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Financing Climate Adaptation and Nature-Based Infrastructure

City Resilience Program

PPIAF Global Infrastructure Hub

GFDRR Global Facility for Disaster Reduction and Recovery

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About PPIAF

Established in 2000, the Public Private Infrastructure Advisory Facility is an initiative funded by multiple donors and implemented by the World Bank. PPIAF helps developing-country governments strengthen policy, regulations, and institutions that enable sustainable infrastructure with private-sector participation. As part of these efforts, PPIAF promotes knowledge-transfer by capturing lessons while funding research and tools; builds capacity to scale infrastructure delivery; and assists subnational entities in accessing financing without sovereign guarantees. Donor-supported and housed within the World Bank, PPIAF's work helps generate hundreds of millions in infrastructure investment. While many initiatives focus on structuring and financing infrastructure projects with private participation, PPIAF sets the stage to make this possible.

About CRP-GFDRR

Established in 2017, the City Resilience Program is an initiative funded by multiple donors, managed by the Global Facility for Disaster Reduction and Recovery and implemented by the World Bank, aimed at increasing financing for urban resilience. CRP's vision is resilient cities with the capacity to plan for and mitigate adverse impacts of disasters and climate change, thus enabling them to save lives, reduce losses, and unlock economic and social potential. The aim of the program is to catalyze a shift toward longer term, more comprehensive multi-disciplinary packages of technical and financial services, building the pipeline for viable projects at the city level that, in turn, build resilience.

Contents

List of Acronyms

BBIC	Belize Blue Investment Company
BBVA	Banco Bilbao Vizcaya Argentaria Colombia S.A.
BOT	Build Operate Transfer
CBI	Climate Bonds Initiative
CSOs	Combined Sewer Overflows
CZMT	Coastal Zone Management Trust
DFC	Development Finance Corporation
DFIs	Development Finance Institutions
EIBs	Environmental Impact Bonds
EMDEs	Emerging Markets and Developing Economies
EPMAPS	Municipal Sewer and Potable Water Company of Quito, Ecuador
FONAG	Fondo para la Protección del Agua, Ecuador
FEMA	Federal Environment Management Agency
GFDRR	Global Facility for Disaster Risk Reduction
GHG	Greenhouse Gas
GSS	Green, Social, and Sustainability
ICMA	International Capital Market Association
IFC	International Finance Corporation
KPIs	Key Performance Indicators
MCC	Millennium Challenge Corporation
NbS	Nature-based Solutions
NGO	Non-Governmental Organization
PPIAF	Public Private Infrastructure Advisory Facility
PPPs	Public Private Partnerships
SPV	Special Purpose Vehicle
TNC	The Nature Conservancy
UK	United Kingdom
USA	United States of America
US EPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

Executive Summary

This report assesses opportunities to increase private sector participation and financing for climate adaptation and nature-based infrastructure in Emerging and Developing Economies (EMDEs). Climate change is intensifying hydrological variability, coastal storms, and heatwaves, and these effects are anticipated to intensify as global temperatures continue to rise in the coming decades. The impacts of climate change will be felt hardest in EMDEs, which are structurally the most vulnerable to climate change. These climate trends are also combining with economic and population growth to drive unprecedented impacts on nature, including biodiversity, ecosystems, and the services they provide.

While substantial knowledge exists in relation to technical infrastructure solutions to address climate risks and nature loss, the collective understanding of viable models to catalyze private participation and investment remains nascent. The replication and upscaling of successful projects is urgently needed, which, in turn, requires better information and awareness on where the best opportunities lie for the private sector and the key barriers to address. This is the knowledge gap that this report seeks to fill. It is an urgent gap, given the scale of the challenges related to climate adaptation and nature loss, combined with the current fiscal limits to public financing facing many EMDEs. Regarding its target audience, this report seeks to inform the efforts of policymakers, project developers, and investors in EMDEs seeking to develop financially viable adaptation and nature-based infrastructure solutions. For the World Bank, the study will inform future technical assistance to EMDE governments, including via a dedicated new program under the Public Private Infrastructure Advisory Facility (PPIAF) to assist governments to test and develop new business models and financing structures for adaptation and nature-based infrastructure.

Private sector participation and financing of adaptation and nature-based infrastructure are complicated by the inherently public nature of such infrastructure. For example, infrastructure solutions to manage flooding or coastal storms do not readily lend themselves to the revenue generation needed to mobilize private investment. This fundamental revenue challenge is further compounded by other constraints, including: (i) data challenges and the inherent uncertainty surrounding long-term climate impacts, making project planning and financing harder; (ii) project complexity and the related need for strong governance and coordination of multi-stakeholder participation; and (iii) capacity and knowledge challenges, such as those related to the design and implementation of green versus grey infrastructure solutions.

Despite these challenges, the study identified a number of promising case-study examples where private sector participation and financing of climate adaptation and nature-based infrastructure had occurred or was expected to occur. These solutions addressed a range of climate adaptation goals, including flood risk management, coastal resilience, water security, and urban heat management. At the same time, they yielded a series of ecological benefits, such as watershed restoration and improved biodiversity.

Comparative review of these case studies showed, first, that all relied on one of four basic models for recovering costs during the operational life of the facility being financed. Basic

cost recovery models used for climate adaptation and nature-based infrastructure are as follows:

- *User pays*—whereby the service provider charges customers directly for use of the services. Of various types of climate adaptation infrastructure, investments in water security can generally be at least partly recoverable via user fees. While less common, examples also exist of charging users for flood management solutions as well as for protecting and restoring water catchment areas.

- *Government pays*—whereby the public sector provides the primary source of revenue for the project. Such payments can take different forms, including availability payments or debt service payments. Government funding is the default option for essential infrastructure where alternative revenue sources are not readily available or politically feasible, or for projects that are inherently public in nature. These resources may come from revenues from existing or new taxes.

- *Land value capture*—whereby governments capture at least some portion of the land value increases that result from public investment and government action. Examples exist where land value capture has supported investments in flood mitigation or coastal resilience; however, such are rare. While in theory this approach is attractive, in practice it is hard to implement successfully.

- *Climate-related funding*—whereby revenue is derived from the achievement of specific, verifiable climate outcomes. These benefits include reduced or captured carbon emissions as a benefit of nature-based infrastructure or as a co-benefit of climate adaptation infrastructure.

The comparative review also identified four financing models that facilitated the upfront flow of capital into these climate adaptation and nature-based infrastructure projects. These upfront financing models (which are predicated in part on the cost recovery models noted above) include the following:

- *Public-Private Partnerships (PPPs) with private finance*: PPPs tend to be more commonly used for projects that generate revenues from user fees, such as from water supply customers. They also tend to be utilized for larger projects, given high transaction costs. They are more prevalent in countries with good track records in developing and managing PPP projects. They may also help to mobilize private finance.

- *Capital markets finance:* Issuing a bond can allow the government to crowd in private capital for large upfront capital investments. This approach can: (i) provide for larger-scale financing at the program level; (ii) allow access to relatively affordable long-term institutional capital; and (iii) encourage the issuer to more rigorously consider climate- or nature-related outcomes. Case study examples illustrate the burgeoning market for climate- and environment-related bonds.

- *Own-source financing*: Under this approach, companies may be willing to invest in climate adaptation and nature-based infrastructure from their own development budget, financed from their own development capital through loans or bonds raised at

the corporate level. Own-source financing may be for smaller-scale investments that are not of sufficient size to attract project finance. For such an investment to occur, it must be justified by a clear business rationale, such as increased energy productivity and efficiency.

- *Public finance, including donor grants:* As case study examples show, such grant funding is particularly valuable and well-targeted at the project development or high-risk pilot stage.

Broadly speaking, the lessons from these case studies, together with wider market experience, point to the following key recommendations for decision makers:

- **Strengthen the economic case for public investment:** A clear theme throughout the study is the need for a minimum degree of government support for project financing and cost recovery. In most cases, even where private finance was mobilized, the public sector remained either partially or entirely responsible for covering the eventual costs of the project. To justify the allocation of scarce public resources, a clear *economic case* for investment is essential. This includes a clear understanding of the benefits generated by a project—specifically, identifying who benefits from the project, and hence who may be willing or obligated to contribute to project costs. The case for public investment can also be strengthened by better climate data and strong national planning processes (e.g., national adaptation plans) to ensure that public resources are allocated to the areas where they are most needed.
- **Strengthen the business case for private investment:** While in many cases government funding will be a crucial part of the solution, this alone will be insufficient to address the scale of the adaptation and nature challenge. Therefore, a stronger *business case* for private investment is also urgently needed to attract private investors at scale. This begins with exploring alternative cost recovery opportunities, whether via integrating adaptation or nature objectives into PPP projects with a user-pays revenue stream; exploring land value capture revenue streams for projects involving land redevelopment; or leveraging new sources of climate-related funding such as carbon finance or other available results-based financing. While the specific circumstances of the project will dictate what is possible, a clear understanding of the options, as well as the benefits and constraints of each, can help promote innovation and crowd-in private investment at the project development stage.
- **Develop bankable project pipelines:** Finally, to reinforce the recommendations above, all stakeholders have a role in developing and promoting the demonstration projects that are urgently needed to accelerate progress.

In addition to local circumstances and the creativity of project developers, the scope for cost recovery will also be a function of the wider enabling environment in which the project is being developed. For example, the ability of the private sector to leverage carbon finance opportunities will be heavily contingent on the regulatory environment for carbon markets, both nationally and internationally. Similarly, governments and Development Finance Institutions (DFIs) will continue to be instrumental in creating the capital markets frameworks and taxonomies needed to allocate "green" finance towards adaptation and nature-based infrastructure projects. And finally, given that adaptation and nature-based infrastructure projects are often geographically complex, governments (and their DFI or

non-governmental partners) will often need to recognize the need for and mobilize intergovernmental and multi-stakeholder collaboration to crowd in private sector participation.

Therefore, while much can be achieved through innovative project-level solutions, the analysis also points to the importance of regulations, governance, capacity, and data. This is reinforced by the fact that many of the more successful cases to date come from developed economies, where the financial sector and public administration are sufficiently developed to support the types of capital market instruments, new tax revenues, and long-term PPP structures that can be needed. In addition to these fundamentals, the case studies also point to three broad enabling environment factors specific to developing the economic and business case for adaptation and nature-based infrastructure projects: (i) improving access to climate data, (ii) creating investment incentives to address market failures, and (iii) strengthening multi-stakeholder organization and governance. These factors are discussed in more detail in Chapter 6.

In short, a concerted effort is needed to address the financing gap and unlock the potential of private investment in climate adaptation and nature-based infrastructure. While this will not be easy, strengthening the economic and business case, developing innovative financing mechanisms, and creating a supportive enabling environment and robust project pipeline will all be critical if we are to build a more climate-resilient and nature-positive future in EMDEs.

Key Definitions

Concept	Definition
Climate Hazard	The likelihood and intensity of a potentially destructive natural phenomenon, such as ground shaking induced by an earthquake or wind speed associated with a cyclone. Climate change and climate variability contribute to the evolution of hazards by altering the frequency, intensity, seasonality, and geographic coverage of these phenomena[1]. These climate hazards include flooding, water scarcity, cyclones, landslides, and extreme heat[2, 3].
Climate Vulnerability	The potential extent to which physical, social, economic, and environmental assets may become damaged or disrupted when exposed to a hazard event. Vulnerability can affect the number of casualties, the loss or disruption sustained, and the community's subsequent recovery time[1].
Climate Exposure	The location, attributes, and value of important community assets that are exposed to the hazard, such as people, buildings, agricultural land, and infrastructure. Population growth, urbanization, and socio-economic development drive the evolution of exposure and have been the primary drivers of disaster losses in recent decades[1].
Climate Risk	The potential for human and environmental systems to be adversely impacted by climate change. Often represented as the probability that a hazardous event or trend occurs multiplied by the expected impact. Risk results from the interaction of vulnerability, exposure, and hazard. 
Climate Adaptation	The process of preparing and adjusting to the expected impacts of climate change[4]. This is often done through investments in climate adaptation infrastructure, environmental management, and land use planning.
Climate Resilience	The capacity of social, economic. and environmental systems to cope with potential climate hazard impacts, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation[5].
Climate-Resilient Infrastructure	Existing and future stock of core infrastructure assets (e.g., energy grids, roads, ports, etc.) that are made to be climate resilient in the face of the expected impacts of climate change.

[1] Global Facility for Disaster Reduction and Recovery (GFDRR). (2014). *Making a Riskier Future: How Our Decisions Are Shaping Future Disaster Risk.* Available at: https://www.gfdrr.org/riskier-future/.
[2] World Bank (2025). *What is Climate and Disaster Risk Screening and why is it important?* Available at: https://climatescreeningtools.worldbank.org/what-climate-and-disaster-risk-screening-and-why-it-important
[3] GFDRR (n.d.). *ThinkHazard!* Available at: https://thinkhazard.org/en/.
[4] Browder et al. (2019). *Integrating Green and Grey: Creating Next Generation Infrastructure.* https://openknowledge.worldbank.org/entities/publication/ddda3ed0-096e-59dd-a25d-3de884254eba.
[5] IPCC (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability: Summary for Policymakers.* Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf.

Climate Adaptation Infrastructure	The additional infrastructure that is specifically designed to modulate climate hazard impacts.
Grey Infrastructure	Grey infrastructure refers to man-made built structures and mechanical equipment such as reservoirs, sea walls, storm drains, etc.
Nature-based Solutions	Actions that protect, sustainably manage, and restore natural or modified ecosystems to address societal challenges while simultaneously benefiting people and the environment.
Nature-based Infrastructure	The use of nature-based solutions to enhance the performance of (or substitute for) traditional grey infrastructure. Examples include reforestation for flood protection or mangrove restoration for coastal protection. Used interchangeably with the term "green infrastructure".

1 Introduction

1.1 Context

Climate change is already exerting substantial impacts on people, economies, and the environment. These effects are anticipated to intensify as global temperatures continue to rise in the coming decades. For instance, the rapid decline of Arctic sea ice, which has been diminishing by 12 percent per decade since 1980[6], is altering global weather patterns and contributing to rising sea levels.[7] In the Amazon rainforest, deforestation is posing a threat to a crucial carbon sink, potentially converting it into a carbon source and exacerbating global warming. Coral reef bleaching, driven by increasing sea temperatures and ocean acidification, has resulted in widespread coral mortality, affecting both biodiversity and the effectiveness of natural coastal storm buffers.

