available to mitigate the impact of hazards, as well as the relative cost of such actions, rather than on the speed of onset and warning time of preventing the occurrence of the hazard itself.

Box 4.3 How to Guidance – Defining Force Majeure in the context of climate change

What to include in the definition? Events associated with weather risk that cannot be foreseen and managed by the concessionaire. Qualifying weather risk events: Where certain natural or climate change- related events occur regularly (such as seasonal rains that result in flooding) and should have been part of the concessionaire's due diligence, the degree of such events should be specified so that only "exceptional" occurrences qualify as force majeure. For example, floods of a magnitude that do not occur more frequently than once every [100] years or earthquakes above a specified seismic intensity.

What should be excluded from the definition? Failure to comply with the risk mitigation plan prescribed by the agency or prepared by the developer and included in the PPP agreement

Guiding questions:

1. Does the Public Partner have the contractual freedom under the law governing the PPP to: (i) define the concept of force majeure; (ii) specify its consequences?

2. Does the Public Partner follow an open approach to define force majeure?

3. Does the Public Partner follow an approach to defining force majeure that includes an exhaustive list of specific events or circumstances?

4. Did the results of the climate risk assessment performed during the Project Appraisal Phase identify any climate risks with a high probability of occurrence?

Source: Inter-American Development Bank (IDB), 2024. Resilient public - private partnerships a regional and multi-sectoral toolkit from preparation to sustainable project financing

Box 4.3 Extreme weather events in PPP force majeure clauses in Japan

In Japan, the definition of force majeure in PPP contracts is informed by previous natural disasters. For example, in a toll road project, additional costs of force majeure events may only be borne by the government if resulting from heavy rains over a certain threshold per hour or 24-hour period or from certain wind speeds, and if the disaster recovery project fulfills legal requirements. Experience in Japan has also indicated that sharing risk between the public and private sector makes disaster response and recovery more efficient than if the public sector were solely responsible.

Source: International Bank for Reconstruction/World Bank, 2019. Guidance on PPP Contractual Provisions. Washington D.C.

Insurance and uninsurability

Climate-related extreme weather events must be included in the insurance package mandated by the PPP contract, a common practice today. If adequate insurance for such risks is available, the Private Partner can assume responsibility for these risks. This can be achieved by either excluding them from the force majeure definition or stipulating that damages and revenue losses from such events are fully borne by the Private Partner.[56]

The Private Partner is responsible for securing appropriate insurance to safeguard its investment, which is also a requirement from financiers as part of their due diligence process. Additionally, most PPP contracts specify the minimum insurance package the Private Partner must maintain, see **Box 4.4**.

Box 4.4 Catastrophe insurance in Chile

PPP regulations in Chile require catastrophic risks to be covered by insurance, thus inadvertently allocating most of the risk for significant earthquakes to the private sector. This led to significant costs of infrastructure damage caused by frequent earthquakes in the 1980s. The country mitigated that effect by exempting earthquakes from force majeure clauses. The majority of Chile's road network was developed using PPPs, thus requiring private partners to bear insurance. The result was that any damage to PPP-built roads from the 2010 Mw~8.8 earthquake, with infrastructure losses totaling $21 million, had almost no fiscal impact.

However, climate change is already challenging the statistical assumptions underlying insurance calculations. The rising frequency of extreme weather events increases the cost of insurable claims as well, resulting in some hazards being already uninsurable. In other words, there may be instances where it is not possible for the Private Partner to find the relevant insurance in which case the Public Partner can purchase the insurance in lieu of the Private Partner and/or be allocated the risk.

Insurance transfers cover risks to third-party insurers. In PPPs, insurance provides significant value by way of third-party due diligence, while instilling disciplined risk-management practices to meet insurers' required standards. Additionally, innovative risk-management tools and products (e.g., weather index-based instruments) are also constantly being developed. In principle, the level of insurance coverage is a trade-off between the expectations of the public sector (aligned with the lenders) for maximum asset protection and affordability, and the expectations of the private sector to optimize coverage with respect to availability and competitiveness.

The insurance industry is actively trying to stay ahead of the curve with regards to responding to climate change-related disasters, though there is

56 GCA, 2024. Reinforcing climate resilience in a PPP. Good practices and technical guidelines.

a chance given the long length of a PPP contract that a particular climate-related event becomes 'uninsurable' at some point over the contract's life.

Uninsurability arises when insurance is unavailable, unaffordable, or unsuitable for a specific risk. This does not mean insurance is entirely absent but indicates that it is either not offered by reputable insurers with adequate credit ratings or that premiums are prohibitively high—not merely expensive. In such cases, the public sector typically acts as the "insurer of last resort," or, less commonly, the private sector retains the risk but demands higher returns.

Ultimately, uninsurable risks are best managed by the Public Partner, as they are uniquely positioned to address them. PPP contracts should include procedures for handling uninsurable climate risks, such as assessing whether additional resilience measures could restore insurability. If such measures are viable but require funding, a contract variation must be negotiated to cover the associated costs.

Establish dispute-resolution mechanisms

As in any complex contract, especially those of a long-term nature, it is not possible to foresee every event that may affect a PPP contract. Changes will happen and this can often lead to disputes. It is expected that such disputes will be more and more triggered by extreme climate events and thus it is necessary to include specific provisions in the contract regarding dispute settlement. This should include a Dispute Resolution Process (DRP), a Dispute Resolution Board (DRB) and an arbitration clause. For climate-related disputes, designating climate experts as mediators, board members or arbitrators could help reach an agreement, or provide recommendations to resolve such disputes.

Making Decisions Under Uncertainty

A well-designed PPP contract provides clarity, certainty, and flexibility for all parties. However, changes are inevitable due to long time frames and evolving conditions. Climate change adds further uncertainty, whether from unforeseen conditions or advancements in technology that improve resilience. Acute climate events may also require rapid adaptation of infrastructure and operations.

The goal of PPP contracts is to balance certainty with flexibility, ensuring clarity while minimizing uncertainty. This involves establishing clear processes and boundaries for change. A practical approach is to include provisions for periodic reviews — every 5 or 10 years — allowing parties to revisit and adjust requirements impacted by climate change through mutual agreement.

Stakeholder Engagement

Managing long-term climate risks requires collaboration between public and private sectors in joint decision-making. Flexibility should be built into all stages, from project selection to contract management, supported by incentive structures that align interests.

Strategic partnerships with stakeholders from insurance, engineering, and climate science are essential. These partnerships should emphasize transparency, cost-effectiveness, and solutions that address technical, financial, legal, and institutional challenges.

Define climate-resilience performance requirements

Performance requirements define the contractual output, construction standards, and service levels for the operational phase. They serve as benchmarks for measuring performance, typically through key performance indicators (KPIs). KPIs track goal achievements and enable year-on-year progress. KPIs should be SMART (Specific, Measurable, Achievable, Relevant, Time-bound) and unambiguous. The contract must define calculation and onsite measurement methods. To prevent disputes, KPIs should be within the Private Partner's control. As they impact costs (penalties or additional funding), they must be clearly described. KPI descriptions should outline data collection, processing, reporting, verification, and how payment deductions will be applied for non-compliance.

Public Partners use performance contracts to ensure private partners meet agreed standards, with payments tied to compliance. The following sections explore how climate resilience should be integrated into these requirements, focusing on service continuity, output specifications, technical standards, and resilience monitoring.

1

Service continuity

The goal of infrastructure assets is to provide their intended services. Occasional disruptions are expected, so redundancies should allow temporary service continuity, such as alternate routes during bridge repairs. Private partners can enhance service levels and resilience through proactive climate risk management, integrating requirements like early warning systems and disaster recovery measures. Service continuity also depends on the asset's criticality, network redundancies, repair time, and communication support, such as public alerts or private updates. Service Standards Performance Metrics (or KPIs) and Targets should be climate-informed and reflect the ability of the infrastructure to withstand and recover from climate-related events. This ensures that the infrastructure meets service standards even as climate risks evolve.

Two sets of Service Level Standards can be distinguished:

- **Service Level Standards that apply in normal circumstances.** These include the occurrence of climate-related weather events that fall outside the definition of force majeure. While specific climate indicators might not be required, climate change may have a significant impact on the efforts needed to achieve the service level standard. The Private Partner must take this into account when preparing the maintenance plan and in the estimation of maintenance costs.
- **Service Level Standards that apply in exceptional circumstances**, including severe climate-related weather events that fall within the definition of force majeure. These service requirements relate to road availability, emergency response and recovery times after the occurrence of the event. Expecting private partners to meet all KPIs during extreme events might be unreasonable, as maintaining response and recovery capabilities can increase costs. PPP contracts typically define minimum performance requirements for emergency response and recovery, which are standard but increasingly critical due to the growing frequency and severity of climate-related disasters.

Output specifications

When the approach of imposing climate resilience requirements is adopted (see Option 2 in previous sections), these requirements are directly specified by the contracting authority in the output specifications, which are included in the RFP and later incorporated into the PPP contract, typically as a technical annex.