The impacts of climate change will be felt hardest in Emerging and Developing Economies (EMDEs)[8]. Poorer countries are structurally the most vulnerable to climate change due to factors such as lower average incomes and high dependency on climate-sensitive sectors (agriculture, fisheries). The expected impacts of climate change on the bottom 40 percent of households are projected to be 70 percent larger than those in the average population[9].

The impacts of climate change are expected to be felt primarily through increased hydrological variability (e.g., a higher incidence of flooding and droughts), intensified coastal storms and floods (e.g., hurricanes, other coastal storms, and sea level rise), and more frequent heatwaves. While these impacts are expected to become more frequent and more severe over time, it is still uncertain as to where and when these impacts will occur, which makes planning more difficult. To address climate risks, not only will existing infrastructure need to be more resilient, but additional infrastructure—both grey and green—will be essential to protect against the impacts of flooding, drought, coastal storms, and extreme heat. Estimates suggest that US$212 billion/year is needed by developing countries to finance adaptation; however, current levels of financing (in 2022) are only a fraction of this at US$76 billion/year[10].

In tandem with and connected to climate change, economic and population growth across the world are also leading to unprecedented impacts on nature (which includes biodiversity, ecosystems, and the services they provide). For example, a 69 percent decline in monitored wildlife populations was witnessed between 1970 and 2016, driven primarily by human activities and related changes to the natural world induced by climate change[11]. While more than half of the world's GDP is generated in industries that depend on nature and its services, paradoxically, this economic activity is undermining the biodiversity and ecosystem services on which the collective economic future depends. This economic activity includes infrastructure, which historically has been one of the major contributors to both climate change

[6] NASA (n.d.). *Arctic Sea Ice Minimum Extent. NASA Climate Change: Vital Signs of the Planet*. Available at: https://climate.nasa.gov/vital-signs/arctic-sea-ice/.
[7] World Bank (2012). *Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided*. Available at: https://unfccc.int/sites/default/files/resource/World%20Bank_Turn%20Down%20the%20Heat.pdf
[8] United Nations Environment Programme (2021). *Step up climate change adaptation or face serious human and economic damage*. Available at: https://www.unep.org/news-and-stories/press-release/step-climate-change-adaptation-or-face-serious-human-and-economic.
[9] Hallegatte, S. and Rozenberg, J. (2017). Climate change through a poverty lens. *Nature Climate Change* ***7****, 250–256 (2017). https://doi.org/10.1038/nclimate3253*.
[10] Climate Policy Initiative (2024). *Global Landscape of Climate Finance 2024*. Available at: https://www.climatepolicyinitiative.org/wp-content/uploads/2024/10/Global-Landscape-of-Climate-Finance-2024.pdf.
[11] World Wildlife Fund (2022). *69% average decline in wildlife populations since 1970, says new WWF report*. Available at: https://www.worldwildlife.org/press-releases/69-average-decline-in-wildlife-populations-since-1970-says-new-wwf-report.

and nature loss. However, the need for far greater international attention to the protection of nature and ecosystem services is increasingly being recognized, as exemplified by the adoption of the Kunming-Montreal Global Biodiversity Framework in 2024, which sets a wide range of targets to achieve by 2030 and an even more ambitious set of goals to accomplish by 2050.[12]

Given the fiscal constraints and capacity challenges facing many EMDEs, mobilizing private sector financing and participation will be essential to delivering the additional infrastructure needed to adapt to climate change and reverse nature loss. In this context, the aim of this report is to assess opportunities for increasing private-sector participation and financing for adaptation and nature-based infrastructure in EMDEs. Drawing on experiences from both the developed and developing world, this report provides insights from a range of case studies, interviews, and desk research to identify potential financing and cost recovery mechanisms to support private-sector participation and the key enabling factors that have contributed to success.

1.2 Study Scope and Definitions

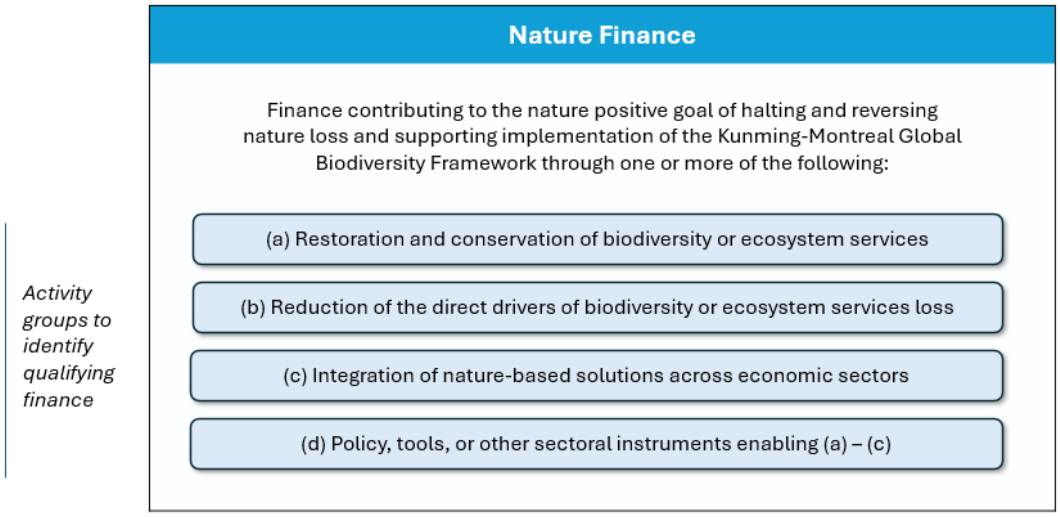
This study seeks to assist stakeholders involved in the development of climate adaptation and nature-based infrastructure—including governments, the private sector, Development Finance Institutions (DFIs), and Non-Governmental Organizations (NGOs)—to learn from experience to date in relation to project financing and cost recovery, and to understand how enabling environment interventions can help reduce the common barriers to developing and delivering such projects. The scope of the study includes projects that have been delivered through Public Private Partnerships (PPPs) between governments and the private sector, as well as projects utilizing private finance but implemented directly by governments or state-owned enterprises.

Nature-based infrastructure

This report uses the term "nature-based infrastructure" to describe infrastructure that integrates Nature-based Solutions (NbS) in place of physical or "grey" infrastructure. This aligns with the World Bank's *Nature Finance Framework* (2024), summarized in Figure 1 below. In practical terms, the integration of nature into infrastructure projects might be via, for example, reforestation for flood management or mangrove restoration for coastal protection[13]. A range of examples, and the ways in which such projects have been financed and costs recovered, are discussed in Chapter 3.

[12] Convention on Biological Diversity (n.d.). *Kunming-Montreal Global Biodiversity Framework: 2030 Targets (with Guidance Notes).* Available at: https://www.cbd.int/gbf/targets.
[13] World Bank (2018). *Nature-based Solutions for Disaster Risk Management.* GFDRR, WBG, WRI. https://wriorg.s3.amazonaws.com/s3fs-public/NBS_for_DRM_brochure.pdf.

Figure 1: Defining Nature Finance



Climate adaptation infrastructure

For the purposes of this report, "climate adaptation infrastructure" is defined as the *additional* infrastructure that is specifically designed to modulate climate hazard impacts, such as flooding, water scarcity, cyclones, landslides, and extreme heat. Climate adaptation infrastructure can include both NbS (described above) and grey infrastructure solutions. At the same time, as suggested above, NbS can certainly confer climate adaptation benefits; therefore, the two categories are not mutually exclusive. The classification of case studies into these two categories, as discussed below and shown in Annex 1, thus represents a matter of emphasis. Examples of grey infrastructure include floodwater conveyance systems such as retention ponds and drains to address increasing flood risk; coastal protection infrastructure such as sea walls and breakwaters to protect against rising sea levels and storm surges; and water storage and wastewater recycling infrastructure to modulate the effects of droughts and increase water availability. A range of examples are discussed in Chapter 2.

It is important to differentiate here between "climate adaptation infrastructure" (i.e., the additional infrastructure needed to address climate risks) and "climate-resilient infrastructure", which generally refers to how the existing and future stock of core infrastructure assets (e.g., energy grids, roads, ports, etc.) can be made to be resilient in the face of the expected impacts of climate change. Whilst both types of infrastructure are often interlinked, numerous studies[14], toolkits,[15] and guidelines[16] already exist related to private sector finance of, and participation in, climate-resilient infrastructure. This report therefore focuses on the question of how to finance and pay for the *additional* infrastructure that will be needed to mitigate climate risks, which is a topic that has so far received much less attention.

[14] World Bank (2021). *Unlocking Private Investment in Climate Adaptation and Resilience*. Available at: https://www.worldbank.org/en/news/feature/2021/03/04/unlocking-private-investment-in-climate-adaptation-and-resilience.
[15] World Bank, et al. (2022) *Climate Toolkits for Infrastructure PPPs*. Available at: https://www.worldbank.org/en/topic/sustainableinfrastructurefinance/brief/climate-toolkits-for-infrastructure-ppps.
Note: Consisting of 6 toolkits, the World Bank's suite of Climate Toolkits for Infrastructure PPPs provides practical steps for climate-proofing infrastructure developed with private sector involvement. There is an umbrella toolkit for broad multisector application, as well as curated guidance on how to climate-proof the transport, digital/ICT, water and sanitation, and energy sectors.
[16] The World Bank has a host of guidance notes and methods for scaling private sector participation in climate-proofing infrastructure. For example: The PPP Fiscal Risk Assessment Model (PFRAM) and the PPP Project Screening and Analytics Tool (PSAT) have been recently updated to include climate considerations.

Interplay between climate adaptation and nature-based infrastructure

The linking of climate adaptation and nature-based infrastructure under this study reflects the natural synergies between these two topics in relation to infrastructure development. First, climate change and nature loss are deeply interconnected and mutually reinforcing. Historically, infrastructure development has been a major contributor to both these problems. Therefore, adapting to climate change through traditional built infrastructure that exacerbates nature loss would be counterproductive. Second, in terms of technical solutions, some of the incremental infrastructure needed to adapt to climate change naturally lends itself to nature-based solutions, offering opportunities for adaptation-nature win-wins. Moreover, in some circumstances a combination of 'grey' and 'green/blue' infrastructure actually may provide the optimal solution. Finally, from a project economics perspective, climate adaptation and nature can be considered public by nature, and hence the benefits are not easily internalized within infrastructure project financing structures. This results in parallels between climate adaptation and nature-based infrastructure in relation to potential financing and cost recovery solutions.

Financing and cost recovery

At a practical, engineering level, there already exists substantial knowledge and capacity to design and implement infrastructure solutions that address climate risks and nature loss. The primary challenge is therefore not technical knowledge but financial resources: how can we mobilize the considerable funding for this infrastructure in an environment where fiscal resources, in most countries, are already stretched? And, if public funding is in short supply, what financing mechanisms and cost recovery models might be feasible to attract private sector participation and investment?

A first step to answering these questions is to map relevant case studies according to the financing approaches and cost recovery mechanisms that facilitate the flow of capital into infrastructure projects. Put simply, *financing* refers to the raising of money for investment (i.e., where does the money come from upfront), and *cost recovery* refers to the revenue sources that pay for the investment, including the upfront capital costs, operations and maintenance, and the financing cost (e.g., interest payments) over the life of the project. The key findings from these case studies, together with a wider discussion of the financing and cost recovery mechanisms, are provided in Chapters 2-5. Finally, given the public nature of infrastructure needed to withstand climate hazards and protect nature, proactive government support (or other forms of collective action) will often be needed to create a supportive enabling environment and to provide the right incentives to crowd in private sector participation and finance. This will be discussed further in Chapter 6.

1.3 Methodology

This report was developed by a team of World Bank staff under the leadership of the Public-Private Infrastructure Advisory Facility (PPIAF), with generous support from the Millennium Challenge Corporation (MCC), the City Resilience Program (CRP), and the Global Facility for Disaster Reduction and Recovery (GFDRR). PPIAF is a World Bank-managed trust fund that helps governments promote private sector investment and participation in infrastructure. The study provides the foundation for a new PPIAF program to support World Bank client governments to scale up private investments in adaptation and nature-based infrastructure.

The findings and insights presented in this report are based on an analytical phase that included the following analytical steps:

- Assembly of an internal team of World Bank specialists to guide the study together with a recruited team of external consultants (Jacobs Engineering);
- Global desk review of 50+ climate adaptation and nature-based infrastructure projects (completed or underway) that have involved private sector participation or financing (see full project list in Annex 2);
- Deep dive into a sample of 18 projects to review project motivations, incentive structures, detailed financing and cost recovery mechanisms, project outcomes, and other aspects of the enabling environment; and
- Interviews with project stakeholders and subject matter experts from governments, the private sector, the financial industry, the insurance industry, the World Bank, and others, to complement the project case studies and provide insights on the market and wider enabling environment.

By drawing on real-world project experiences and expert insights, the report is intended to help guide stakeholders who are seeking to develop similar projects, including via future World Bank support.

2 Climate Adaptation Infrastructure

The infrastructure solutions needed to address climate change, as well as the corresponding financing and cost recovery options, will vary substantially according to the type of climate hazard that needs to be addressed. As such, this chapter will explore these in turn, across the categories of flood risk management and coastal resilience, water security, and urban heat management.

This chapter focuses on projects that relied primarily on grey infrastructure solutions, while Chapter 3 focuses on projects that relied heavily on NbS. However, several examples in this chapter also utilized NbS to some degree, while examples provided in the next chapter may also provide adaptation benefits, as described in the text. Table 1 provides a summary of the projects covered in this chapter, while more detailed versions of these case studies are available in Annex 1.

Table 1: Climate Adaptation Infrastructure Projects Reviewed in Depth

Climate adaptation goals	Project name	Infrastructure solution description	Financing model	Cost recovery model
Flood risk management and coastal resilience	Fargo-Moorhead River Diversion Project (USA)	• Grey - Flood channel to store and divert stormwater	PPP with private finance	Government pays (Availability payment)
			Public finance	Government pays (Public budget)
	Broadland Flood Protection (UK)	• Grey - Elevating and strengthening dykes and levees • NbS – Wetlands and natural floodplains	PPP with private finance	Government pays (Performance-based contract)
	Canal del Dique (Colombia)	• Grey - Elevating and strengthening dykes and levees • NbS - Wetlands and natural floodplains	PPP with private finance	Government pays (Availability payments)
				User pays (Transport tariff)
	Mission Rock, San Francisco (USA)	• Grey - Sea wall and pier rehabilitation	PPP with private finance	Land value capture (Developer rights payments and special property taxes)
	Msimbazi River Basin (Tanzania)	• Grey - Elevating and strengthening dykes and levees	Public finance, including donor funds	Government pays (Public budget)
				Land value capture (Property sales and leases)
Water security	As-Samra Wastewater Recycling Plant (Jordan)	• Grey - Wastewater reuse for agricultural use	PPP with private finance	Government pays (Availability payment, partially tariff recovered)
Urban heat management	Paris District Cooling PPP (France)	• Grey - District cooling networks • NbS – Natural water reuse	PPP with private finance	User pays (Cooling tariff)

2.1 Flood Risk Management and Coastal Resilience

As climate change intensifies, many countries will have to deal with more severe and more frequent impacts of flooding. The world is already seeing an increase in the number of flood events as a result of extreme precipitation due to climate change, and these impacts are projected to worsen as global temperatures continue to rise over the coming decades. Flooding already affects 1.8 billion people, and it is estimated that around US$10 trillion in economic activity is financially exposed to flooding (equivalent to around 12 percent of global GDP in 2020)[17]. Sea levels globally have risen, on average, around 21–24 cm since 1880, and 2023 recorded the highest annual average on record[18]. Exposure to these risks will vary greatly across different countries and regions, and modeling projections of flood impacts can be complex. *Chapter 5* contains an overview of the different types and sources of data and models typically used for modeling climate-induced flood risk.

For the purposes of this chapter, flood management and coastal resilience projects are considered together, since they both relate primarily to addressing flood risk, whether as a result of sea level rise, extreme precipitation, or increased storm surges. Flood mitigation and coastal resilience strategies can be implemented at different scales. Individual households and businesses can take their own precautions by protecting individual assets, although to effectively mitigate flooding risks at scale, climate adaptation infrastructure solutions (such as sea walls, dikes, and channels) can often be more feasible and cost-effective to protect assets and communities from damages. Additionally, NbS such as mangroves, coral reef systems, and coastal wetlands can offer cost-effective and complementary alternatives to grey infrastructure, as explored further in Chapter 3[19].

While flood risk management and coastal resilience is not a typical area for private participation, several national and local projects have found ways to leverage private sector participation and finance, including via PPPs and land value capture, which will be discussed in turn. Capital markets solutions are also relevant on this topic, which will be covered in Chapter 5.

Public Private Partnerships (PPPs)

PPPs can be used as an alternative to public sector delivery for almost any infrastructure service. They tend to be more commonly used for projects that generate revenues from user fees (e.g., from passengers on metro systems, toll road users, and water supply customers). However, they can equally be structured under "government pays" contracts, whereby the government reimburses the private sector based on specific performance metrics, often referred to as availability payments.

In the case of flood management infrastructure, a government-pays cost recovery model is logically the most likely approach, given the lack of user fee opportunities. Box 1 summarizes three examples of where PPPs have been used to support large-scale flood management. Both the Fargo-Moorhead project in the US and the Broadlands project in the UK are based on a government-pays model, although the nature of this government funding varies substantially, with the Fargo case relying on local funding raised from project beneficiaries via local sales

[17] Rentschler, et al. (2022). *Flood exposure and poverty in 188 countries*. Available at: https://doi.org/10.1038/s41467-022-30727-4. Note: This study was supported by the Global Facility for Disaster Reduction and Recovery (GFDRR).
[18] US Global Change Research Program: 1880 – 2023 data: https://www.globalchange.gov/indicators/sea-level-rise
[19] Browder et al. (2019). *Integrating Green and Grey: Creating Next Generation Infrastructure*. Available at: https://www.wri.org/research/integrating-green-and-gray-creating-next-generation-infrastructure.

taxes and the Broadlands project relying on national budgets. The Canal del Dique project in Colombia also operates on a government-pays model, although as the flood management elements are tied to a larger waterway concession contract, in this case the project is funded through both availability payments and user fees. On the financing side, the projects did leverage private finance to varying degrees, although for both Fargo and Broadlands, the use of PPPs appeared to be motivated primarily by the potential for increased efficiency and risk transfer, rather than private financing.

Box 1: Large-Scale Flood Management PPPs

Fargo-Moorhead Area River Diversion Project (USA): Given their flat topography and exposure to seasonal snowmelt, the cities of Fargo and Moorhead in the northern US are prone to flooding, the incidence of which has been increasing in severity and frequency over the past 30 years. In response, the Fargo-Moorhead Area River Diversion Project was designed to build resilience to withstand 100-year floods and to mitigate against 500-year floods. The US$2.8 billion project includes a dam embankment and 30-mile diversion channel to increase flood protection from the six rivers that contribute to flooding in the Fargo-Moorhead area. While primarily relying on built infrastructure, the design also incorporated green investments, including planting 85,000 trees to restore the natural flood mitigation potential of wetlands and other local ecosystems.

- **Financing:** This project was financed through a 30-year PPP with a combination of public and private sector financing. US$1.6 billion of the total project cost came from various federal and state sources, including two US-specific government support mechanisms: grants from the US Army Corps of Engineers (US$750 million) and the Infrastructure Investment and Jobs Act (US$437 million). US$1.2 billion of the total project cost was financed by the private sector, which comprised a mix of tax-exempt municipal bonds (US$470 million), equity from project sponsors (US$48 million), and loans (US$643 million)[20, 21]. Motivations for the PPP approach related primarily to efficiency—it was estimated that the PPP option would save US$330 million in construction costs and would be completed 10 years sooner than otherwise. Given the complexity of the project for the public sector, the PPP also enabled the transfer of long-term performance risks onto the private partner.
- **Cost Recovery:** The private partner is reimbursed via availability payments from the government, based on performance milestones. The government, in turn, has mobilized revenue to fund the project via a mix of local and—to a lesser extent—national revenue sources, including a dedicated sales tax supplement,[22] annual maintenance district levies, and stormwater maintenance fees. Because of the long construction duration, milestone payments are made based on the completion of specific sections of work, incentivizing the private partner to adhere to the project schedule, as opposed to "typical" PPPs, whereby payments are only made once construction is complete and the project is in operation.
- **Results:** The project has resulted in flood protection for 235,000 residents, the safeguarding of US$19 billion in property value, and environmental improvements. Properties will benefit from the removal of flood insurance requirements upon completion of the project in 2027.

Broadland Flood Protection, UK: The Broadland Flood Protection project covers a 30,000-hectare area in the low-lying east of England, UK. The area includes residential communities, endangered species, wetland habitats, productive farmland, transportation infrastructure, and archeological sites. While the region was already protected by flood defenses, these were increasingly strained in the face of sea level rise and increased rainfall, with US$12 million spent on emergency repairs following catastrophic failures in the levees in the years leading up to the project. In addition to the cost motivation, a new solution was needed to overcome the traditional compartment-by-

[20] Headwaters Economics (2020). *Overcoming Financial Obstacles: Fargo, North Dakota*. Available at: https://headwaterseconomics.org/wp-content/uploads/Fargo-Report-R5.pdf.
[21] Realfin (2024). *Private infrastructure transactions between 2013-2023*. Note: derived through World Bank PPIAF analysis of Realfin data.
[22] Local residents approved multiple sales tax initiatives - two ½-cent local sales taxes and one ½-cent countywide sales tax – until 2084.

compartment approach to flood protection, which meant that investments in one area risked increasing flood risk in another.

Given the size and complexity of the project area, it was unrealistic to expect the private sector to accurately project the scale of investment required to meet the project objectives at the time of bidding. Therefore, a key feature of the project was the inclusion of an initial two-year survey and modelling phase, which allowed the private partner to gather the detailed data needed to confirm the viability of the project, reimbursed at cost, with the provision of an exit clause. This helped to reduce risk, allowing the contractor to gain confidence they could deliver on the project's specifications within the allotted budget and schedule. The allocation of maintenance responsibilities between the contractor and public sector, as a result of storm damage after a clearly defined service-level storm event, also helped manage the risk profile.

- **Financing:** The PPP was financed via the UK Private Finance Initiative under a US$190 million 20-year O&M performance-based contract. The selection of the PPP was based on a mix of independent analysis, which assessed that the PPP route would be 10 percent cheaper than public delivery, as well as political leadership that at the time was in favor of leveraging private participation.
- **Cost Recovery:** Payments to the operator came from the Environment Agency based on a performance-based contract. These services were funded through the UK National Budget, and hence there was no project-specific cost recovery mechanism.
- **Results:** The project addresses both climate adaptation (adapting to rising tides and increased flooding) and biodiversity preservation (rising tides and floods threaten biodiversity in this ecologically sensitive wetland) through a combination of green and grey infrastructure approaches. The project resulted in the upgrading and maintenance of 240 km of flood banks, protecting 24,000 ha of highly productive farmland and 1,700 properties.

Canal del Dique PPP (Colombia): Canal del Dique is a 118 km manmade waterway built in the 16th century in Colombia that connects Colombia's two main colonial ports (Cartagena and Santa Marta) and the Magdalena River[23]. The canal has significant social and economic importance. It was one of the first engineering projects undertaken in the Americas, dug by hand using basic tools, and even today the 1.5 million people living in the area consider it as a key source of their livelihood[24]. In 2022, a 15-year concession was awarded to a private company to design and build upgrades and to operate and maintain the infrastructure, including control of sediment for transit, mitigation of flooding risk by controlling water levels in the canal, and restoration of the surrounding ecosystems[25, 26].

- **Financing:** The Canal del Dique is a US$1.2 billion project (US$680 million of which is for design and construction) financed through a 15-year PPP granted to Ecosistemas del Dique, a Special Purpose Vehicle (SPV) wholly owned by Sacyr Concesiones, which raised the equity and debt needed to finance the project[27]. Under Colombian PPP law, the SPV takes on the risk of design and construction and is reimbursed by the government following completion[28].
- **Cost Recovery:** The public funding source to cover the availability payment is a combination of royalties from user fees (from use of the channel), the Colombian national budget, and local government contributions (guaranteed by the national government).

[23] Royal HaskoningDHV (n.d.). *System improvement Canal del Dique*. Available at: https://coastalsolutions.ireport.royalhaskoningdhv.com/12001001A1.
[24] UNESCO (2012). *Canal del Dique—Dike Canal*. Available at: https://whc.unesco.org/en/tentativelists/5756/.
[25] Ecosistemas del Dique (2025). *Proyecto*. Available at: https://ecosistemasdeldique.com/proyecto.
[26] Sandoval and Posada (2022). *Canal del Dique—Public Bidding for the Second Fluvial Project of the 5G Concessions in Colombia*. Available at: https://cms.law/en/col/publication/canal-del-dique-public-bidding-for-the-second-fluvial-project-of-the-fifth-generation-5g-of-concessions-in-colombia
[27] Realfin (2024). *Private infrastructure transactions between 2013-2023*. Note: This was derived through World Bank PPIAF analysis of Realfin data.
[28] Agencia Nacional de Infraestructura (ANI) (2022). *The Public-Private Partnerships*. Available at: https://www.as-coa.org/sites/default/files/inline-files/Colombia%20Infrastructure%20Presentation%202022.pdf

- **Results:** The primary goal of the project is to protect 19 municipalities (and 1.5 million people) from catastrophic flood risk[29]. The concession was awarded in 2022, and results are not yet available.

Land Value Capture

While the examples of flood management PPPs described above rely heavily on public funding for their revenue, another avenue to mobilize the funding needed for flood risk management is to leverage the intrinsic increase in land value of the area for which flood risk is being mitigated. If governments are able to capture a portion of this value increase, this can be used as a revenue source for the project. This tends to be more feasible in the case of new developments where land value can be captured by the government via, for example, developer fees or the leasing of public land. Box 2 provides examples of how this approach is being applied in a climate adaptation context.

In terms of its replication potential, it is important to emphasize that, even more so than with PPPs, pursuing a land value capture approach can be complex in practice and requires a high level of capacity and a supportive enabling environment, particularly in relation to property rights. For these reasons, land value capture, while conceptually appealing, has often proven to be difficult to realize and replicate in practice, especially in EMDEs.

Box 2: Land Value Capture Approaches to Flooding and Coastal Resilience

Mission Rock, San Francisco: The San Francisco Bay Area is vulnerable to sea level rise. By the year 2100, current climate trend projections indicate the risk that sea levels in the area could rise in the region by 3 to 6 feet. Within the Bay Area, the 28-acre site of Mission Rock was historically used as a port and industrial site but was no longer needed for that purpose given changing economic activity in the city. The site offered a central and high-value location for development in the heart of the city but was highly exposed to flood risk. In response, the city came up with a plan to tender the rights to redevelop the site for commercial and housing purposes, combined with the responsibility to adapt the site to long-term flooding risks and to invest in the creation of new green space.

- **Financing:** To finance the infrastructure needed for the project, "special use districts"[30] were created for the site, which provided the basis for issuing bonds and local tax revenue regulations needed for the project. The budget for the initial horizontal infrastructure improvements was US$265 million, funded through developer fees, bond proceeds, and special taxes. The developer was responsible for constructing these infrastructure improvements, with reimbursement based on completion and satisfactory inspection. As such, the agreement transfers long-term performance risks to the developer.
- **Cost Recovery:** Upfront government investments are being recovered via local tax revenue collection from special use districts and fees from the private developer.
- **Results:** Approved in 2018, the redevelopment is now largely complete, and the project includes 1,500 of flood-resilient housing units (40 percent affordable), 8 acres of new parkland, over 1 million square feet of commercial and office space, and public infrastructure. It is the largest mixed-use waterfront neighborhood in San Francisco.