A clear distinction is made between design/construction specifications and maintenance/operational specifications[57]:

57 GCA, 2024. Reinforcing climate resilience in a PPP. Good practices and technical guidelines.

- **Design/Construction Specifications.** These focus on the infrastructure and the integration of resilience features. There are two ways to define such specifications. The first involves specifying the maximum severity of extreme events the infrastructure must withstand, leaving the choice of design features to the Private Partner. It is essential that design specifications align with the definition of force majeure. For instance, the threshold for severe weather events classified as force majeure should also define the minimum requirements for infrastructure resilience. This ensures the infrastructure can withstand any event below the force majeure threshold. Alternatively, resilience features could be specified, for instance a minimum level of elevation of earthworks or the discharge capacity of culverts and drainage channels.
- **Maintenance/operational specifications** relate to the preparedness and response when extreme weather event outside the design specifications occurs. The output specifications prescribe the minimum performance in terms of availability and recovery time in relation to a hazard of a specified intensity. For example, 'in the case of heavy rain of 80mm in 24, 50% of the network must be available and recovery time to 90% of functionality within 48 hours'.

2 Design standards, including environmental and social safeguards

The Public Partner has the opportunity to specify in the contract documents clear design standards or safeguards that the project should meet for increased resilience. Nevertheless, overly **prescriptive** standards may prevent the Private Partner from coming up with innovative solutions to climate adaptation problems. Contracting authorities are advised to consider climate resilience measures which may require deviations from standards or adopting techniques, which may not be included in the standards and norms of the project country but are proven elsewhere. Furthermore, prescriptive standards may be counterproductive in output-based contracts, which are typically based on performance. The latter is a common misconception of contracting authorities. Yet, in such designs, the public sector assumes all the risk of any failures in design, all while paying the higher price of upgraded design requirements.

Each country will have specific engineering, construction and built environment standards, codes, rating systems and best practice guidance. Many standards rely on historical trends rather than future scenarios, and climate change integration is lagging. However, resilience is becoming more common in design codes, financial reporting, and due diligence. For instance, Scotland's flood risk assessments now include climate change projections[58], and Canada's PIEVC Protocol[59] helps assess infrastructure components needing adaptation.

Procuring authorities play a key role in embedding these standards during procurement or contract terms by engaging climate and infrastructure experts to define project-specific requirements. Public Partners can require private partners to meet predefined resilience standards (see **Box 4.5**), making compliance mandatory for bids. Clear resilience benchmarks, even exceeding statutory requirements, should be articulated in contracts. Environmental and social safeguards must be included alongside resilience in PPPs, with infrastructure delivering broader social and environmental co-benefits.

58 Scottish Environment Protection Agency, 2023.

59 Institute for Catastrophic Loss Reduction, 2024. PIEVC Engineering Protocol.

Box 4.5 Example of standards, certifications or ratings for resilience

ISO 1409x series. The climate adaptation standards series was published by the International Standardisation Organisation in 2019. It encompasses four standards which, collectively, offer a consistent, structured and pragmatic approach for organizations to address climate adaptation. The standards apply to any organization, regardless of size, type and nature, including local, regional and international businesses and administrations.

National Building Code of Canada (NBCC). The 2025 editions of the National Building Code of Canada and the Canadian Highway Bridge Design Code (CHBDC) both include considerations of future climate scenarios, linked to degrees of global warming based on climate projections.

Envision. Envision is a third-party rating system that identifies clear requirements of sustainable infrastructure and incentivizes higher performance beyond minimum requirements. The system uses 64 sustainability and resilience indicators organized around the following categories: climate and resilience, natural world, resource allocation, leadership and quality of life.

3 Monitoring and evaluation, including co-benefitsWhile continuity of service of the infrastructure asset itself is critical to the performance requirements, the indirect benefits of climate-resilient infrastructure should also be clearly identified by the private partner and assessed regularly throughout the operation and maintenance of the asset. The Private Partner should indicate and undertake a clear monitoring, evaluation and reporting plan to ensure continuity of quality service and report back on the trends in co-benefits, including a data collection protocol. This could potentially serve other subnational, national, or supranational goals by providing centralized data on resilience indicators (e.g., contributions to carbon reduction or disaster risk reduction plans).

Procurement strategy options

The procurement strategy determines how the private sector partner will be selected and aims to achieve the best value for money (VfM). When alternatives are legally feasible, the project team should develop a strategy that creates the right incentives for all stakeholders. The Public Partner must first decide the procurement approach to use. Options include open tender, restricted procedure, negotiated process, and dialogue or interaction process.

The dialogue process is particularly useful for climate-resilient projects, as it allows for discussion and refinement of the Request for Proposal (RfP). While it requires more planning, this strategy is ideal for complex projects with multiple potential solutions. In this process, bidders are qualified based on specific criteria and engage in dialogue with the Public Partner before submitting a final proposal.

Two-step procurement processes are becoming standard in PPPs, consisting of a Request for Qualifications (RfQ) and a Request for Proposals (RfP). This section discusses options for embedding climate resilience in both the RfQ and RfP phases of infrastructure PPPs.

Request for Qualifications

The RfQ is the first step of the procurement process. It is a pre-qualification stage, which is intended to allow the contracting authority to evaluate and select candidates that are most capable of meeting the objectives during the project's lifecycle. By issuing a RfQ, a contracting authority:

- Affirms the significance of the PPP project
- Publicizes information about the PPP project and the services/infrastructure that it requires

- Provides information about the timeline of the tender and qualification criteria
- Creates a framework for evaluating candidates and selecting the one most capable of meeting the objectives during the project's lifecycle.

RfQs are formal processes in which potential bidders are required to provide information to a contracting authority, based on which contracting authorities determine whether they have the capacity required to bid. Contracting authorities typically request information about potential bidding consortia's project management capabilities (such as the roles of key personnel, expected advisors, and references), technical capabilities (such as subject matter expertise and experience, including in comparable projects), and financial capability (financial stability and the ability to raise financing).

RfQs are an opportunity to embed climate resilience early in the PPP lifecycle, by adding resilience-related criteria. The RfQ should ensure that prospective bidders possess the right capabilities and experience in implementing climate resilience and adaptation measures. Depending on the vulnerability of the asset, climate resilience may have a greater weighting in the evaluation.

Setting relevant qualification standards for bidders in another key entry point to ensure that climate resilience is integrated in the project, see **Box 4.6**.

Box 4.6 Required technical capabilities for the Private Partner

The contracting authority must ensure that the Private Partner has available technical capacity to bring to the project. The private partner should be in a position to demonstrate a climate resilience team with the following skillsets:

- Climate risk assessment
- Design and implementation of hazard mitigation plans and activities
- Engineering economic analysis and financial modeling, preferably in the context of climate risks and resilience
- Environmental asset economic modeling and assessment
- Environmental impact assessment
- Critical infrastructure resilience planning
- Engineering design, based on the type of infrastructure project (e.g. transportation, water).

Such criteria may be evaluated using pass/fail rating, ranking, or both. **Table 4.5** below outlines some of the most common climate resilience criteria used in RfQs and the most appropriate evaluation method.

Table 4.5 RfQ evaluation criteria and methods

Criterion	Pass/Fail	Ranking
Key personnel with the relevant mix of climate resilience expertise	Yes	
References from previous clients regarding projects related to climate resilience	Yes	
Subject matter expertise regarding infrastructure climate resilience	Yes	Yes
Experience in managing and implementing infrastructure resilience PPPs	Yes	Yes
Financial strength to implement the PPP throughout its lifecycle	Yes	
Ability to raise financing as required by the PPP structure	Yes	
Preliminary proposal: quality of CRA, NBS, gender considerations.		Yes

Pass/fail ratings are based on some minimum standard: any firm or consortium which meets or exceeds that minimum standard is qualified. Ranking is based on some qualitative scale and is used to create a shortlist of bidders, for example. In practice, contracting authorities typically use a combination of criteria, with a combination of pass/fail assessment and ranking, see **Box 4.7** below.

Box 4.7 Example of how to evaluate climate-resilient criteria using different methods

Pass/fail rating system: Sufficient experience managing projects with a similar climate profile.

Ranking: Extent of past experience with a similar climate risk profile and the design and implementation of effective mitigation measures. Evaluated using a 100-point scale.

Pass/fail and ranking: Extent of past experience with a similar climate risk profile and the design and implementation of effective mitigation measures. Evaluated using a 100-point scale, and RfQ applicants must receive a passing score of 70 points to qualify under this criterion.

Request for Proposals

The RfP is the second stage in a two-step procurement process and may be the only constituent of a single-stage process. Key activities at RfP stage are shown on **Figure 4.3**. The RfP is the key document in the PPP procurement process. It should specify:

- What documents bidders must produce regarding their technical and financial proposals
- What information they shall give concerning their own organization for the project and its set of internal agreements
- What guarantees they shall present with their bids
- What mechanism will apply for exchanging information between the contracting authority and the bidders during the tender
- How long the procurement and selection procedure will last
- Which criteria will be used to assess their proposals

The RfP offers unique opportunities for embedding climate resilience in the PPP procurement process. Its particular value lies in that it is a legally binding document. Contracting authorities may include minimum requirements for achieving climate resilience objectives through the PPP contract or add a certain number of evaluation criteria related to climate resilience, see **Table 4.6** and **Box 4.8**.