[29] Expansion (2022). *Sacyr wins contract for Canal del Dique in Colombia for 640 million.* Available at: https://www.expansion.com/empresas/inmobiliario/2022/12/08/63922042e5fdead4408b461e.html

[30] Special use districts in the US are independent, special-purpose governmental units that exist separately from local governments such as county, municipal, and township governments, with substantial administrative and fiscal independence.

Msimbazi Basin, Tanzania: The Msimbazi River Basin is an economically, geographically, and environmentally significant region, home to about 1.6 million people and critical transportation infrastructure that connects the Central Business District of Tanzania's most populous city, Dar es Salaam, with growing parts of the city to the north and west. However, flooding has become increasingly severe over the past decade, which is expected to increase with urbanization and climate change.

As a result of publicly financed flood mitigation investments under an ongoing World Bank-supported project, 57 hectares of developable land are expected to become available for development just 10 minutes from the city center. The concept is to recontour the river basin to accommodate floods while developing terraced land that would have low flood risk on higher ground. This resulting high-value land would then be available for development into market-rate housing, driving the financial viability of the project, together with affordable housing to meet social inclusion goals. The low-lying area would then be developed as a large city park, with a mix of green and blue spaces also then doubling as a detention basin for flood management during high rainfall events.

- **Financing:** The redevelopment of the site forms part of a wider US$260 million Msimbazi Basin Development Project, financed through credits from the World Bank and the Spanish Agency for International Development Cooperation, combined with a grant from the Netherlands Ministry of Foreign Affairs through Invest International[37].
- **Cost Recovery:** The World Bank project does not directly mobilize private capital, but it will strengthen institutions and capacity building to enable private sector real estate investments on this developable land near the central business district. If successful, the project will increase existing property values and revenue for the city and the national government, and potential future revenue streams from the sale of land for real estate units.
- **Results:** The flood management infrastructure work is expected to begin during 2025 along with the detailed planning of the park and developable land. The developable land would be stabilized and resistant to floods up to a 100-year return period. It would convert an inundated distressed area to a valuable urban area, which, by initial estimates, may result in the delivery of up to 14,500 new housing units over 10-20 years.

2.2 Water Security

At the opposite end of the climate risk spectrum from flooding is drought and water scarcity. Climate change is expected to intensify the earth's natural hydrological variability, increasing the frequency and severity of water shortages during drought periods. Furthermore, rising temperatures will lead to higher evapotranspiration rates, reducing the efficacy of man-made water storage systems. As such, in many countries there is a need to increase investments in water security, which is defined as the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments, and economies[31].

While many countries already face water scarcity issues due to naturally low precipitation, combined with increasing demand due to population and economic growth, climate change will impact the severity and urgency of the challenge. As such, the need for both financing and cost-effective technical solutions will continue to grow. For example, dammed reservoirs could run dry more often, as the City of Cape Town in South Africa witnessed when it experienced a 1 in 400-year drought between 2015 and 2018[32]. The city came within one month of running out

[31] Grey and Sadoff (2007). Sink or Swim? Water Security for Growth and Development. *Water Policy*, 9 (6). Available at: 10.2166/wp.2007.021.
[32] Brookings (2023). *Cape Town: Lessons from Managing Water Scarcity*. Available at: https://www.brookings.edu/articles/cape-town-lessons-from-managing-water-scarcity/.

of water ('Day Zero') when the crisis was averted via a mix of emergency investments and behavior change solutions[33].

On the water efficiency side, water losses of 40 percent or more that are common across many EMDE utilities will become increasingly untenable, which will likely open more space for private participation, for example, via performance-based contracts to reduce water losses. Desalination and the reuse of wastewater could become more widespread in the absence of more cost-effective alternatives, as is already happening in the Middle East and North Africa region (see Box 3 below).

Technically, water security solutions are well known and, in most regions, will require a mix of increased water storage together with improved water efficiency across domestic, agricultural, and industrial use. Furthermore, unlike for flood management and coastal resilience projects, it is conceptually much more feasible to fund water projects on a "user pays" basis due to the widespread use of water tariffs and hence to mobilize private financing via traditional PPP structures or commercial financing via corporatized public utilities. However, the track record of achieving this in practice is relatively limited in the majority of EMDEs. This often stems from the interconnected issues of low water pricing (and the politics of increasing prices), weak capacity and creditworthiness of public water utilities, and political sensitivity surrounding both tariffs and private sector supply of basic water services. The upshot of these factors is lower levels of investment and private sector participation rates in the water sector compared to other core infrastructure sectors such as energy and transport.

While climate change will exacerbate the water scarcity challenge, in most countries, it does not change the fundamental priorities of improving operational performance and financial sustainability in the water sector. A considerable literature is already devoted to these topics for readers interested in further information[34]. However, there are innovative examples of PPPs combined with blended finance approaches in the water sector specifically addressing issues in water scarcity. Box 3 demonstrates such an example in Jordan for wastewater recycling to supplement water for irrigation.

Box 3: Water Security PPP Example

As-Samra Wastewater Recycling Plant, Jordan: Jordan is one of the most water-scarce countries in the world, with water resources significantly below the threshold that defines severe water scarcity[35]. Climate change and overuse of water resources are expected to cause a further 15 percent decline in freshwater resources by 2040[36]. Jordan's Water Strategy for 2023-2040 shows that around 50 percent of water consumed is used for irrigation and seeks to increase the amount of non-conventional water (including recycled wastewater) for irrigation purposes, with private sector participation being a central pillar to implement the plan.

The As-Samra Wastewater Treatment Plant (WWTP) is one example of a wastewater treatment plant delivering recycled water for irrigation in partnership with the private sector. Jordan's experience with PPPs for wastewater treatment and recycling for irrigation started in 2006 when the government awarded a 25-year Build-Operate-Transfer (BOT) contract for Phase 1 of the As-Samra Wastewater Treatment Plant (WWTP). This was the country's first PPP[37]. In 2015, Phase 2 of the PPP was awarded

[33] Jourbert and Ziervogel (n.d.). *Day Zero: Once City's Response to a Record-Breaking Drought*. https://dayzero.org.za/. Note: Day Zero was estimated to be on 21 April 2018, and this was cancelled in March 2018.
[34] See, for example: https://www.worldbank.org/en/topic/water/publication/funding-a-water-secure-future
[35] UNICEF (n.d.). *Jordan: Water, sanitation and hygiene*. Available at: https://www.unicef.org/jordan/water-sanitation-and-hygiene#:~:text=Jordan%20is%20the%20second%20most,which%20defines%20severe%20water%20scarcity.
[36] Ministry of Water and Irrigation (2023). *Jordan's National Water Strategy 2023-2040*. Available at: https://www.mwi.gov.jo/EBV4.0/Root_Storage/AR/EB_Ticker/National_Water_Strategy_2023-2040_Summary-English_-ver2.pdf.
[37] World Bank (2016). Jordan: As-Samra Wastewater Plant Expansion. Available at: https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/959621472041167619/blended-financing-for-the-expansion-of-the-as-samra-wastewater-treatment-plant-in-jordan.

to a private company to expand the WWTP, which included a wastewater reuse program that enabled high-quality treated wastewater from As-Samra to be used in agriculture, freeing up freshwater for higher-value use in municipalities[38].

- **Financing:** A blended financial package was used to finance the US$233 million Phase 2 expansion of the As-Samra Wastewater Treatment Plant. The project was awarded to a private operator that is delivering a 25-year BOT from 2015-2040 to finance, upgrade, and operate the treatment plant. The blended finance package comprised US$93 million in viability gap grant funding from the Millennium Challenge Corporation (MCC) and US$20 million from the Government of Jordan. This was used to mobilize US$110 million in private financing from a syndicate of local banks and financial institutions[39] of 13-year tenor (extendible to 20 years). This tenor marks the longest maturity that Jordanian banks offered to date for a local currency limited-recourse loan. The blended finance approach brought down the capital costs for the project, which enabled the project to be financially viable[40].
- **Cost recovery:** The operator's revenues come from government availability payments from MWI and are guaranteed through a reserve account, the replenishment of which is in turn backed by a guarantee from the Ministry of Finance[37].
- **Results:** Construction on the project began soon after financial closure, and the treatment plant became operational in October 2015. The expanded plant provides 133 million cubic meters of high-quality treated wastewater per year—equivalent to over 10 percent of Jordan's annual water resources. The As-Samra plant also generates around 80 percent of its own energy needs from biogas (produced from biosolids) and hydropower[38].

2.3 Urban Heat Management

Urban areas are particularly vulnerable to rising temperatures caused by climate change, since physical structures such as buildings, roads, and other infrastructure absorb and re-emit heat much more than natural environments. The number of cities exposed to extreme temperatures will nearly triple over the next decades. This increase in extreme heat has critical implications on the overall health and well-being of citizens, as well as putting pressure on essential services in cities, such as energy, water, and transport.

Infrastructure solutions to address urban heat can include both grey and green solutions. Grey solutions can include the use of recycled or recovered water for district cooling (a system that supplies chilled water to buildings through a network of pipes) and the installation of water features in public spaces. Green solutions, such as tree planting, green roofs, and bioswales can reduce heat while also helping address flood management.

The review of global experience suggests that most urban cooling projects to date are small both in terms of geographic area and cost (e.g., targeting specific town centers or public facilities, such as schools). In the real estate sector, there are also numerous examples of private-sector financed cooling projects delivered voluntarily by the private sector, driven by zoning, building codes, and other incentives offered to developers. However, in terms of dedicated infrastructure projects led by, or with participation from, the private sector, experience to date is more limited. While this remains a nascent space for private participation,

[38] Millennium Challenge Corporation (2018). As-Samra Wastewater Treatment Plant Expansion Project. Available at: https://www.mcc.gov/resources/story/section-jor-ccr-as-samra-project/.
[39] World Bank (2016). Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan. Available at: https://documents1.worldbank.org/curated/en/959621472041167619/pdf/107976-Jordan.pdf.
[40] World Bank (2016). Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan. Available at: https://documents1.worldbank.org/curated/en/959621472041167619/pdf/107976-Jordan.pdf.

it is likely to grow in importance as more cities suffer the negative temperature impacts of climate change. Box 4 below provides an example of a grey infrastructure solution using a PPP for a district cooling system in Paris (funded by a "user pays" model).

Box 4: Private Sector Participation in Urban Heat Management

Paris District Cooling Network (France): In 1991, the City of Paris built a district cooling system through a 20-year Public-Private Partnership (PPP) contract with Special Purpose Vehicle (SPV) Climespace, which was a wholly owned subsidiary of ENGIE. The project built ten generation plants and four energy storage sites, supplying over 700 customers with cooling using renewable energy. In 2022, a new PPP (20-year concession) was awarded to SPV, Fraîcheur de Paris, which is majority owned by ENGIE. The new concession covers the operation and maintenance of the existing district cooling infrastructure as well as investment in the expansion of the district cooling network by 158 km by the end of the contract period.

- **Financing:** The PPP is being delivered by Fraîcheur de Paris, which received US$590 million in investment from its owning companies.
- **Cost Recovery:** The PPP revenues come from user charges through the district cooling network's 700 customers. 10-year contracts have been established with these customers, and it is estimated that the project revenues will be US$2.4 billion by the end of the contract period.
- **Results:** The district cooling network is run via 100 percent renewable energy, increasing energy efficiency by 50 percent, reducing electricity consumption by 35 percent, and reducing carbon emissions by 50 percent[41, 42].

[41] Engie (2022). *What carbon-free solution can we offer for the Paris district cooling system?* Available at: https://www.engie.com/en/business-case/engie-x-fraicheur-de-paris.
[42] Fraîcheur de Paris. (n.d.). *Refreshing Parisians, strengthening the city's resilience, adapting Paris to global warming.* Available at: https://www.thegpsc.org/sites/gpsc/files/paris_district_cooling.pdf.

3 Nature-Based Infrastructure

As introduced in Chapter 1, "nature-based infrastructure" encompasses a range of activities that can contribute to halting and reversing nature loss. This includes: (i) restoration and conservation of biodiversity or ecosystem services; (ii) reduction of the direct drivers of biodiversity or ecosystem services loss; (iii) integration of nature-based solutions across economic sectors; and (iv) policy, tools, or other sectoral instruments enabling the first three of these categories[43].

In practical terms, the most obvious application for nature-based infrastructure relates to the integration of nature-based solutions (NbS) into infrastructure projects, such as mangrove reforestation for coastal resilience or bioswales for flood risk management[44]. As such, this chapter focuses on opportunities to expand NbS in infrastructure and specifically on the experience in relation to financing and cost recovery under such projects. However, it should be noted that nature finance also includes grey infrastructure intended to reduce direct drivers of biodiversity or ecosystem loss (for example, solid waste management or wastewater treatment projects to improve environmental quality in biodiversity hotspots). This will be briefly discussed at the end of the chapter.

The review of global experience points to a range of common challenges to mainstreaming nature within infrastructure. Key amongst these include: (i) contending with the high degree of uncertainty in outcomes for infrastructure projects utilizing nature-based solutions, which are made even more complex with climate change; (ii) nature-based solutions requiring very different skill sets versus typical engineered infrastructure; (iii) limitations and uncertainty in data required to measure performance and therefore estimate revenues and cash flow on which private investment relies; and (iv) the nascent state of revenue incentive mechanisms for achieving nature-positive outcomes.

Addressing these barriers will require progressively building experience and confidence in the use of NbS, which in turn will require strong regulatory and financial incentives to encourage project developers to take on the perceived higher risk. While this will not be easy, especially in EMDEs, the research does point to a growing pool of positive examples of private sector participation in nature-based infrastructure.

Table *2* provides a summary of the cases examined in this section. More detailed case studies are included in Annex 1.

Table 2: List of Nature-based Infrastructure Projects Examined in Depth

Goals	Project name	Infrastructure solution description	Financing model	Cost recovery model
Water security	Greater Cape Town Water Fund (South Africa)	• NbS - Watershed restoration and managing invasive species	Own-source financing	Corporate and government pays (Corporate and public budget)

[43] World Bank (2024). *Note on Nature Finance Tracking Methodology*. Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099020524182036310/bosib1722f330c0fd18f8818b41d9bbe465.
[44] World Bank (2018). *Nature-based Solutions for Disaster Risk Management*. GFDRR, WBG, WRI. https://wriorg.s3.amazonaws.com/s3fs-public/NBS_for_DRM_brochure.pdf.