Figure 4.3 Key activities at the RfP stage

1 Prepare and issue the RFP
- Draft and review
- Develop evaluation criteria
- Obtain necessary approvals

2 Run RFP process
- Hold information meetings
- Respond to questions

3 Evaluate RFP submissions
- Receive RFP submissions
- Evaluate responsiveness and robustness
- Rank technical and financial proposals
- Select preferred bidder

Table 4.6 Approaches for embedding climate resilience in the RfP

	Minimum requirements	Evaluation criteria
Example	Demonstrate sufficient financial and technical capacity to develop innovative low-carbon solutions and to respond to extreme climate events.	Points awarded to bids that include innovative efforts related to greenhouse gas reduction or climate risk management.
When to use	• The Contracting Authority has a good understanding of its requirements in terms of climate resilience. • Procurement and/or Contract Management.	The Contracting Authority wants bidders to differentiate on climate resilience.
Required for use	The Contracting Authority has the expertise to set requirements.	The Contracting Authority has the expertise to evaluate climate resilience approaches.

Box 4.8 Climate resilience criteria to include in an RfP

The following is a list of potential climate resilience criteria to include in an RfP:

1. Minimum qualifying criteria that require potential bidders to:

- **a.** Demonstrate sufficient financial and technical capacity to develop innovative low-carbon solutions and to respond to disaster events
- **b.** Provide evidence for sufficient knowledge to identify and assess carbon impacts, low-carbon solutions as well as climate change events (e.g. experience in the construction of 'green' buildings as demonstrated by relevant certifications)
- **c.** Prove sufficient insurance coverage with regard to potential climate-related risks
- **d.** Submit appropriate environmental (and social) management plans as well as disaster prevention and risk response plans.

2. Technical specifications on better lifecycle performance, including reducing greenhouse gas emissions and mitigating identified climate change risks

3. Bid evaluation criteria that is not solely based on price, but that also assesses bidders' low-carbon performance and competence to address climate change (for example with additional points given to bids that include innovative efforts related to greenhouse gas reduction or disaster risk management).

Source: World Bank, 2024. Preparing, Procuring and Implementing Climate-Smart PPPs.

4.4 Set climate-related bid evaluation criteria

Evaluating bids based solely on financial criteria may overlook the complexities of PPP projects. Combining financial and technical criteria better captures the concept of maximizing VfM. Using 'best value' criteria allows contracting authorities to achieve various objectives and enables bidders to differentiate themselves beyond price. However, defining appropriate, quantitative criteria and their weightings can be challenging. Even if the evaluation is not purely technical, it is essential to ensure the proposed technical solution is feasible, deliverable, meets minimum requirements, and aligns with the financial structure. The choice of evaluation and scoring criteria for alternative bids is a key consideration, as discussed in the next section.

Evaluation criteria significantly influence the market's willingness to submit bids. For transparency, the RfP should define each criterion and explain the main factors considered when assessing sub-criteria. The evaluation should assess how well the private partner understands the project objectives and performance requirements, and their technical capacity to meet them. Since PPPs focus on performance, the technical requirements in the RfP should be output-based, emphasizing service quality through KPIs, rather than prescribing specific inputs or activities. The technical proposal evaluation should focus on whether the bidder's proposed methods meet the minimum requirements of the RfP and contribute to the quality and reliability of the service output.

The Public Partner can choose whether to specify resilience options that bidders must include in the project design. While this decision is context-specific, it is generally recommended to allow bidders to propose resilience options, leveraging private sector innovation and facilitating comparisons across bids.

The financial package is sometimes evaluated for its reliability, including the equity investor's commitment, financing availability, and the robustness of the project finance structure. In staged evaluations, it can be challenging to assess the financial package without knowing the reliability of the financial structure or inferring the price. Bidders should be instructed not to disclose the overall price in their financial package documentation.

In some jurisdictions, the technical and financial criteria are evaluated sequentially, with the financial (price) evaluation occurring only after the technical evaluation is complete. This approach, common in the EU, is recommended for climate-resilient infrastructure, as the long-term public value and societal returns often outweigh the initial investment costs.

To ensure clarity in the evaluation process, each technical and quality criterion should be assigned a specific weight in the overall scoring. For certain projects, additional weight may be given to sub-criteria to provide further clarity on evaluation priorities (see **Tables 4.7** and **4.8**).

Nature-based Solutions

Integrating NBS at the early stages of decision-making for infrastructure projects is crucial, particularly in the planning and procurement processes. Including NBS in procurement documents, such as invitations to tender and contracts, can encourage project developers, funders, and insurers to gain the necessary expertise to secure contracts and deliver projects that comply with policies. An example criterion for an RfP might be: 'demonstrate prior experience in NBS and Ecosystem-based adaptation design.'

During the tender phase, bidders should be asked to consider using NBS for addressing climate and environmental challenges in their project plans, tenders can even include specific criteria that require bidders to incorporate NBS in their project proposals. While NBS might not be suitable or possible in every situation, making it a standard requirement to evaluate NBS during project development will help demonstrate their feasibility compared to other options and encourage their use.

Source: Watkins, G., Silva, M., Rycerz, A., Dawkins, K., Firth, J., Kapos, V., Canevari, L., Dickson, B. and Amin, A.-L., 2019. Nature-based Solutions: Scaling Private Sector Uptake for Climate Resilient Infrastructure in Latin America and the Caribbean. Inter-American Development Bank.

Table 4.7 Example bid criteria with weightings – climate resilience as a separate criterion

Criteria category	Category weight	Criteria	Sub-criteria	Weight
Financial	50%		• NPV of payment	50%
Technical	20%	Construction	• Quality of project design • Flexibility of construction term • Quality of assurance methods	9% 6.5% 4.5%
	10%	Operations	• Quality of operating procedures • Commitment of means	6% 4.0%
	10%	Maintenance	• Quality of proposed maintenance methods	10%
	5%	Environmental & Social	• Thoroughness of Environmental and Social Management Plan (ESMP)	5%
	5%	Climate resilience	• Quality of climate risk adaptation plan	5%

Table 4.8 Example bid criteria with weightings – climate resilience as a sub-criterion

Criteria category	Category weight	Criteria	Sub-criteria	Weight
Financial	50%		• NPV of payment	
Technical	20%	Construction	• Quality of project design, including consideration of climate risks, exposure and vulnerability • Flexibility of construction term • Quality of assurance methods, including consideration of climate risks	8.5% 7.0% 4.5%
	10%	Operations	• Quality of operating procedures, including consideration of climate risks and adaptation • Commitment of means	6.5% 3.5%
	10%	Maintenance	• Quality of proposed maintenance methods, including consideration of climate risks	10%
	10%	Environmental & Social	• Thoroughness of ESMP, including evidence that climate risks are considered in the plan	10%

Including gender-sensitive considerations

The evaluation of RfQs and RfPs can be done with gender inclusion in mind. Bidders' expertise regarding gender inclusion, previous experience in building gender-responsive infrastructure and their plans to address gender issues should be a key indicator of the qualification of bidders to have the contract. Additionally, in awarding the contract, the evaluation panel should include clauses which detail gender provisions, define penalties for non-compliance with gender equity commitments and even include incentives for exceeding gender-related performance targets. The evaluation and selection of bids should be done with similar transparency in the Project Appraisal Phase. This transparency should be enforced throughout the project lifecycle and can include a requirement for bidders to continuously track and report on gender-related performance indicators[60]. Moreover, it is in this phase that the foundation for gender responsiveness can be set – establishing adjustment mechanisms that ensure protection measures and prioritization for women are in place and effective.

Case Study - Safeguards in PPP. Mainstreaming environmental displacement, social and gender concerns in Madhya Pradesh Urban Development Project, India

This project, funded by the World Bank, aims to improve urban infrastructure services in various cities across Madhya Pradesh. It includes climate-resilient interventions like stormwater drainage systems, water supply networks, and urban mobility solutions. The project integrates a gender-responsive approach by addressing the specific needs of women and vulnerable groups throughout its design and implementation phases:

- Inclusive Urban Planning – Women were involved in consultations during the planning phase to ensure their concerns were addressed. This led to the prioritization of areas like improved street lighting and sanitation, which are crucial for women's safety and well-being.
- Employment and Training Opportunities – The project included training programs specifically targeting women for employment in the construction and maintenance of urban infrastructure, thereby promoting gender equity in traditionally male-dominated sectors.
- Improved Mobility and Accessibility - The project focused on enhancing public transportation and pedestrian pathways, making them more accessible for women, children, and the elderly. This has helped reduce travel time and increase access to economic opportunities for women.
- Climate Resilience for Women – By improving infrastructure like drainage systems and water supply, the project reduces the time women spend collecting water or managing household disruptions during floods, enhancing their resilience to climate-related shocks.

Source: World Bank, 2017. India - Madhya Pradesh Urban Development Project (English).

Post-Tender Award Phase

This phase begins with the selection of a preferred bidder and concludes with financial close. Key activities include finalizing the PPP agreement and all related contracts (e.g., financing agreements, construction subcontracts). The following factors fundamentally influence the final contract's content, including its climate resilience provisions:

- The project's specific requirements.
- The chosen procurement methodology.
- The selected PPP structure (e.g., BOT, DBFO).
- The results of the tender evaluation.
- Negotiations with the preferred bidder. The requirements of lenders and investors.

60 World Bank, 2024. Applying a Gender Lens throughout the PPP Project Cycle.

This process ensures the contract clearly defines performance obligations, risk allocation, payment mechanisms, and mechanisms for addressing unforeseen events, including those related to climate change. Due to the wide array of potential climate risks and adaptation measures, a complete listing of all possible contractual provisions is beyond the scope of this module. However, the principles already presented in this module should provide a framework to define and integrate appropriate provisions based on project-specific needs and risks.

Mobilizing Climate Finance

Developing countries continue to grapple with challenges in effectively accessing climate finance to support resilience efforts. A number of international climate funding opportunities exist, and they can be helpful to complement financing and funding arrangements of PPP projects and ensure that climate resilience and adaptation efforts are adequately funded. Countries and eligible institutions need to understand procedures, policies and requirements of the various climate funds (see **Table 4.9**).[61]

The need to mobilize climate finance can materialize at different stages of the PPP project lifecycle. For example, at the Tender and Award phase, new adaptation measures can be identified by the Private Partner requiring additional CapEx. A need for additional adaptation interventions might also become apparent during the Contract Management Stage, which can span over decades and is most affected by climate uncertainty. As some of these climate funds expect a level of co-funding, there might be an opportunity for blended finance solutions.

A climate finance screening is the first step in the project development process to determine whether a project or program is eligible for climate finance. Although the private partner or investor will ultimately seek funding to implement the project, this kind of analysis will help explore the project's eligibility for innovative climate financing sources and trigger the inclusion of provisions in the PPP contract structure to make the project more attractive to such financing sources. Questions to determine if an intervention is eligible for climate finance (adaptation) include:

1. Does the project have an adaptation focus?
2. Will the project result in measurable adaptation impacts?
3. Is financing required for the incremental cost* associated with addressing climate change?
    a. if requested for incremental cost: Potentially eligible for finance from dedicated climate change funds (potential sources include GCF, AF, GEF, CIF– see table below) and other sources of climate finance
    b. if not requested for incremental cost: Potentially ineligible for finance from dedicated climate change funds. The project may be eligible for funding from other climate finance providers, such as multilateral development banks and bilateral donors.

(*) cost of capital of the incremental investment and change of operation and maintenance costs for a mitigation or adaptation project in comparison to a reference project (IPCC, 2014)[62]

Different climate finance sources take different approaches to servicing incremental costs. The GCF, for example, funds the whole or part of the incremental costs of a funded activity, while other costs must be co-financed by other sources. When sufficient data and capacity are available, quantitative estimates of incremental costs should be developed as part of the economic analysis, which forecasts the costs and benefits of the proposed project over its estimated economic lifetime in scenarios that compare the baseline costs and benefits of the project with and without climate considerations.

61 Commonwealth Secretariat, 2022. Toolkit to Enhance Access to Climate Finance A Commonwealth Practical Guide .

62 Intergovernmental Panel on Climate Change (IPCC), 2014. Climate Change 2014: AR5 Synthesis Report. Geneva.

Table 4.9 - List of main climate finance sources [63]

Climate Finance Source	Description	Focus	Financing Instruments
Green Climate Fund (GCF)	The mandate of the GCF is to promote a paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and adapt to the impacts of climate change, taking into account the needs of those developing countries particularly vulnerable to the adverse effects of climate change.	Mitigation, adaptation and cross-cutting activities	Grants, concessional loans, equity, guarantees Co-financing not required
Adaptation Fund (AF)	The AF was established to finance concrete adaptation projects and programs in developing countries that are Parties to the Kyoto Protocol and are particularly vulnerable to the adverse effects of climate change. It predominantly supports food security, agriculture, water management and disaster risk reduction projects for the promotion of community resilience.	Adaptation	Grants, co-financing not required
Climate Investment Funds (CIF)	The CIF comprises two multi-donor trust funds: (i) the Clean Technology Fund (CTF); and (ii) the Strategic Climate Fund (SCF). CIF's resources are disbursed through MDBs to recipient countries as assistance and advisory services for public and private sector operations, often through non-reimbursable grants; and as investments, deployed through a variety of financial instruments.	Mitigation, adaptation and cross-cutting activities	Grants, contingent grants, concessional loans, market-rate loans, equity, guarantees Investments should leverage additional financial resources, including from the private sector, where feasible.
Global Environment Facility (GEF)	The GEF aims to help developing countries and economies in transition contribute to the overall objective of the UNFCCC to mitigate climate change while enabling sustainable economic development. The GEF is intended to cover the incremental costs of measures to address environmental issues such as climate change relative to a business-as-usual baseline	Mitigation, adaptation and cross-cutting activities	Grants, concessional loans, equity, guarantees. GEF has co-financing requirements

63 Illustrative purpose only. Readers are advised to look at the further readings section for more on climate finance

Whilst there are increasing numbers of climate funding sources available, this does not directly translate into easier access for developing countries.

The process of identifying and selecting suitable climate finance sources involves the following key steps[64]:

1. Develop a clear understanding of country needs and context
   - Assess the roles and capacities of domestic institutions in accessing and channeling climate finance.
   - Outline clear mitigation and/or adaptation needs in national policies, including NDCs, NAPs, sectoral actions, and stakeholder considerations.
   - Analyze national climate budgeting systems to ensure they align with the standards required by climate funds.
2. Obtain a clear understanding of relevant financing sources
   - Compile and assess detailed information on available finance sources from bilateral, multilateral, and private sector levels.
   - Create a national inventory of relevant climate funds, detailing funding windows, eligibility criteria, and allocation limits.
3. Select suitable financing channels
   - Compare different access modalities (direct and/or international) for climate funds and assess their compatibility with existing national structures and systems, ensuring fiduciary, environmental, and social standards are met.
   - Based on this assessment, select the most relevant access modality that aligns with the country's context and needs.

To access funding, eligible countries and institutions need to go through a process of 'accreditation' that varies across climate funds and is designed to assess whether they are capable of strong financial management and safeguarding funded projects and programs.

Box 4.9 Mobilizing climate finance: Nadi Flood Alleviation Project, Fiji

Fiji has been significantly impacted by climate change, particularly due to frequent and severe flooding. The Nadi River region is especially vulnerable, experiencing repeated flooding that affects thousands of residents and critical infrastructure.

The Nadi Flood Alleviation Project aims to reduce flood risks and enhance climate resilience in the Nadi River Basin by improving flood control infrastructure, such as riverbank reinforcements and improved drainage systems. It is designed to protect infrastructure, support sustainable development, and safeguard livelihoods. It includes NBS such as mangrove restoration, reforestation, and riverbank stabilization, enhancing the region's overall climate resilience. The project is financed through a combination of sources:

- GCF – GCF approved approximately $31 million in financing for this project, aimed at reducing the risks of climate-induced flooding and ensuring long-term sustainability.
- Government of Fiji – The Fiji government committed a significant portion of its own funds to complement the GCF grant and ensure successful implementation.
- Development Partners – Development banks and international organizations like the Asian Development Bank (ADB) and the World Bank have provided technical support and additional financial resources.

Source: UNDP/UN-Habitat, 2023. IUR – SIDS Integrated urban resilience in small island developing states and coastal cities national and city 'state of play' Nadi, Fiji.

64 Organisation for Economic Co-operation and Development (OECD), 2024. Scaling Up Adaptation Finance in Developing Countries.

Recap

- Risk allocation plays a major role in identifying the most appropriate contractual strategy for the PPP project.
- Important factors to be considered are the definition and inclusion of force majeure clauses, insurability, contract adjustment mechanisms, and setting climate-resilient performance requirements.
- There are several opportunities to integrate climate resilience in the tendering process. These include setting climate resilience requirements in bidder qualifications, tender documentation, and bid evaluation.
- A number of international climate funding opportunities exist. They can be helpful to complement financing and funding arrangements of PPP projects and ensure that climate resilience and adaptation efforts are adequately funded

Contract Management Phase

5. Contract Management Phase

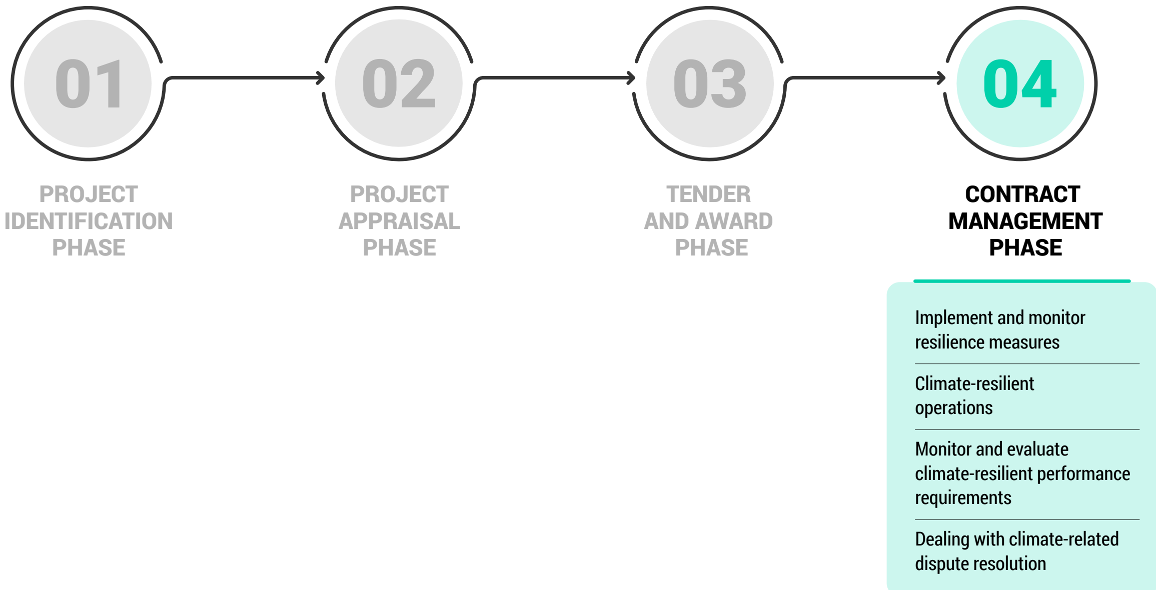
Description: This section will identify how to embed resilience principles into the PPP Contract Management Phase, which typically includes design, construction, operations and maintenance.