Goals	Project name	Infrastructure solution description	Financing model	Cost recovery model
	Quito Water Protection Fund (Ecuador)	• NbS - Watershed restoration and managing invasive species	Own-source financing	Corporate and government pays (Corporate and public budget)
			Public finance, including donor grants	User pays (Water tariffs)
	Itaipú Paraguay Biodiversity Project (Paraguay)	• NbS - Watershed restoration and managing invasive species	Public finance, including donor grants	User pays (Energy tariffs)
Coastal resilience	Vida Manglar Blue Carbon Project (Colombia)	• NbS - Mangrove reforestation and community capacity building	Own-source financing	Climate-related funding (Carbon credits)
	Quintana Roo Coral Reef Restoration (Mexico)	• NbS - Coral reef restoration	Public finance, including donor grants	Government pays (Public budget, special tourism taxes)
	Tibar Bay Port (Timor-Leste)	• NbS - Mangrove reforestation, coral reef restoration	PPPs with private finance	Government pays (Viability gap funding)
				User pays (Transport tariff)
Urban heat management	Adelaide Airport heat reduction trial (Australia)	• Grey - Water recycling for facility cooling • NbS - Crops for cooling	Own-source financing	User pays (Airport fees and revenues)

3.1 Water Security

While examples of the integration of NbS into infrastructure projects can be found across most sectors, it is in the water sector where this experience appears to have been the most extensive to date. The use of improved watershed management to improve water quality and reduce hydrological variability pre-dates concerns about climate change. In practice, such watershed management includes activities such as forest protection or reforestation, improving environmental practices by farmers to reduce pollutant runoff and sedimentation, and riverbank restoration to reduce erosion and improve water quality.

An early and well-documented project of this kind was the Catskills watershed management program in New York. This initiative was designed to preserve and enhance the water quality of New York City's water supply, which is sourced from a vast area of over 2,000 square miles in the upper catchment. By the 1980s, increased urbanization, industrial development, and farming were threatening water quality, triggering the preparation of huge investments in water treatment plants, with an estimated cost of US$4-US$6 billion for the Catskills-Delaware watershed alone.[45] Competing against traditional grey infrastructure options, however, was analysis showing that a comprehensive program of watershed protection would cost far less than filtration while producing a range of positive environmental externalities. This prompted the birth of the Catskills watershed management initiative that has since invested over US$1.5 billion into payments for environmental services to farmers to adopt practices that

[45] Appleton, A.F. (2002) *How New York City Used an Ecosystem Services Strategy Carried out Through an Urban-Rural Partnership to Preserve the Pristine Quality of Its Drinking Water and Save Billions of Dollars and What Lessons It Teaches about Using Ecosystem Services.* Available at: https://www.cbd.int/financial/pes/usa-pesnewyork.pdf.

would reduce pollution and water extraction; land purchases to protect the watershed from further development and associated contamination; and improvements to the wastewater system in the watershed area.

Since then, a growing number of local governments and utilities have invested in catchment-level NbS, both to improve water quality (and hence reduce treatment costs) and to reduce fluctuations in water supply (based on the natural retention qualities of catchment vegetation). More recent examples include the efforts by Anglian Water in the UK,[46] and Quito water company in Ecuador through the Quito Water Protection Fund.[47] In such cases, investing in NbS has reached the point of "business-as-usual", funded as part of the typical investment program of the utility without reliance on fiscal transfers or donor resources.

In EMDEs, such catchment-level NbS initiatives have tended to be developed, especially in the early years, with strong support from international NGOs, notably The Nature Conservancy (TNC), which has been instrumental in driving this agenda through their Water Funds work[48]. The presence of such a neutral convening partner can be invaluable given the organizationa complexity of watershed NbS initiatives, which usually involve many stakeholders and arms of government. For example, water utilities are responsible for water treatment but do not manage the agricultural and environmental activities that impact water quality.

As per the Catskills example, watershed-level NbS can be motivated as much by financial as environmental considerations, at times offering a more cost-effective option than the large capital investments required to increase water storage and treatment. Having said this, the cost-effectiveness of such approaches will always be very context-specific. Based on a sample of over 500 cities, research from TNC estimates that a positive return on investment exists for around 1 in 4 cities, not accounting for the positive environmental externalities[49].

It should also be noted that_this topic is not always connected to climate adaptation, as motivations have often been driven by water quality considerations (driven by unsustainable human uses) rather than water security. However, in the face of growing water stress, NbS may increasingly become an adaptation solution also, as exemplified in the cases of Cape Town in South Africa, and Quito in Ecuador in Box 5 below.

Box 5: Nature-based solutions for water security with private participation

Greater Cape Town Water Fund, South Africa: South Africa is a naturally water-scarce country, and climate change is exacerbating this challenge for cities such as Cape Town. This situation came to a head in 2018 when, after 3 years of drought conditions, the city was approaching "Day Zero" of no water availability, with dam reservoir storage dropping below 20 percent capacity. At the same time, Cape Town is a biodiversity hotspot. The tiny Cape Floral Kingdom is one of only six floristic kingdoms in the world. It is also the smallest: it represents less than 0.5 percent of the area of Africa but is home to nearly 20 percent of the continent's species of flora[50]. It is threatened by the ongoing urbanization of Cape Town.

To address this crisis, the city considered various options to enhance the water resource base, including desalination, groundwater exploration, and increasing storage capacity. However, in parallel, researchers found that 67 percent of the dams and rivers with the Cape Town catchment

[46] Anglian Water. (n.d.). *Working together to Get River Positive.* Available at: https://www.anglianwater.co.uk/environment/river-health/working-together-to-get-river-positive/.
[47] Fondo para la Protección del Agua (FONAG). (n.d.). *Fondo para la Protección del Agua - FONAG: Quito, Ecuador.* Available at: https://www.fondosdeagua.org/content/dam/tnc/nature/en/documents/latin-america/wfquito.pdf.
[48] Latin American Water Funds Partnership. (n.d.). *The Water Funds.* Available at: https://www.fondosdeagua.org/en/the-water-funds/.
[49] The Nature Conservancy. (n.d.). *Urban Water Blueprint: About.* Available at: https://water.nature.org/waterblueprint/about/.
[50] See https://whc.unesco.org/en/list/1007/.

system were affected by invasive species, which were estimated to be reducing the quantity of water supply to the city by 55 billion liters annually. These invasive plants and trees had also adversely affected the local biodiversity, eliminated the native plants and floral species, distorted the soil ecology, and increased the severity of wildfires. Removing such species was estimated to be a minimum of 5x more cost-effective per liter saved versus available grey infrastructure solutions[51].

In 2018, a multi-stakeholder partnership came together to establish the Greater Cape Town Water Fund. The fund was used to pool resources from the public and private sectors to clear invasive species in the catchment.

- **Financing:** The fund aims to raise US$25 million over 30 years to 'unlock' 100 billion liters of water in the catchment, equivalent to one-third of Cape Town's water needs[51]. Based on the success of the pilot phase, discussions are underway to further scale the fund and develop a long-term sustainable financing source via an Impact Bond.
- **Cost Recovery:** Rather than generating direct revenue, the project is intended to reduce the pressure on the city to invest in capital-intensive water storage, thereby improving the overall financial health of the city's water supply.
- **Results:** As of March 2025, the project cleared 38,482 initial hectares and 41,832 follow-up hectares of invasive alien plants. As a result of all invasive alien clearing completed in the GCTWF, a total of 34.53 billion liters per year is restored back into the streams. This translates to a water supply yield benefit of 18.17 billion liters per year at a 1:100-year assurance of supply for the City of Cape Town.

Quito Water Protection Fund, Ecuador: The upper basin of the Guayllabamba River serves one of the most densely populated areas of Ecuador. This includes the city of Quito, home to around 2.6 million people. Quito faces problems related to both water scarcity and pollution, resulting in the progressive depletion and deterioration of groundwater aquifers. In response, in 2000, the Municipal Sewer and Potable Water Company of Quito (EPMAPS) partnered with other government agencies, NGOs, and private sector companies to establish the Fondo para la Protección del Agua, 'FONAG', a water conservation fund designed to protect the Guayllabamba watershed through conservation projects and ecological restoration.

- **Financing:** FONAG is a US$22.5 million trust fund that was financed via grant contributions from government, public utilities, electric companies, private companies, and NGOs.
- **Cost Recovery:** The Quito water company currently provides 2 percent of revenue to the water fund, providing a sustainable revenue source for long-term investment.
- **Results:** As of 2018, more than 28,000 ha of land has been restored, with more than 3,500 households participating in projects.

While the above examples were motivated by concerns related to basic water supplies, a similar watershed management approach can also prove cost-effective in relation to dam-based hydropower projects. Many hydropower dams suffer from sedimentation, resulting in a loss of storage volume and hence expensive dredging costs. Interventions such as forest protection and reforestation, for example, can help to stabilize slopes and retain soil that might otherwise be washed into dams. A good example of this approach comes from the Itaipú biodiversity project in Paraguay (*Box 6*).

Box 6: Catchment management for hydropower

Itaipú Paraguay Biodiversity Project (Paraguay): The Itaipú Hydroelectric Dam, located on the Paraná River, was developed in the 1980s as a US$17 billion joint venture between Brazil and Paraguay to provide hydroelectric power to both countries' industrializing economies. The dam's

[51] The Nature Conservancy (2020). *Greater Cape Town Water Fund: Fact Sheet*. Available at: https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf.

creation was part of a treaty that resolved a longstanding border dispute. The dam provides 90 percent of Paraguay's electricity and 16 percent of Brazil's electricity as of 2020.

During the planning phase of the project, it was determined that the dam would face significant sedimentation and unreliable flows during dry weather, requiring expensive and continual dredging. Furthermore, with the populations and economies of both countries growing rapidly, runoff containing sediment and agricultural chemicals from the watershed (driven by erosion, pesticide use, and excess fertilizer) was leading to eutrophication and algal growth, further threatening water quality and electricity generation.

Recognizing these challenges, the operating company, Itaipú Binacional, has continued to invest in watershed restoration programs as a core part of its business plan. Part of Itaipú's conservation activity includes the Paraguay Biodiversity Project, which combats deforestation levels in the Atlantic Forest, considered Latin America's most important biome for biodiversity after the Amazon Forest.

- **Financing:** Finance of US$18.5 million for the project was sourced from the Global Environment Facility (US$4.5 million), Itaipú Binacional (US$9.7 million), the Paraguayan government (US$3.5 million), and local beneficiaries (US$830,000).
- **Cost recovery:** Itaipú Binacional funded its contribution through its budget, recovered through user fees, and justified by the project benefits and efficiency gains, which would result in reduced dredging costs and increased electricity revenue.
- **Results:** A cost-benefit analysis by the United Nations Environment Programme (UNEP), and the Inter-American Development Bank (IDB) in 2020 for the Itaipú watershed conservation as a whole, including the Paraguay project, estimated a Net Present Value of US$45 million in direct financial benefits[52]. In terms of the environmental impact, more than 230,000 ha were restored through the Paraguay Biodiversity Project, which also supported the protection of nearly 300 bird species[53].

Conceptually, the approach pursued under the Itaipú project would appear to be a sensible one to pursue under many hydropower projects. However, the fact that examples of successful implementation are relatively few suggests that the concept is more challenging to apply in theory than in practice. While the precise reasons for this will always be case-specific, general barriers include: (i) lack of watershed-level hydrological data on which to base watershed-level investment decisions; (ii) the perception of high risks and transaction costs, linked to the organizational complexity of dealing with competing land demand and stakeholders; and (iii) weak policy and regulatory environments, for example, for enforcement and oversight of environmental rules and practices.

3.2 Coastal Resilience

Compared to water security interventions, there are fewer examples of private sector investment in NbS to modulate the impacts of storms, sea level rise, and coastal flooding. However, more recently private finance in this sphere has been growing, linked to the expanded use of innovative financing mechanisms, including carbon finance and parametric insurance.

[52] International Finance Corporation (2022) Catalogue of Nature-Based Solutions for Infrastructure Projects. Available at: https://www.ifc.org/content/dam/ifc/doc/2023/catalogue-of-nature-based-solutions-for-infrastructure-projects.pdf.
[53] World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. Available at: https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

The restoration of coastal ecosystems—in particular mangroves—provides dual benefits both as a natural buffer against storm surges and as an extremely effective carbon sink (mangroves store up to 10 times more carbon per hectare than terrestrial forests)[54]. As a result, a growing number of projects are emerging that offer a revenue stream from carbon credits to protect and restore coastal ecosystems ("blue carbon"), resulting in climate mitigation benefits via carbon storage, climate adaptation of coastal zones, and ecosystem health benefits. Many of these projects are still nascent, as is the wider voluntary carbon market on which they rely for revenue (see Box 7 for example).

Box 7: Funding coastal resilience via nature-based carbon credits

Vida Manglar Blue Carbon Project, Colombia*:* Colombia is one of the world's most biodiverse countries. It is home to 14 percent of known plant species in the world, one-third of the world's bird species, and over 1,400 species of mammals[55]. However, this biodiversity is under threat due to economic activity, notably deforestation, and climate change, which is impacting not only animal species but also the ecosystem services that help regulate droughts, water security, and flooding. The Gulf of Morrosquillo is home to some of the most important mangroves and marine-coastal protected areas of the Caribbean coast, but despite the government declaring the Cispatá Bay on the Caribbean coast a marine protected area in 2006, mangroves continued to be cleared for cattle and agriculture. These activities have had a negative impact on the ecosystem services that local communities rely on for income and livelihoods[56].

The Vida Manglar Blue Carbon Project in the Gulf of Morrosquillo is restoring 11,000 ha of mangrove forests along Colombia's Caribbean coast, backed by revenues generated from carbon credits certified by Verra[54],[57]. The Project began in 2015 and is expected to run for 30 years and sequester around 1.2 million tons of CO_2[58].