Learning outcomes: After completing this module, you will be able to:

- Discuss the importance of ensuring that the resilience measures included in the project's design are implemented.
- Describe how to monitor and evaluate climate-resilient performance requirements and deal with climate-related contractual changes.
- Describe actions to embed climate resilience and adaptation in operations, including periodic assessment of climate resilience needs, maintenance and renewals, and emergency preparedness and response.
- Discuss key points for integrating climate change consideration in the asset transfer process (applicable to BOT).
- Identify ways to leverage stakeholder engagement and ensure continued integration of NBS and gender considerations during the asset's operational life.

The Contract Management Phase aims to ensure that the services specified in the output specifications are obtained and to ensure ongoing affordability and appropriate risk transfer. It also provides an opportunity to proactively address future needs as climate projections become more accurate. As climate-related impacts will largely be felt during this phase, integrating climate resilience will be particularly relevant to monitoring and evaluating performance requirements and dealing with change. **Figure 5.1** below identifies entry points for integrating climate resilience and the stakeholders taking action at this stage.

Figure 5.1 Key entry points for climate resilience in the Contract Management Phase



5.1 Implement resilience measures

Resilience and adaptation options are first identified during the Project Appraisal Phase. At the Tender and Award stage, the contractual strategy determines how climate risks are addressed, and resilience and adaptation options are designed and implemented.

As discussed in the Tender and Award Phase, climate risk allocation broadly follows two main approaches. Under **Option 1** (see Tender and Award Phase, **Figure 4.2**), the Public Partner transfers most climate risks to the Private partner, incentivizing innovative adaptation solutions. In this model, the private partner has the flexibility to refine resilience measures, leveraging technical expertise to meet service performance targets. This promotes creativity and cost-effective solutions while holding the private partner accountable for long-term performance. Conversely, **Option 2** (see Tender and Award Phase, **Figure 4.2**) involves the Public Partner specifying detailed resilience requirements and performance thresholds. These could include defining the maximum severity of hazards the infrastructure must withstand, such as storm surges or heatwaves, or mandating specific resilience features like elevated structures or drainage capacities. Aligning these thresholds with force majeure definitions ensures the infrastructure endures events below these limits while clarifying liability.

In PPP projects, private partners typically undertake detailed climate risk assessments during the **detailed design phase**, following contract award and before construction begins. This step refines the broad climate resilience strategies identified earlier, tailoring them to site-specific risks and aligning with contractual obligations.

Detailed climate risk assessments focus on identifying vulnerabilities to hazards such as flooding, storm surges, heatwaves, landslides, or sea-level rise. Advanced tools like geotechnical analysis, hydrological modeling, and scenario planning are employed to evaluate these risks and guide design adaptations. For example, flood modeling might inform decisions to elevate infrastructure or expand drainage capacity, while assessments of heat risks could lead to the selection of more durable materials. These assessments are particularly crucial in performance-based contracts where private partners are incentivized to ensure uninterrupted service and penalized for failures. By understanding specific risks, private partners can develop designs that meet or exceed resilience standards outlined in the contract.

Integrating these findings into the infrastructure's design ensures compliance with resilience specifications, operational continuity under extreme conditions, and minimized lifecycle costs. This approach not only aligns with contractual requirements but also fosters innovation and long-term climate resilience in public infrastructure projects.[65]

Engaging multidisciplinary teams, including engineers, environmental scientists, and community stakeholders, is critical. Collaborative efforts ensure designs not only address projected climate risks but also meet operational, social, and environmental objectives. Through these approaches, the detailed design phase establishes a strong foundation for sustainable and climate-resilient infrastructure assets.

Stakeholder Engagement

A whole-community approach is needed in the Contract Management Phase. The Public Partner, Private Partner and shareholders play a significant role in this phase, with lenders and users supporting. The case study below exemplify the key role of stakeholder engagement in the design and construction of a major infrastructure, as a key determinant of the success of the project.

65 ICSI, 2022. Infrastructure Pathways.

Case Study – Engaging with stakeholders during delivery of major projects: Sydney Metro

Sydney Metro is Australia's largest public transport project, aiming to provide a fast and reliable rail service to the growing population of Sydney. During the design and construction phase, the Sydney Metro team implemented several strategies to engage end users, including aboriginal groups:

- **User feedback mechanisms.** Regular online and in-station surveys were conducted to gather feedback on user experience, safety, and service quality. Furthermore, the team organized focus groups with different user demographics to understand specific needs and challenges.
- **Community information sessions.** Sydney Metro held community sessions where users could learn about upcoming changes, provide feedback, and ask questions. These sessions helped address community concerns and fostered a sense of ownership among users.
- **Real-time communication.** The introduction of real-time updates via a mobile app allowed users to receive live information about service status, delays, and maintenance schedules.
- **User Advisory Group.** A user advisory group was established to involve representatives from various commuter demographics, ensuring diverse perspectives in decision-making processes regarding service improvements and maintenance priorities.

Source: *NSW Government, Sydney Metro, Chapter 3 Stakeholder and community engagement*

In the **construction phase** of a PPP infrastructure project, detailed designs are transformed into physical assets and operational systems. Key measures include employing robust materials and construction techniques tailored to withstand extreme weather conditions and meeting updated resilience standards.

Sustainability goals must guide construction practices, emphasizing the use of energy-efficient equipment and minimizing environmental disruption. Implementing resilience-based performance criteria and testing is essential to confirm the asset's readiness for future challenges. Collaboration among engineers, environmental specialists, and stakeholders is vital to integrate nature-based solutions (NBS) and hybrid green-gray infrastructure approaches.

Furthermore, a comprehensive monitoring framework is necessary to track progress, evaluate risk management effectiveness, and adapt to unforeseen challenges during construction. For example, risk assessments at the construction site location are required to adapt construction methods to address potential climate events occurring during construction.

Stakeholder Engagement

External actors involved at this stage include Independent Engineers and Independent Certifiers who provide independent technical assessments of the project process as mandated by the Public Partner and the lenders. Their scope of work includes review, inspection and monitoring of construction works, examining the designs and drawings for their conformity with the concession agreement, and conducting tests and issuing completion certificates during the construction period. It is recommended that the Independent Engineer's scope of work explicitly requires them to monitor climate resilience measures and therefore their skills/competencies align with those discussed in the Tender and Award Phase.

Box 5.1 Managing risks at design vs O&M phases

The specific context of the project, including its complexity, stakeholder needs, and the nature of the risks involved, will determine how the risk allocation that is agreed between the Public and Private Partner at the Tender and Award Phase will be implemented across the design/construction and O&M phases.

Some of the risks identified and allocated at the Tender and Award phase belong to the detailed design phase with a view to help control costs as modifications during the design phase are generally less expensive than during operation. Furthermore, a focus on risk during design can lead to better overall project planning and resource allocation and can help avoid legal issues later in the O&M phase. However, this may come with a risk of over-engineering and early decisions may constrain options for subsequent improvements.

On the other hand, risks that belong to the O&M phase are assessed based on actual operational data, leading to more informed decision-making and continuous improvement or risk management solutions based on real-world feedback. However, addressing risks during operation can be significantly more expensive, especially if issues disrupt services or require major fixes. Furthermore, operational risks can lead to service interruptions, which affect project performance, generate negative public perception, damage trust with stakeholders, and result in fines or legal complications in case of compliance violations. A balanced approach that incorporates risk management throughout both phases may often yield the best results.

5.2 Climate-resilient operations

O&M is a key element because the medium- and long-term climate-related physical and transitional risks will lead to financial, operational, and service delivery impacts for the Private Partner throughout the PPP.

Effective contract management is essential during the operational phase to achieve project objectives and realize the benefits of a PPP. While the core tasks, methods, and procedures remain largely the same, managing a PPP in a changing climate introduces distinct challenges. Active oversight and adaptability are crucial to ensure the PPP remains aligned with its objectives in the face of climate uncertainties.

Key climate-informed actions for the contract management team and the Private Partner at the O&M stage of the project lifecycle are as follows:

- Periodically revise CRAs and resilience needs
- Enhance maintenance and renewals
- Ensure adequate emergency preparedness and response.

Periodically revise CRAs and resilience needs

As scientific and technological advancements improve warning times for extreme weather and enhance climate projections, periodic reviews should be incorporated to assess the need for contract adjustments. Climate-related obligations and insurance policies can be revisited based on updated scientific findings.

CRAs are essential to implementing effective resilience measures. These assessments, informed by downscaled climate models and catastrophe risk modeling, help quantify risks and estimate potential losses. While such assessments are typically conducted during project identification and appraisal, they should be updated regularly as models evolve, vulnerabilities shift, and new data emerges. Updated assessments can inform contract modifications, such as revising performance KPIs or force majeure clauses.

The climate resilience measures implemented during the construction phase of a PPP project may become insufficient over time for several reasons[66]:

- **Uncertainty of Climate Change:** The rate of climate change is unpredictable. A faster increase in the intensity or frequency of climate risks than anticipated at the start of the PPP contract could necessitate greater adaptation measures than originally planned.
- **Phased Implementation:** Even if climate change evolution is predictable, it may be more cost-effective to implement resilience measures gradually as climate risks increase.

The contract management team should periodically assess climate resilience measures and evaluate the costs and benefits of additional measures. If further measures are found to be beneficial, a contract variation proposal should be prepared (see later section on dealing with climate-related contractual changes). The frequency of updates will depend on the rate of climate change, with one example being the potential for climate risks to become uninsurable.

Infrastructure assets do not operate in isolation, making it critical to consider system-wide risks and interdependencies. This includes integrating operational performance goals, system vulnerabilities, and climate-related opportunities. Some interdependencies only become apparent during operation or in the aftermath of a disaster. Such a comprehensive approach ensures that climate adaptation and hazard mitigation efforts remain effective and relevant over time.

Enhance maintenance and renewals

Maintenance is crucial for minimizing deterioration and reducing the likelihood of infrastructure failures. While maintenance typically does not modify assets, climate change may necessitate CapEx investments and upgrades, such as raising road platforms due to increased flooding or repairing port facilities after hurricanes. These costs can be significant relative to the project's lifecycle cash flow.

Given the high upfront CapEx for climate-resilient infrastructure and substantial maintenance costs, lenders often require concessionaires to allocate funds for anticipated maintenance expenses through a Major Maintenance Reserve Account (MMRA). This reserve ensures maintenance is performed as scheduled, mitigating the risk of loan repayment delays.

Accounting for known climate risks from the start helps avoid costly rework during O&M. Resource limitations necessitate a risk-based preventive maintenance approach that incorporates CRAs and considers lifecycle costs. Maintenance schedules should be informed by vulnerability assessments but optimized for economic sustainability.

A feedback loop between monitoring, inspection, and maintenance processes is essential to detect potential asset failures and maintain agility in crisis response. This approach protects critical components effectively while adapting to evolving risks and changes in supply and demand. Periodic reviews of maintenance strategies ensure they remain relevant and responsive to climate dynamics.

Monitoring and inspection regimes are an inherent part of infrastructure operations. They underpin the planning of maintenance and renewal activities but are also pertinent to climate resilience. They may identify a need to revisit the assumptions, underlying data or approaches of an original vulnerability assessment, or to refine resilience strategies and processes, such as emergency plans or preventive maintenance.

To support climate resilience, monitoring and inspection programs should be informed by periodic CRAs and broader vulnerability evaluations, considering climate stressors and trends. Risk-informed programs track asset conditions, predict deterioration, and assess inspection ease. Modern techniques combine traditional methods with advanced technologies to improve accuracy, reduce costs, and predict maintenance needs. These include visual inspection, remote sensing (satellite imagery, LiDAR, infrared and thermal imaging), drones, non-destructive testing (ultrasonic, magnetic particle, ground penetrating radar), structural health monitoring systems (strain gauges, accelerometers, fiber optic sensors), robotics, acoustic emission monitoring, digital twins, and corrosion monitoring.
These approaches are already applied across various infrastructure sectors and offer the advantage of optimizing costs through precision, without overlooking high-risk assets. Inspection programs typically include:

- **Regular inspections:** Routine checks for early detection
- **Annual inspections:** More detailed than regular checks
- **Special inspections:** Post-extreme weather damage assessments to update high-risk asset lists.

66 GCA, 2024. Reinforcing climate resilience in a PPP. Good practices and technical guidelines.

Ensure adequate emergency preparedness and response

Emphasis should be put on robust emergency response plans, which – with regular testing and updates – become critical for adapting to changing climate conditions. Project-specific emergency and response performance indicators, established during the Tender and Award Phase, are enforced during the operational phase.

Responding to disruptions involves two key actions: providing essential services to affected populations and repairing damaged systems. For example, a power outage would require emergency power for critical facilities (e.g., hospitals and police stations), mass care for vulnerable groups, and expedited restoration of the power grid. Operators must maintain safe conditions and restore normalcy promptly. While critical infrastructure operators are not expected to manage all aspects of crisis response, the demands of disasters often exceed what private sector firms are prepared for.

Business continuity and emergency management are critical for infrastructure resilience (see **Box 5.2**). Business continuity ensures operations continue during disruptions, while emergency management protects assets and mitigates impacts on people and infrastructure. Both require a comprehensive, risk-driven approach that integrates efforts across public, private, and non-profit sectors. While business continuity is typically the private sector's responsibility and emergency management falls to the public sector, both are closely linked in the context of critical infrastructure.

Early Warning Systems (EWS) play a crucial role in both business continuity and emergency management by reducing damage from climate impacts. They help mitigate the effects of sudden-onset hazards such as hurricanes and floods and forecast slow-onset threats like droughts. EWS provide the time and data needed to take proactive measures, such as deploying flood barriers, isolating vulnerable assets, or activating emergency plans to minimize the impact of natural hazards.

Box 5.2 Checklist: Business continuity and emergency management considerations for climate-resilient PPPs

- Include the operator's preparedness, response and recovery capabilities from climate-related events in the PPP agreement as performance requirements.
- Prepare business continuity and emergency preparedness and response plans, and communicate both to local, regional and national emergency management authorities.
- Regularly update business continuity and emergency preparedness and response plans to reflect actual and anticipated climate change (prepared by the Private Partner and approved by the contract management team).
- Consider the impact of infrastructure interdependencies across the supply chain on business-as-usual and emergency operations.
- Require private partners to exercise their emergency response plans on a regular basis (e.g. annually) with input from the contract management team.

5.3 Monitor and evaluate climate-resilient performance requirements

Monitoring is pertinent for the contract management of PPPs during the construction, operation and maintenance of climate-resilient infrastructure. The construction phase begins with a detailed design based on preliminary work included in the tender. This may include refining design specifications or undertaking more granular CRAs, which present an opportunity to enhance and optimize the design of climate resilience measures identified at previous stages. Monitoring is critical at this phase to ensure that the work progresses according to the schedule and technical requirements and that the latest findings of CRAs are reflected in the final blueprints of the project.

During the O&M phase, performance monitoring seeks to ensure that: (i) the Private Partner is meeting service performance requirements, including service standards or target levels of service in a changing climate when it comes to operations, and (ii) safety, good condition, and performance are maintained throughout the lifecycle when it comes to the maintenance of the asset.

KPIs are normally established at the Tender and Award Phase. A periodic review of KPIs is a way to deal with uncertainty, adapt to change and integrate resilience into performance monitoring. These KPIs should be designed with resilience principles in mind (see **Box 5.3**). A useful tool to identify resilience-related KPIs is the World Bank Resilience Rating System (see **Box 5.4**).

Box 5.3 UNDRR Principles for Resilient Infrastructure

The Principles for Resilient Infrastructure have been developed by the UN Office on Disaster Risk Reduction (UNDRR) to help nations achieve resilient infrastructure. A Handbook is available to provide guidance on the implementation of the principles, developing key actions into interventions from different stakeholders, and associated KPIs to measure and monitor improvement in the resilience of national infrastructure.

Examples include emergency preparedness, community participation, and consumption of local, sustainable resources.

Source: United Nations Office for Disaster Risk Reduction (UNDRR), 2023. Handbook for Implementing the Principles for Resilient Infrastructure.

Box 5.4 World Bank Group Resilience Rating System

The World Bank Group developed the Resilience Rating System (RRS) to help guide investment decisions and improve climate resilience in project design and outcomes. RRS provides guidance and specific criteria to assess the resilience of the project (i.e. assess the expected effectiveness of the project's climate adaptation measures) and resilience through the project (i.e. how the project is expected to help improve the resilience of the communities and systems it serves). In a nutshell, RRS is a simple method for assessing adaptation and resilience considerations in a project, a reporting tool to monitor progress on these considerations, and a way to improve project design to better manage climate risks.

Source: World Bank, 2024. Resilience Rating System: A Methodology for Building and Tracking Resilience to Climate Change.

As already discussed in the Tender and Award Phase, infrastructure owners and operators should define operational thresholds of acceptable risk, as these are essential to enable future planning for climate change. These should capture the point at which a climate-related parameter might lead to operational disruption or otherwise impact on safety, business or the environment. They might include maximum wind speeds, maximum or minimum temperatures and humidity, and water and flood depths. Defining and updating these thresholds is a key input to vulnerability assessments, developing EWS, and triggering contractual or insurance mechanisms, see **Box 5.5**.

Stakeholder Engagement

Stakeholder engagement is also a critical part of performance monitoring of climate-resilient infrastructure. At different points in the project, the Public Partner can conduct public consultations to gauge user satisfaction with the infrastructure asset itself, the effectiveness of existing climate resilience measures and eventually the need to adjust them, and any other benefits that they have derived beyond the direct service.