- **Financing:** The upfront project costs are financed through the sale of carbon credits. The Vida Manglar project is an "umbrella" project that aggregates local community projects under a multi-stakeholder partnership comprised of Conservation International, Colombia's Marine and Coastal Research Institute, national environmental authorities, local NGOs, and community-based associations of mangrove workers. The combined carbon impacts across Vida Manglar projects were certified using Verra methodologies, and carbon credits were issued in 2021[59].
- **Cost Recovery:** The sale of carbon credits on the voluntary carbon market provides the revenue to justify investment in mangrove rehabilitation and reforestation[60]. Over 90 percent of these revenues will go back to community groups to invest in the conservation management plan[57].
- **Results:** Between 2015 and 2018, the project has sequestered 69,000 tons of carbon dioxide, generating revenues of over US$1 million from carbon credit sales. The project aims to remove a further 930,000 tons CO_2 over the next 20 years[61]. Within the project's first monitoring period, Vida Manglar reported a 69 percent reduction in unplanned deforestation compared with the projected annual deforestation rate in the project area[62].

[54] Conservation International (n.d.). Share the Facts About Mangroves. Available at: https://www.conservation.org/act/share-the-facts-about-mangroves.
[55] BBVA (2024). *BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue*. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.
[56] Natural Climate Solutions Alliance (2024). *Vida Manglar*. Available at: https://www.wbcsd.org/wp-content/uploads/2024/08/Vida-Manglar.pdf.
[57] South Pole Carbon Asset Management (2020). *Blue Carbon Project Gulf of Morrosquillo "Vida Manglar"*. Available at: https://registry.verra.org/app/projectDetail/VCS/2290.
[58] Verra (n.d.). *Blue Carbon Project Gulf of Morrosquillo "Vida Manglar"*. Available at: https://registry.verra.org/app/projectDetail/VCS/2290.
[59] Conservation International (2022). *Vida Manglar Impact Report*. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/cispata-bay-mangroves-2022-impact-report.pdf?sfvrsn=2b5b6f4d_3.
[60] OCTO (2024). *Vida Manglar Project: Certifying conservation actions to reduce carbon emissions and benefit local communities*. Available at: https://octogroup.org/vida-manglar-project-certifying-conservation-actions-to-reduce-carbon-emissions-and-benefit-local-communities/.
[61] Vida Manglar (n.d.). *Vida Manglar*. Available at: https://www.vidamanglar.co/#proyecto.
[62] Conservation International (n.d.). *Vida Manglar Carbon Project*. Available at: https://www.conservation.org/projects/vida-manglar-carbon-project.

While the use of carbon finance is linked primarily to climate mitigation (with the climate adaptation benefits being a positive secondary impact), in other cases preserving and enhancing coastal ecosystems can be motivated primarily by resilience concerns. The preservation of coral reefs, for example, is vital for biodiversity reasons, but also for their capacity to absorb wave energy (up to 97 percent in some cases), which is of huge economic importance for coastal businesses and communities that rely on them as a natural barrier against storm surges. In other parts of the world, mangroves can play an equally crucial role in absorbing storm surges and preventing erosion.

While coastal ecosystems can therefore provide essential services for resiliency against natural disasters and climate change, mobilizing sources of collective funding for their conservation is not straightforward, given the inherent collective action problem. While the fallback option tends to be reliance on public sector funding, another interesting area of private sector innovation relates to parametric insurance. Under a parametric scheme, insurance payouts are made as soon as an event is triggered (such as low rainfall for agricultural insurance, or wind speed for coastal hurricane insurance), avoiding the longer wait times associated with traditional indemnity insurance, which requires verification of losses before claims can be made. The potential use of this approach for funding of coastal ecosystem conservation is well illustrated through the case of Quintana Roo, Mexico, as presented in Box 8 below. This example demonstrates the use of parametric insurance to protect investments in nature-based infrastructure (in the form of coral reef restoration), whilst also demonstrating a case of collective action that mobilized taxes from local tourism businesses to fund the insurance premiums.

Box 8: Parametric Insurance for Coastal Ecosystem Conservation

Quintana Roo Coral Reef Restoration, Mexico: The Quintana Roo coral reefs cover approximately 100 miles of the Yucatan Peninsula's coastline, including the tourist towns of Cancun, Puerto Morelos, and Playa del Carmen. Tourism along the Mexican Caribbean coast is worth US$9 billion in assets. The reef absorbs 97 percent of a wave's energy before it hits the shore, which mitigates both storm-related damages and daily coastal erosion. The loss of coral reefs due to rising sea temperatures is leading to increased storm risks and beach erosion, threatening the region's key income source.

In 2005, two hurricanes struck the Cancun coast, causing US$8 billion in damages; however, areas with intact reefs suffered significantly less damage. Economic analysis assessed that storm damage along the coastline could triple from future storms[63], and by 2030, assuming that current reef loss trends continue, the region's economy could be halved as a result of the impact of coral reef decline[64]. In response, an insurance-based reef restoration project was developed in 2018 under a multi-stakeholder partnership involving the state government, local hotel owners, the reinsurance company Swiss Re, and TNC. The project used a parametric insurance approach, where payouts are triggered based on fixed trigger climatic parameters (in this case, recorded wind speed, given the correlation between hurricane strength and reef damage).

- **Financing:** The cost of reef and beach restoration after a storm is financed via the parametric insurance payouts, channeled through a Coastal Zone Management Trust (CZMT). The CZMT is a trust fund established by the State of Quintana Roo in 2018 that receives taxes from the local tourism industry to fund ongoing coral reef restoration works. Part of the funding received by CZMT is used to pay the premiums required for the reef insurance policy.

[63] Green Finance Institute (2018). *Quintana Roo Reef Protection (Parametric Insurance).* Available at: https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/quintana-roo-reef-protection-parametric-insurance/.
[64] Swiss Re (2021). How insurance is protecting the world's second biggest coral reef. Available at: https://www.swissre.com/risk-knowledge/mitigating-climate-risk/insurance-protecting-coral-reef.html.

- **Cost Recovery:** The CZMT is funded through taxes paid to the municipal government by tourism companies, hotels, and coastal landowners.
- **Results:** In 2020, Hurricane Delta hit the Quintana Roo coverage area, breaking up substantial coral structures53. An insurance payout of US$800,000 was paid to the CZMT, which funded a team to assess damage, carry out immediate repairs, and plan and implement longer-term restoration of the beaches and reef for the next 2 to 3 years.

A final area of potential private activity in nature-based coastal resilience relates to port development. Similar to the case of hydropower, maintaining ports can often require expensive dredging, which can be reduced via investments in coastal ecosystems to reduce runoff and siltation. As such, in principle, coastal solutions that leverage ecosystems such as coral and mangroves to provide storm buffering and shoreline stabilization infrastructure services can prove a natural ally of port projects. Inland watershed management schemes that stabilize riverbanks and slopes also reduce sediment loading on deltas. The global review suggests, however, that practical experience of NbS implemented directly within port investments, as well as analytical work on the potential cost-benefits of such investments, remains fairly limited. Where positive impacts of NbS projects on ports are documented, it tends to be as a positive side effect of wider coastal restoration projects.[65] One of the few cases identified of NbS implemented directly by the port operator is in Tibar Bay, Timor-Leste, documented in Box 9.

[65] GFDRR, et al. (2018). *Nature-based Solutions for Disaster Risk Management*. Available at: https://wriorg.s3.amazonaws.com/s3fs-public/NBS_for_DRM_brochure.pdf. Note: Includes examples from Alabama, the Netherlands, and Vietnam.

Box 9: Nature-Based Coastal Resilience Linked to Port Infrastructure

Tibar Bay Port Project, Timor-Leste: The Tibar Bay Port project is the first Public-Private Partnership (PPP) and the largest private investment in Timor-Leste. The port, which became operational in 2022, was constructed to replace the congested and capacity-strained Dili port and to facilitate expansion and efficiency in shipping operations in Timor-Leste.

The Tibar Bay site was selected with the aim to minimize negative environmental and social impacts, coupled with the need for appropriate land size, good navigational access, and proximity to Dili Port. Environmental impact assessments formed the basis for the design and construction of the project and the implementation of mitigation strategies to minimize adverse effects on the aquatic habitats, mangroves, fauna, and seagrass. While these measures were primarily driven by environmental impact goals, it was recognized that the focus on NbS would also have long-term benefits for port maintenance.

The motivations for this strong emphasis on environmental impacts came both from the government, which recognized the importance of ecosystems and biodiversity for the Timor-Leste economy, and from the International Finance Corporation (IFC), which, as transaction advisor for the PPP, brought strong Environmental and Social (E&S) standards and experience to bear.

- **Financing:** The 30-year PPP is being delivered through a Special Purpose Vehicle (SPV) (Timor Port) at a project cost of US$280 million, which comprises US$45 million equity from Bolloré, US$105 million from loans[66, 67], and US$130 million viability gap funding from the Government of Timor-Leste as a capital subsidy (minimum subsidy bidding criteria).
- **Cost Recovery:** The SPV generates revenue through user charges for port services based on a tariff schedule defined in the PPP concession agreement. The government receives royalty fees from the SPV based on the volumes of cargo passing through the port. The private partner bears the traffic and performance risk for the project.
- **Results:** So far, this investment has restored 20 ha of mangroves to mitigate the impact of coastal floods and erosion; 15 ha of seabed grass protection to reduce sedimentation and improve water clarity, which can reduce the need for dredging; and 23 ha of coral reef conservation, which helps maintain a natural barrier against waves and storm surges. Timor Port was awarded the BiodiverCity label (from the International Biodiversity & Property Council) at the end of the construction phase.

3.3 Urban Heat Management

Nature-based solutions can also be used for urban heat management, which in some cases such as green roofs and bioswales can have dual heat and flood management benefits. Heat-specific interventions also include measures like tree planting, parks, lakes, and water spray systems. For example, planting trees lowers air temperature by providing shade and by drawing water from the ground and evaporating it through the leaves.

As discussed in the prior chapter, urban cooling solutions tend to be localized and target specific sites such as schools or town centers. Examples of projects at more of an infrastructure scale are limited, although Box 10 provides an interesting example of a project in Adelaide, Australia, trialing NbS to cool airport runways in conjunction with spraying recycled water in partnership with a local water utility.

[66] Realfin (2024). *Private infrastructure transactions between 2013-2023*. Note: This was derived through World Bank PPIAF analysis of Realfin data.
[67] Global Infrastructure Hub (2022). *Tibar Bay Port*. https://www.gihub.org/innovative-funding-and-financing/case-studies/tibar-bay-port/.

Box 10: Nature-Based Urban Heat Management Project

Adelaide Airport Heat Reduction Trial (Australia): Adelaide City is expecting to see an increase in the number of days per year exceeding 40 degrees Celsius over the next few decades. Adelaide Airport is at particular risk of high temperatures, which affect aircraft performance and cause delays and cancellations—a significant impact in terms of operational revenues. In 2015, a trial aimed to prove the benefits of irrigation (using recycled water) of a 4-hectare area of the airfield. A crop (lucerne, also known as alfalfa) was planted to cool the air and provide a source of additional revenue[68, 69].

- **Financing:** The project was a joint venture between the privately owned Adelaide Airport and the state-owned company (water utility) SA Water to trial the cooling infrastructure solution. A cost-benefit analysis developed for the project estimated CAPEX for irrigation and crop planting to be at AUD 2.88 million (US$ 1.8 million). The investment was co-financed by Adelaide Airport and the local water utility[70].
- **Revenue:** Adelaide Airport recovered their costs through the project benefits, including efficiency gains and avoided losses, from urban heat management. The outcome from this trial was that the financial benefits for the airport would create a positive cash flow after 7 years of operation (which included the capital cost of the infrastructure to irrigate and crop the land) [71].
- **Results:** The trial demonstrated a 2.4-to-3.8-degree Celsius reduction in temperature in the irrigated area compared with the non-irrigated area on hot days. The cost-benefit assessments showed favorable results in using irrigation to support lucerne crops instead of grass on the airport site[69,72].

3.4 Addressing the Drivers of Nature Loss

While NbS can be invaluable in boosting positive nature impacts within infrastructure, addressing the drivers of nature loss can also often require grey infrastructure solutions. For example, untreated wastewater and plastic debris are having severe impacts on marine ecosystems, especially in developing countries where solid waste management and wastewater treatment are often chronically underfunded[73, 74, 75]. As such, increasing the scale and efficiency of physical wastewater treatment and solid waste management infrastructure in biodiversity hotspots will be critical to improving ecosystem health and the economic activities, such as tourism, that depend on it.

While private participation and financing of solid waste and wastewater treatment in EMDEs remains the exception rather than the rule, experience from PPIAF suggests a growing interest among governments to find ways to crowd in private investment in these areas:

[68] Airport Technology (2019). *Adelaide Airport in Australia trials heat mitigation methods*. Available at: https://www.airport-technology.com/news/adelaide-airport-heat-mitigation/?cf-view.
[69] Qian et al. (2020). Investigation on Airport Landscape Cooling Associated with Irrigation: A Case Study of Adelaide Airport, Australia. *Sustainability*, 2020, 12(19), Available at: https://doi.org/10.3390/su12198123.
[70] Stantec (2017). *Adelaide Airport irrigation project: Financial and Economic Analysis*. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0008/424727/Adelaide-Airport-irrigation-project.pdf
[71] CRC for Water Sensitive Cities (n.d.). *Adelaide Airport Irrigation Trial*. Available at: https://watersensitivecities.org.au/wp-content/uploads/2018/10/13-Adelaide-Airport_FINAL.pdf.
[72] Ingleton, et al. (n.d.). *Adelaide Airport Heat Reduction Trial. SA Water*. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0019/419203/Airport-Case-Study.pdf.
[73] Wen, et al. (2024). *Analyzing the effect of public private partnership mode on sewage treatment in China. Scientific Reports*, 14 (1), 9531. Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC11045736/#CR1.
[74] Marzouk and Ali (2018). Mitigating risks in wastewater treatment plant PPPs using minimum revenue guarantee and real options. *Utilities Policy*, 53, 121–133. Available at: https://doi.org/10.1016/j.jup.2018.06.012.
[75] Cetrulo, et al. (2019). An analytical review of the efficiency of water and sanitation utilities in developing countries. *Water Research*, 161, 372–380. Available at: https://doi.org/10.1016/j.watres.2019.05.044.

- Solid waste: PPIAF is currently providing technical assistance related to solid waste management PPPs in Latin America and the Caribbean, Africa, Asia, and the Middle East. In Belize, for example, the government is seeking to develop waste management PPPs in tourism hotspots to address the impact of solid waste on coral reefs and other ecosystems. As Belize is home to the Meso-American Barrier Reef, the second largest reef system in the world, the health and biodiversity of that reef system provide infrastructure services, including storm surge buffering and coastline stabilization.
- Wastewater treatment: PPIAF technical assistance is supporting the rollout of wastewater treatment PPPs in several countries in South Asia. For example, in Bangladesh, the Ministry of Local Government and the PPP Authority are developing wastewater management PPPs in connection with the Dhaka Rivers Project, which seek to help restore the ecological health of the country's water resources, which have been severely impacted by urban and industrial development[76].

The specifics of how to boost private participation and investment in areas such as wastewater treatment and solid waste management are broad topics, each worthy of separate stand-alone reports, and therefore beyond the immediate scope of this study. Readers interested in these topics are encouraged to refer to the World Bank PPP Resource Center, which includes a range of case studies of successful PPPs in both solid waste and wastewater treatment[77]. On the solid waste topic, another useful resource is the World Bank's *What a Waste* website, which provides extensive data and knowledge on the topic[78]. The report *What a Waste 2.0* includes a detailed chapter on financing and cost recovery for waste management systems, while the next iteration, *What a Waste 3.0,* is scheduled for publication in 2025 and is expected to include more recent insights on this topic.

[76] https://www.ppiaf.org/activity/bangladesh-ppps-under-dhaka-rivers-ecological-restoration-project#:~:text=To%20address%20Dhaka's%20wastewater%20management,in%20and%20around%20Dhaka%20City
[77] https://ppp.worldbank.org/public-private-partnership/node/7392#Water%20Supply%20and%20Sanitation
[78] https://datatopics.worldbank.org/what-a-waste/

4 Capital Markets

The examples discussed in the previous chapters demonstrate that it is possible to engage the private sector directly in the development of climate adaptation and nature-based infrastructure. Nevertheless, many governments will prefer to develop and deliver the infrastructure themselves or via publicly owned utilities. This, however, does not preclude the opportunity for attracting private financing, as governments can turn to capital markets to finance large-scale infrastructure, especially in countries with well-established financial markets. Table 3 lists the projects with capital markets financing that were reviewed in detail for this report.

Table 3: List of Adaptation and Nature-based Infrastructure Projects with Capital Markets Financing

Nature / climate goals	Project name	Infrastructure solution description	Financing model	Cost recovery model
Flood risk management and coastal resilience	**Delta Programme (Netherlands)**	• Grey - Dikes, flood defenses, water management systems • NbS – Wetlands and natural floodplains	**Capital markets finance**	Government pays (Public budget)
	DC Water Rock Creek Project A (USA)	• NbS - Bioretention and urban wetlands	**Capital markets finance**	User pays (Special water tariff)
Coastal resilience	**Belize Blue Bonds for Ocean Conservation (Belize)**	• NbS - Mangrove and coral reef protection	**Capital markets finance**	Government pays (Debt service payment on blue loan)
Addressing drivers of nature loss	**Biodiversity Bond (Colombia)**	• NbS – Aligns with IFC Biodiversity Finance Reference Guide categories	**Capital markets finance**	User pays (Commercial loan repayments)

The examples in Box 11 illustrate two such projects, one a large-scale national-level program in the Netherlands financed via a sovereign green bond and funded via the national budget, the other a smaller-scale innovative city-level project in Washington, DC, financed via a municipal bond linked to environmental performance and funded by a user charge.

Box 11: Capital Market Financing for Climate Adaptation

Delta Programme, the Netherlands: The Netherlands is a low-lying country with 26 percent of its area below sea level[79], making it highly vulnerable to climate hazards such as sea level rise and flooding. It is estimated that, in the absence of flood defenses, 60 percent of the country would be inundated on a regular basis. In 2011, the 2050 Delta Programme was launched to protect the Netherlands from intensifying flood risk, to secure supplies of freshwater, and to reduce the vulnerability of the country through better spatial planning for adaptation. For the period 2021-2034,

[79] Schiermeier (2010). "Few fishy facts found in climate report". *Nature*. 466 (170). Available at: https://doi.org/10.1038/466170a.

EUR 15 billion (US$15.3 billion) has been budgeted for the program, with more than 55 percent of this amount to be invested in new adaptation measures[80, 81].

The Netherlands is able to utilize a Green Bond to finance adaptation by virtue of the EU Taxonomy (which was recently amended to include flood risk mitigation and NbS) and the Capital Market Association (ICMA) Green Bond Principles, 2021[79]. The Dutch Treasury was able to fully map Delta programme expenditures to these standards, enabling transparency in line with international climate investment standards[82]. For the Netherlands, the result is access to long-term private institutional capital at lower rates than would be possible under typical sovereign issuances.

- **Financing:** Financing is sourced through issuances of sovereign Green Bonds. The latest issuance was in October 2023 for EUR 4.98 billion (US$5.1 billion), maturing in 2044[83]. Proceeds from the Green Bond go towards financing central government expenditures that contribute to climate change mitigation and adaptation.
- **Funding:** Green Bond debt service payments are funded through national government budget allocations.
- **Results:** The environmental and social indicators tracked under the bond include the percentage and length of flood defenses that are operational at safe levels, the reduction in land loss from inundation and coastal erosion, and the reduction in flood damage costs. As of 2023, 219 km of dykes and 138 flood defenses were improved to adhere to new flood risk standards, which is around 15 percent and 36 percent, respectively, of the program pipeline[81]. Nature-based solutions are prioritized where feasible.

DC Water Rock Creek Project A (USA): Prior to 2016, heavy rainfall events were overwhelming Washington, DC's sewer infrastructure, resulting in Combined Sewer Overflows (CSOs), which posed public health and pollution hazards due to their release into nearby rivers. To mitigate this flooding risk, DC Water developed the Clean Rivers Project, which built a system of deep tunnels, sewers, and diversion facilities to reduce the incidences and volumes of CSOs. The Clean Rivers Project also included green infrastructure projects using NbS—the first being the Rock Creek Project A—which involved the installation of approximately 20 acres of bioretention, permeable pavement, and two green infrastructure parks in the Rock Creek sewershed[84, 85].

- **Financing:** To finance the Rock Creek project, DC Water issued US$25 million of tax-exempt Environmental Impact Bonds (EIBs). In addition to the tax incentive, the bonds also introduced a risk-sharing mechanism through an 'outcome payment' system. If CSO volume reduction was greater than expected (greater than 41.3 percent reduction), then an additional outcome payment would be made to bondholders over and above the standard coupon payment. If below a minimum threshold (18.6 percent reduction), purchasers would pay a risk share payment to DC Water. If the project performed as expected (between 18.6 percent-41.3 percent reduction), only the standard coupon payment would be made to investors[82].
- **Funding:** An incremental fee was added to the customers' water bill, calculated based on a property's 'impervious area', which is the area that contributes to rainwater runoff into the

[80] Government of the Netherlands (n.d.). *Delta Programme: flood safety, freshwater, and spatial adaptation*. Available at: https://www.government.nl/topics/delta-programme/delta-programme-flood-safety-freshwater-and-spatial-adaptation.
[81] Dutch State Treasury Agency (2023). *State of the Netherlands Green Bond Framework*. Available at: https://english.dsta.nl/binaries/dsta-english/documenten/publication/2023/09/08/green-bond-framework---updated-8-september-2023/State+of+the+Netherlands+-+Green+Bond+Framework+-+updated+8+September+2023.pdf.
[82] Dutch State Treasury Agency (2023). Water investments at the heart of the new Dutch Sovereign Green Bond. Available at: https://english.dsta.nl/news/news/2023/09/08/water-investments-at-the-heart-of-the-new-dutch-sovereign-green-bond-the-dutch-state-treasury-agency-announces-the-new-green-dsl-to-be-issued-on-17-october-2023
[83] Dutch State Treasury Agency (2024). *State of the Netherlands Green Bond Report 2023*. Available at: https://www.dsta.nl/binaries/dsta/documenten/publicaties/2024/05/29/groene-obligatie-rapportage-2023/Green+Bond+Report+2023.pdf.
[84] District of Columbia Water and Sewer Authority (n.d.) *FACT SHEET: DC Water Environmental Impact Bond Results*. Available at: https://www.dcwater.com/sites/default/files/finance/eib-factsheet.pdf.
[85] District of Columbia Water and Sewer Authority (n.d.). *Clean Rivers Project*. Available at: https://www.dcwater.com/cleanrivers.

district's sewer system. This fee provides a funding stream for all stormwater projects (including the EIB debt service payments)[86].

- **Results:** The project reduced the volume of CSOs by nearly 20 percent compared with previous levels. This was an 'as expected' result, meaning that only the standard coupon was made with no outcome payments or risk premium adjustments.

These examples demonstrate how governments, utilities, and financial intermediaries are seeking to utilize capital markets to raise finance from investors seeking to achieve a range of positive environmental or social outcomes. This market has grown and evolved rapidly since the first Green Bonds were issued in 2007 and 2008 by the European Investment Bank (EIB) and the World Bank. For example, the Climate Bond Initiative (CBI), an international organization that provides tools, data, and knowledge to support governments to access capital markets for green and climate investments, reports that US$4.4 trillion of green, social, and sustainability (GSS+) instruments were issued in 2023. Among these, around US$6 billion in issuances were 'blue or water-labeled', meaning they primarily financed activities related to sustainable use of water, flood protection, and marine resources while fostering livelihood improvement. The CBI reported a 163% increase in water and blue-labeled debt year-on-year. While these instruments still account for less than 1% of the GSS+ debt market, it highlights a rapidly growing trend for the infrastructure asset types covered in this report[87].

In parallel to, and in support of, this market development has been the growth of a wide range of sustainable investment guidelines and taxonomies, which provide investors with guidance and criteria to identify and define investments that fall within the relevant goal (be it green, blue, or otherwise). To date, there have been over 40 sustainable investment taxonomies published covering climate, green, and overall sustainable economy investments.[88]

Amongst these, in 2022, the Biodiversity Finance Reference Guide,[89] published by IFC, became the first to specifically target biodiversity finance. Building on the Green Bond Principles and the Green Loan Principles, the guide provides a systematic methodology for investors to identify eligible use of proceeds that constitute biodiversity finance, hence helping direct financial flows to investments that promote the sustainable management of natural resources and conserve and enhance ecosystems and ecosystem services. The Guide also maps investment activities' contribution to the targets of the Kunming-Montreal Global Biodiversity Framework to halt and reverse biodiversity loss by 2030.

When it comes to infrastructure, while the various green, blue, and biodiversity taxonomies and guidelines include all relevant infrastructure investment categories, they are, by design, economy-wide rather than infrastructure-specific. For example, the IFC Biodiversity Finance Reference Guide covers the categories of productive land use and agriculture, freshwater and marine sustainable production, waste and plastic management, forestry and plantations, and (eco)tourism services. As such, it is not the intention to suggest that all proceeds under such instruments are utilized for infrastructure-related investments.

[86] District of Columbia Water and Sewer Authority (n.d.). *Impervious Area Charge*. Available at: https://www.dcwater.com/customer-center/rates-and-billing/impervious-area-charge.
[87] Climate Bonds Initiative (2023). *Sustainable Debt Global State of the Market 2023*. Available at: https://www.climatebonds.net/files/reports/cbi_sotm23_02h.pdf.
[88] Sustainable Banking and Finance Network (SBFN) (2024). *SBFN Toolkit: Sustainable Finance Taxonomies*. Available at: https://www.sbfnetwork.org/wp-content/uploads/2024/05/SBFN-Toolkit_Sustainable-Finance-Taxonomies.pdf.
[89] IFC (2022). *Biodiversity Finance Reference Guide*. Available at: https://www.ifc.org/en/insights-reports/2022/biodiversity-finance-reference-guide.

Box 12 illustrates two capital market examples of nature finance instruments: one a sovereign bond from Belize and one a privately issued bond in Colombia. The Belize Blue Bond provided a means for the Government of Belize to refinance a pool of commercial debt at a lower interest rate based on commitments to invest in marine conservation, while in Colombia the world's first biodiversity bond was issued in 2024 by Banco Bilbao Vizcaya Argentaria Colombia S.A. (BBVA) and IFC. In the Belize case, the marine conservation investments include NbS such as mangrove and coral reef restoration, which will strengthen coastal resilience, but also non-infrastructure investments such as sustainable fishing and marine spatial planning. The BBVA Bond includes eligible use of proceeds as defined in the IFC Biodiversity Finance Reference Guide.

Box 12: Leveraging Capital Markets for Nature-Based Infrastructure

Belize Blue Bonds for Ocean Conservation: Belize is a marine biodiversity hotspot, and the country's ecological resources are a significant driver of tourism, which is a critical part of the economy. Tourism alone contributes over US$150 million annually, making up over 12 percent of GDP. Fisheries add another US$14 million to US$16 million per year, supporting local livelihoods. Additionally, these ecosystems provide coastal protection valued at US$231 million to US$347 million annually by preventing erosion and storm damage.

Climate change is increasing the frequency and severity of hurricanes in Central America, and Hurricanes Eta and Iota caused massive flooding in Belize in 2020, creating significant damage to the country's infrastructure and ecological resources. This damage, combined with other economic factors, resulted in a 16.7 percent reduction in GDP and increased national debt to 133 percent of gross domestic product. As a result, the country suspended payments to bondholders. A US$553 million Eurobond ("Superbond"), which represented a quarter of its total debt, was trading at a deep discount of approximately US$0.38 on the dollar[90].