Box 5.5 Relief mechanisms to support operations in the Dar Es Salaam Bus Rapid Transit System project

With a population of 7 million, Dar es Salaam, Tanzania is the largest metropolitan area in eastern Africa. The city's infrastructure is under intense twin pressures from a growing frequency of extreme weather events and population growth, both of which put pressure on existing infrastructure. The public transport system consists of over 8,000 privately owned minibuses and a number of larger buses operated by a government-owned operator. Despite the reliance on the public transport system, a 2016 World Bank Study estimated that only 20% of the roads were in 'good' condition. Although bus rapid transit (BRT) systems had already been used in Latin America, Dar es Salaam was the first city in eastern Africa to use such a system, consisting of 130 km of dedicated bus lanes, off-board fare-collection and central bus terminals.

The motivation for procuring the Dar Es Salaam BRT system as a PPP lay in achieving VfM as compared to traditional procurement and providing the kind of efficient public services which the government recognized it lacked the technology, skills and expertise to deliver. As the PPP in this instance is structured as an operations contract, most climate risk to infrastructure falls outside the purview of the private sector. However, the risk of flooding to operations is crucial. Under typical BRT operations contracts, the responsibilities of the Public Partner include maintaining and keeping the busway available, while any event leading to loss and damage for the service provider is most commonly the responsibility of the service provider.

In such contracts, flooding can be defined as a relief event. At the time of writing, no flood events had triggered any such claims, despite a flood in 2019 in which the bus depot was inundated, leaving several buses – all the property and responsibility of the operator – unusable. Floods in the terminal have provided lessons learned for any future contract with an independent operator. Whilst relocation of the bus depot should prevent this in the future, it is the kind of event which could trigger relief in any future contract.

Source: GCA, 2022. Scaling Up Climate-Resilient Infrastructure PPP Masterclasses in Africa - Case Study Collection. Unpublished

5.4 Deal with climate-related contractual changes

The lifecycle of infrastructure PPP contracts often spans decades, making it essential to address changes in the operating environment, including shifts in performance or service demand. Extreme weather events may impact infrastructure operations beyond the original PPP contract scope. For example, rising temperatures could increase electricity demand for air conditioning or require additional water supply.

The Public Partner must respond efficiently to new events or changes, especially shifts in the climate risk profile, ensuring minimal disruption to the project. Climate-related agreements established during the Tender and Award Phase should be monitored, while unforeseen climate risks are addressed promptly. To manage these changes, PPP contracts should include a clear change process, supported by climate resilience expertise within the contract management team to evaluate variation requests effectively. This expertise is particularly critical for projects with medium to high climate risks and helps ensure proactive and informed responses to evolving risks.

Box 5.6 provides a checklist for how to institute mechanisms to accommodate climate resilience in PPP contracts.

Box 5.6 'How to' Guidance – How to institute mechanisms to accommodate climate resilience in PPP contracts?

The following checklist can provide useful tips for including climate resilience considerations in PPP contracts, adapted from the Inter-American Development Bank.[67]

Pre-Identifying and Pricing Climate-Related Changes

- ☑ Are there any **climate-related changes or variations** to the infrastructure asset (e.g., higher sea wall) that can be foreseen?
- ☑ Can these changes be **pre-identified and priced** as part of the PPP contract?

Process for Climate-Related Changes

- ☑ Is the process for executing changes to the PPP **clear and easy to follow**?
- ☑ Is there a streamlined process specifically for **climate-related changes**, with fewer approvals or required documents?
- ☑ Does the change process require an explanation of how the proposed change impacts the project's **resilience to climate change**?

Access to Climate Expertise

- ☑ Does the **contract management team** include someone with climate change expertise to review changes and their impact on resilience?
- ☑ If not, is it easy to access **climate change expertise** when needed?

67 Inter-American Development Bank (IDB), 2024. Resilient public - private partnerships a regional and multi-sectoral toolkit from preparation to sustainable project financing

Assessment of Force Majeure Events

Due to climate change, the frequency of extreme weather events is increasing, causing some events to become 'normal' and no longer qualify as force majeure. When a Private Partner claims relief or compensation for a climate-related event, contract management must assess whether the event meets the criteria for force majeure. Simply having damage is not sufficient evidence. Typically, the contract management team will consult meteorological data to confirm whether the weather event meets the severity criteria outlined in the force majeure definition within the PPP contract.

Uninsurable climate risks

Climate change may make certain risks uninsurable, either due to increased frequency or severity. PPP contracts generally include a procedure for assessing uninsurable risks, requiring the parties to negotiate a mutually satisfactory solution. If no solution is found, the contracting authority assumes the risk as the insurer of last resort. In these negotiations, the potential for implementing additional climate resilience measures must be considered. These measures can either restore the insurability of the risk or minimize costs and losses for the contracting authority when a risk event occurs.

5.5 Integrating climate considerations in the transfer/handover process

At the end of a PPP Build Operate and Transfer (BOT) contract, infrastructure assets are transferred back to the procuring authority. This transfer process ensures that assets meet established performance standards, are free from liabilities, and are ready for continued public use. Typically occurring after 10 to 50 years, this process follows the Private Partner's recovery of investment and fulfillment of obligations, including maintenance and debt clearance.

To prevent deferred maintenance or renewals that could degrade asset quality, hand-back criteria should require that assets retain a reasonable remaining useful life. However, overly strict criteria may inflate project costs and lead to higher user charges or government payments. Defining these criteria during the tendering phase allows bidders to integrate the associated costs into their financial models.

Best practices for the hand-back process include advance inspections and reserve funds. Independent third-party inspections conducted several years before contract expiration (e.g., three years) identify deficiencies and guide necessary investments. Annual inspections track progress. Additionally, retaining a percentage of annual revenues (e.g., 2%) in a dedicated maintenance fund ensures resources for asset renewal. Any surplus, subject to compliance, is returned to the Private Partner at the contract's conclusion.[68]

Climate resilience is critical in the transfer process. Comprehensive documentation should detail resilience measures implemented, their performance under climate stressors, associated costs, maintenance logs, and asset condition. This enables the Public Partner to assess future climate resilience needs, considering evolving science, policy, and standards. A final assessment of climate-resilient performance metrics should also accompany the transfer.

Incorporating transitional support from the Private Partner post-handover may be necessary to ensure continued resilience. Contractual provisions should mandate resilience in design, construction, and maintenance phases, include provisions for mid-term upgrades, and require end-of-term resilience testing. Penalties for non-compliance should reinforce accountability, ensuring the infrastructure remains durable and adaptable to future climate challenges.

68 APMG International. PPP Certification Guide. Handback Process.

Nature-based Solutions

- Performance Monitoring: Establish indicators and monitoring systems to track the performance and impact of NBS throughout the project lifecycle.
- Adaptive Management: Implement adaptive management practices to modify and improve NBS based on monitoring results and changing climate conditions.
- Maintenance Plans: Develop long-term maintenance plans to ensure the sustainability and effectiveness of NBS.

Case Study – Adaptive management practices to modify and improve NBS: Chesapeake Bay Program, United States

Chesapeake Bay, the largest estuary in the United States, faces significant environmental challenges, including nutrient pollution, habitat loss, and the impacts of climate change. The Chesapeake Bay Program is a partnership aimed at restoring and protecting the bay's health. Established in 1983, the Program incorporates several adaptive management practices:

- **Monitoring and Assessment:** The program employs extensive monitoring of water quality, habitat health, and biodiversity. This data collection is crucial for understanding the bay's changing conditions and the effectiveness of implemented solutions.

- **Nature-Based Solutions:** The program emphasizes the use of NBS, such as wetland restoration, forest buffers, and green infrastructure. These initiatives are designed to improve water quality and enhance resilience against climate impacts.

- **Feedback Loops:** Regular assessments and monitoring create feedback loops that inform decision-making. When monitoring results indicate that certain NBS are not performing as expected (e.g., insufficient pollutant removal), the management strategies are adjusted accordingly.

- **Adaptive Management Framework:** It utilizes an adaptive management framework, which allows for iterative planning and implementation. This means that as new scientific data and climate information become available, strategies can be modified to enhance effectiveness.

- **Community Involvement:** Stakeholders, including local communities, are engaged in the process. Feedback from these groups helps refine projects and ensures that solutions are socially acceptable and environmentally effective. Locally Led Adaptation is very important in ensuring the adaptation solutions are contextually appropriate, addressing the specific vulnerabilities and needs of the affected communities, and leveraging local knowledge and resources for optimal impact.

The adaptive management practices have led to improved water quality in some areas of the bay, as management strategies were adjusted based on monitoring results. In addition, the integration of NBS has helped enhance the resilience of coastal ecosystems, making them better equipped to handle the impacts of climate change, such as rising sea levels and increased storm intensity. Last, the ongoing monitoring and adaptive approach foster collaboration among various stakeholders, facilitating shared learning and improved outcomes over time.

Source: US Environmental Protection Agency.

Mobilizing Climate Finance

Consider the case for adjusting OpEx or looking for additional finance for renewals based on changing adaptation needs.

Case Study – Adjusting OpEx to address climate adaptation: Flood Resilience Project, Bangladesh

Bangladesh, being highly vulnerable to climate change impacts such as flooding and cyclones, initiated this project to enhance the resilience of communities and infrastructure. Funds were allocated to upgrade and maintain drainage systems to handle increased rainfall and flooding. This resulted in higher operational costs for regular maintenance and management. In addition, the project involved restoring mangroves and wetlands, which requires ongoing operational funding for monitoring and maintenance. Furthermore, the project sponsored training programs delivered to local communities in disaster preparedness and response. The project utilized funds from various climate finance sources, such as the GCF and bilateral aid, to cover both the initial CapEx and the ongoing OpEx associated with these adaptation measures.

Source: Green Climate Fund.

Gender Considerations

Performance monitoring in the Contract Management Phase should include predetermined gender factors that were established to judge the success of the project's gender inclusion. Regulatory authority is set by the local government and as a result, varies between countries; however, it is important that the regulatory body uses KPIs that reflect the underlying value of the right to gender equality.[69] Maintaining a gender focus requires an active effort by private partners and stakeholders and as such, should be closely monitored and if necessary, reinforced. This can be carried out by anticipating and monitoring the tangible impacts of the PPP project and by ensuring transparency of communication in managing and maintaining the project.[70]

In PPPs focused on climate change adaptation – the scope of which is often wide-reaching – the need for effective contract management applies to both physical changes, but also social change. Often PPP infrastructure projects are considered a procurement and financing model and therefore the Contract Management Phase is more overlooked than the other phases.[71] Heightened by the uncertainty of climate change, poor management can lead to inadequate quality of service which not only will become reflective of the bankability and management quality of future projects but may impact the welfare and quality of life of local communities.[72]

Ideally, development partners' contribution towards gender inclusion shouldn't be restricted to minimal standard requirements but should involve innovation, redefining the standards of gender inclusion

69 Jannings, M. and Gaynor, C. 2004. Public Private Partnerships, Infrastructure, Gender and Poverty. World Bank Institute.
70 Ibid.
71 World Bank/PPIAF, 2022. Climate toolkits for infrastructure PPPs. Washington D.C.
72 Ibid.

and preemptively pioneering future solutions regarding gender integration, accessibility and equity.[73] Additionally, gender adaptation and inclusion should be established and maintained sustainably, with a long-term focus on narrowing social and economic gender gaps.[74] To do this, gender-sensitive impact assessments – using KPIs designed to address gender inequality – can be carried out periodically to ensure continued benefits and address any emerging gender accessibility issues. This is becoming more standard practice, such as in the Coastal Protection Development project in Beira, Mozambique, where disaggregating the effect on women from men is woven into the core project development objective indicators.[75] The case studies below highlight examples of projects that have implemented a gender action plan (GAP), see **Box 5.7**.

Box 5.7 Implementing Gender Action Plans (GAPs)

Case Study – Trung Son Hydro Power Project, Vietnam

The Trung Son Hydropower Project is a $400 million infrastructure project, construction of a hydroelectric power station on the Ma River in Vietnam – one that will supply affordable clean electricity for domestic consumption. It also relied on the relocation of 1,691 households, damaging 7,546 peoples' livelihoods and causing disruption to local rural settlements. To mitigate this, supervised by both independent monitoring consultants and the World Bank, who funded the project, a strong GAP was implemented.[76] While the plan was considered very good practice, external evaluators found that men and women were not ensured to benefit equally as planned.[77]

As a result of this evaluation, the project requested technical assistance to help update the design, implementation and monitoring mechanisms for their livelihood, ethnic minority and resettlement programs – monitoring that would capture gender disaggregated progress results.

As a result of this shift in contract management, women were provided with improved access to resettlement compensation as instead of only including the husband as 'head of household' on the receipt, it named both husband and wife as beneficiaries, resulting in an increase in joint husband and wife compensation and lowering household vulnerability to poverty. Participation of women beneficiaries also increased through the establishment of common interest groups that provided training courses as part of the community livelihood improvement plan.[78]

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73 United Nations, 2023. Youth Delegates Demand Greater Inclusion in Discussions about Digital Policies, Innovation, Protocols, as Commission on Status of Women Continues Session.

74 World Bank, 2024. Applying a Gender Lens throughout the PPP Project Cycle.

75 World Bank, 2024. Development Projects: Mozambique: Cyclone Idai and Kenneth Emergency Recovery and Resilience Project - P171040.

76 World Bank, 2012. Trung Son Hydro Power Project, Vietnam.

77 World Bank, 2017. Results of Collaboration for Social Inclusion in the Trung Son Hydro Power Project, Vietnam.

78 ibid.

Case Study – Road Safety and Social Protection in Cambodia

This PPP project saw over 500 km of roads built across Cambodia to facilitate the connection between poor rural areas and markets, social services and business centers. Gender equality was embedded throughout the project and monitored and reinforced in the Contract Management Phase. Through a community-based road safety program (CBRSP) and an HIV/AIDS and human trafficking prevention program (HHTPP) – both of which are outlined in a GAP – the potential consequences post-construction, which are often gender imbalanced, were mitigated. These programs which, by 2018, had reached around 105,000 people, 48% of whom were women.[79] These training sessions were gender accessible, meaning they were held at convenient times and in venues accessible to women, taking into account additional domestic and household responsibilities.

Secondly, the HHTPP provided voluntary confidential counselling and testing, mother-to-child transmission prevention programming, contraceptive distribution and education on HIV prevention. This program reached over 13,000 local women in addition to many male and female construction workers and truck drivers. Over 150,000 condoms were distributed as well as 550,000 posters and leaflets on HIV prevention.

Throughout the project, gender sensitivity and equality were integrated using tools such as a sex-disaggregated database of private partners used to hire more equitably, training on labor-based appropriate technology, which helped promote women's access to jobs in rural road construction and maintenance, and even gender-sensitization training for supervisory and managing roles, such as people within the ministry of rural development.
Ultimately, gender equality and the empowerment of local women stakeholders were prioritized throughout the Contract Management Phase of the project. The project also provided capacity-building and educational initiatives that local communities will benefit from beyond the project lifecycle.

Sources:

World Bank. 2017. Results of Collaboration for Social Inclusion in the Trung Son Hydro Power Project, Vietnam.

UN Women, UNOPS. 2019. Guide on Integrating Gender throughout Infrastructure Project Phases in Asia and the Pacific.

79 ibid.

Conclusion

Climate resilience is an evolving field, with continually improving science, emerging adaptation approaches, and innovations in risk management. As we conclude this handbook, it's important to reflect on the journey from understanding the key principles of climate resilience and adaptation to implementing them effectively in PPP infrastructure projects. The challenges presented by climate change to our infrastructure systems require not just awareness but deliberate, informed action at every phase of the PPP project lifecycle.

"

Climate resilience is an evolving field, with continually improving science, emerging adaptation approaches, and innovations in risk management.

While the economic rationale for climate-resilient infrastructure is well-established, practical implementation of climate resilience and adaptation requires specialized knowledge, collaborative effort, and continuous adaptation. This handbook has equipped you with methodologies to assess climate risks, identify appropriate resilience measures, structure contracts that share risks appropriately, and monitor performance throughout the asset's operational life.

The true value of this handbook lies not in its first reading but in its application as a working reference. We encourage you to return to specific sections as they navigate different phases of PPP projects. The checklists, decision frameworks, and case studies are designed to support your day-to-day work in developing infrastructure that delivers reliable services in a changing climate.

For practitioners seeking to formalize their expertise, the Climate Resilient Infrastructure Officer certification program offers a structured pathway to professional recognition. This credential enables professionals to demonstrate their capacity to lead the development of climate-resilient infrastructure projects and signal their commitment to excellence in this critical field.

The path to climate-resilient infrastructure may be challenging, but this handbook provides a map for the journey. We invite the reader to use it as reference, share it, and contribute to the growing community of practice that is transforming how we plan, design, finance, build, and operate infrastructure for a resilient future.

Further Reading

Knowledge Module on PPPs for Climate-Resilient Infrastructure
https://gca.org/knowledge-module/

Climate Models and their evolution
https://www.ipcc.ch/report/ar4/wg1/climate-models-and-their-evaluation/

Principles for Locally Led Adaptation Action
https://gca.org/wp-content/uploads/2022/04/Locally_Led_Adaptation_Principles_-_Endorsement_Version.pdf

Climate Toolkits for Infrastructure PPPs
https://www.ppiaf.org/feature/new-climate-toolkits-infrastructure-ppps

JASPERS practical sectoral guidance on climate resilience proofing
https://jaspers.eib.org/knowledge/publications/jaspers-practical-sectoral-guidance-on-climate-resilience-proofing

Scaling investments in Nature-based Solutions for Climate Resilient Infrastructure
https://gca.org/scaling-investments-in-nbs-for-climate-resilient-infra/

Financing Nature-Based Solutions for Adaptation at Scale
https://gca.org/wp-content/uploads/2025/02/Financing_NbS_for_Adaptation-GCAOxford2023-finalv2-1.pdf

Global Climate Finance Architecture
https://climatefundsupdate.org/about-climate-finance/global-climate-finance-architecture/

Green Bonds for Climate Resilience
https://gca.org/reports/green-bonds-for-climate-resilience-a-guide-for-issuers/

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