To resolve this national debt crisis, in 2021 the government of Belize worked with The Nature Conservancy (TNC) to establish a subsidiary LLC named the Belize Blue Investment Company (BBIC). BBIC worked with Credit Suisse to issue highly rated blue bonds and then to provide a "blue loan" to the Government of Belize, enabling the government to buy back the US$553 million Superbond at 55 cents on the dollar[91]. The loan was backed by political risk insurance from the United States International Development Finance Corporation (DFC) and parametric insurance to cover debt repayments in the event of hurricanes[88],[89]. This reduced Belize's debt by 12 percent of GDP and saved the government USD 189 million in principal outstanding. In return for these savings, the government of Belize agreed to spend approximately US$4 million per year on marine conservation until 2041[91].

- **Financing:** In addition to covering the cost of retiring the Superbond, the blue loan to the Government of Belize included a US$24 million endowment for future conservation activities. This funding is combined with annual government contributions and managed by a multi-stakeholder trust fund, the Belize Fund for a Sustainable Future (BFSF), established in 2022. BFSF issues grants to government and non-government partners that are developing projects for the sustainable use of coastal and marine resources.
- **Cost Recovery:** The government contributions to BFSF are funded through the national government budget based on the savings generated from the blue loan, and the premise that investing in nature and biodiversity will be good for the Belize economy, and hence future tax revenues.
- **Results:** The debt restructuring reduced Belize's debt-to-GDP ratio by 12 percent and provided US$189 million in debt service savings, attracting international institutional investors to

[90] The Nature Conservancy (2022). *Case Study: Belize Blue Bonds for Ocean Conservation*. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Belize-Debt-Conversion-Case-Study.pdf.
[91] IMF (2022). *Belize: Swapping Debt for Nature*. Available at: https://www.imf.org/en/News/Articles/2022/05/03/CF-Belize-swapping-debt-for-nature.

conservation finance. As of 2023, the Government of Belize had completed the first three of eight milestones contained in Belize's conservation commitments under Blue Bonds agreements. This has included expansion of the area of Belize's ocean in Biodiversity Protection Zones, the designation of public lands as Mangrove Reserves, and the initiation of a Marine Spatial Planning process. As of 2023, the BFSF has approved around US$9 million in government allocations and grants for marine conservation across 14 projects[92].

Biodiversity Bond, Colombia*:* As noted above, Colombia is one of the world's most biodiverse countries,[93] but this biodiversity is under threat. Addressing these issues is imperative, as biodiversity loss not only undermines the ability to meet climate goals but also impacts local communities' livelihoods and the country's long-term sustainable development.

In response, BBVA Colombia, in collaboration with the International Finance Corporation (IFC) and IDB Invest, pioneered the issuance of the world's first biodiversity bond. This US$70 million bond is dedicated exclusively to financing projects that combat biodiversity loss in Colombia. The bond proceeds are earmarked for projects focusing on reforestation, the regeneration of natural forests on degraded land, mangrove conservation or restoration, climate-smart agriculture, and wildlife habitat restoration, among others[91]. The project categories and criteria are aligned with the IFC's Biodiversity Finance Reference Guide[94] and aligned with the objectives of the Kungming-Montreal Global Biodiversity Framework [95, 96].

- **Financing:** BBVA Colombia is the largest foreign investor in the Colombian financial system and the fifth largest in the country. With BBVA acting as the issuing bank and the IFC and IDB Invest as the main investors (each subscribed up to US$35 million), the US$70 million bond will be utilized for green projects that address the key drivers of biodiversity loss[92],[93].
- **Cost Recovery:** As a commercial bank, the proceeds from the bond will be reinvested via loans to the private sector, which will generate the revenue stream to service the bond payments.
- **Results:** The first tranche of biodiversity bonds was issued in 2024. While it is too early to report specific results, the bond is expected to increase access to finance for investments that address key drivers of biodiversity loss, as well as more broadly increasing attention on the biodiversity impacts of commercial investments in the country. Furthermore, as the first issuance of its kind, it is hoped the bond will have a demonstration effect, encouraging other financial intermediaries to explore the use of similar instruments.

[92] Belize Funds for a Sustainable Future (BFSF) (2023). *Annual Impact Report 2023*. Available at: https://belizefund.bz/download/annual-impact-report-2023/?wpdmdl=54276&refresh=67bbb2b8ef9ff1740354232.
[93] BBVA (2024). *BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue*. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.
[94] IFC (2023). Biodiversity Finance Reference Guide. Available at: https://www.ifc.org/content/dam/ifc/doc/mgrt/biodiversity-finance-reference-guide.pdf.
[95] IDB Invest (2024). *IDB Invest and BBVA Colombia Announce Successful Placement of First Biodiversity Bond by a Financial Institution in LAC*. Available at: https://www.idbinvest.org/en/news-media/idb-invest-and-bbva-colombia-announce-successful-placement-first-biodiversity-bond.
[96] UNEP (2024). *Kungming-Montreal Global Biodiversity Framework*. Available at: https://www.cbd.int/gbf

5 Financing and Cost Recovery

The proceeding three chapters describe a diverse range of technical and financial approaches, both to develop the incremental infrastructure needed to adapt to climate change and to enhance the nature-related outcomes of infrastructure development. While this analysis demonstrates that there are valuable cases to draw lessons from, clearly this remains a relatively nascent space, especially with respect to private sector participation and financing. The reasons for this dearth of project cases appear to be due to: (i) the public nature of climate adaptation and nature-related infrastructure and the related lack of revenue mechanisms to attract private investment; (ii) short political cycles and a lack of long-term thinking related to climate change, especially given that the most serious climate impacts will materialize over the medium-long term; and (iii) the fact that international taxonomies and disclosure requirements for adaptation or nature-related investments are still taking shape, meaning that some relevant investments may be happening but are not being consistently tagged or reported as such.

Nevertheless, while it may be difficult to draw quantitative conclusions from experience to date, aggregating insights from the review of case studies, interviews, and global literature provides ideas and inspiration for others seeking to address these challenges.

A first step is to map the case studies according to the financing approaches that facilitate the flow of capital into infrastructure projects and the cost recovery mechanisms used to pay for those investments. Put simply, financing refers to the raising of money for investment (i.e., where does the money come from upfront?). Cost recovery refers to where the revenue comes from to pay for the investment, including the financing cost (e.g., interest payments), over the life of the project. A summary of the key projects that were reviewed in-depth for this report, together with the ways in which the project was financed and the cost recovery model, can be found in Table 4. Then, since the approach chosen for upfront financing is predicated in part on the potential for cost recovery over the life of the project, we first discuss: (1) cost recovery models, followed by (2) financing approaches.

Table 4: Financing Models, Instruments, and Cost Recovery Mechanisms

Financing model	Financing instruments	Project name	Cost recovery
PPPs with private finance	Corporate budget	Broadland Flood Protection (UK)	Government pays (Performance-based contract)
	Mix of equity, loans and government subsidy	Paris District Cooling PPP (France)	User pays (Cooling tariff)
		Tibar Bay Port (Timor-Leste)	User pays (Transport tariff)
			Government pays (Viability Gap Funding)
		As-Samra Wastewater Recycling Plant (Jordan)	Government pays (Availability payment) – partially tariff recovered
		Canal del Dique (Colombia)	Government pays (Availability payments)
			User pays (Transport tariff)
	Mix of municipal bonds, equity, and commercial loans	Fargo-Moorhead River Diversion Project (USA)	Government pays (Availability payment)

Financing model	Financing instruments	Project name	Cost recovery
	Project bonds	Mission Rock, San Francisco (USA)	Land value capture (Developer rights payments and special property taxes)
Capital markets finance	Biodiversity bond	Biodiversity Bond (Colombia)	User pays (via commercial loan repayments)
	Blue bonds	Belize Blue Bonds for Ocean Conservation (Belize)	Government pays (Debt service payment on blue loan)
	Green bonds	Delta Programme (Netherlands)	Government pays (Public budget)
	Municipal bonds	DC Water Rock Creek Project A (USA)	User pays (Special water tariff)
Own-source financing	Carbon credits	Vida Manglar Blue Carbon Project (Colombia)	Climate-related funding (carbon credits)
	Corporate budget	Adelaide Airport heat reduction trial (Australia)	User pays (Airport fees and revenues)
	Municipal budget, donor grants	Greater Cape Town Water Fund (South Africa)	Corporate and government pays (corporate and public budget)
		Quito Water Protection Fund (FONAG) (Ecuador)	Corporate and government pays (corporate and public budget)
Public finance, including donor grants	Donor grants and loans	Msimbazi River Basin (Tanzania)	Government pays (Public budget)
			Land value capture (Property sales and leases)
	Grants	Itaipú Paraguay Biodiversity Project (Paraguay)	User pays (Energy tariffs)
		Quito Water Protection Fund (FONAG) (Ecuador)	User pays (Water tariffs)
	Grants and government loans	Fargo-Moorhead River Diversion Project (USA)	Government pays (Public budget)
	Parametric insurance payout	Quintana Roo Coral Reef Restoration (Mexico)	Government pays (Public budget, special tourism taxes)

5.1 Cost Recovery

To attract private investment, an infrastructure project (or portfolio of projects) must be able to generate a reliable and stable source of revenue over the life of the project[97]. When it comes to the topics of adaptation and nature-based infrastructure, this question of how to generate the revenue needed for the project is arguably the biggest challenge, since much of the infrastructure covered by this report—such as for flood management and coastal resilience—does not readily lend itself to straightforward revenue generation approaches.

The project examples discussed in the preceding chapters show a range of different options to tackle these challenges. Broadly speaking, the cost recovery models found under these projects can be classified as: (i) user pays, (ii) government pays, (iii) land value capture, and (iv) climate-

[97] Global Infrastructure Hub (2020). *Unpacking complexity to provide solutions for funding and financing of infrastructure.*

related funding. These categories are not mutually exclusive, and almost all the projects leveraged some combination of these revenue sources. The lines between them can also sometimes be blurred, as is discussed further below. However, for the purposes of thinking through potential cost recovery mechanisms, it is a useful categorization approach.

(i) User pays

A 'user pays' model is where the service provider (public or private) charges customers directly for use of the services[98]. These charges come in the form of service fees, tolls, or tariffs.

Certain areas of climate adaptation infrastructure do lend themselves to user fee generation. This is particularly true in the water sector, where investments in water security will in almost all cases be at least partially recoverable via user fees charged by the public or private water service provider. This can be used for both grey and NbS solutions, and the established examples of catchment-level water security programs, such as the Catskills in New York, Anglian Water in the UK, and Quito in Ecuador, have all become part of the core investment program for the respective utility or city government (albeit at times complemented by government or philanthropic funding sources). Nevertheless, in many countries the water sector continues to rely heavily on government funding, and in such cases strengthening the financial sustainability of the sector is likely to be a prerequisite for addressing the climate adaptation investment challenge, especially in water-scarce countries.

On the flood management topic, while a user-pays approach is inherently more challenging, the project examples do provide some insights. For example, DC Water funded the green stormwater investments under its Environment Impact Bond via a surcharge on water bills that was tied directly to the property's runoff area. In the case of the Fargo-Moorhead and Quintana Roo reef projects, a substantial portion of the funding was raised via local taxes. Although this might technically be labelled as "government pays", the result was that funding was tied to the specific beneficiaries, in contrast to the Broadlands project in the UK or the Delta Programme in the Netherlands, where all funding came from central government budgets. The Canal del Dique project also utilized user fees to fund flood management investments since this was integrated as part of the overall concession for the waterway.

Finally, experience shows, perhaps unsurprisingly, that the use of user fees to fund NbS will be a direct function of the underlying revenue structure of the infrastructure project. The Itaipú project in Paraguay, for example, is a commercially viable project easily capable of absorbing the cost of the catchment watershed program, which is small relative to the scale of revenues generated from energy sales. In Tibar Bay, the NbS costs were likewise subsumed as part of the overall project costs, which were mainly funded via fees charged to port users. In the Tibar case, this was complemented by a government capital investment subsidy of around one-third of the total cost, which is common for higher-risk user-pays PPPs where investors are exposed to long-term commercial risk (the case of Canal del Dique similarly combined availability payments with user fees to reduce risk for the private partner).

(ii) Government pays

A 'government pays' model is one where the government provides the primary source of revenue (in some cases, the sole source) for the project. This revenue can come in different forms, for example, as availability payments (where governments pay for the asset or service to be

[98] Yescombe and Farquharson (2018). *Public-Private Partnerships for Infrastructure: Principles of Policy and Finance*. 2nd ed. Elsevier, Oxford.

available at contractually defined conditions or quality)[99], or as debt service payments for privately placed bonds or loans.

Government funding generally becomes the default option for essential infrastructure where alternative revenue sources are not readily available or politically feasible. It is also a logical source of funding for projects that are public in nature (a fundamental rationale for paying taxes being to cover the cost of public assets that are best funded at a collective scale). In the government-pays examples reviewed under this study, funding was generally sourced from existing tax revenues channeled through the public budget. That said, with many countries suffering from growing fiscal constraints, relying on general budgets will often be a limiting factor. For these reasons, creativity may be needed in terms of how government funding is raised, such as in the Fargo-Moorhead project, which was able to raise additional revenue in the form of a special sales tax linked to the project's beneficiaries.

(iii) Land Value Capture

Land value capture (LVC) involves a set of land-related policy, administrative, and financing mechanisms that enable governments to recover and reinvest revenues generated via land value increases that result from public investment and government actions. In the context of climate adaptation, there can be a direct link between a project that mitigates climate risks and the value of the land impacted. For example, a flood management project will increase land value and reduce insurance premiums in areas that would otherwise be flood-prone. If part of this increase can be recovered by governments via property taxes, or fees charged to developers for new real estate permits, this provides a source of revenue to offset the upfront investment costs.

Under this study, two such cases were identified. Both fall under the flood mitigation and coastal resilience category. This included the Mission Rock project in San Francisco, which successfully leveraged the latent value of a defunct industrial site to fund a new flood-resilient neighborhood and supporting infrastructure. Meanwhile, the real estate development under the Msimbazi project in Dar es Salaam, while still at the stage of master planning, and facing different market and political-economic conditions, is also valuable in conceptualizing how such an approach could be applied in a developing country context.

While we did not encounter examples of green infrastructure projects that have successfully converted increasing land value into project revenues, such opportunities should exist in theory, given the positive relationship between land value and NbS investments. For example, studies in the USA and Latin America demonstrate an increase in property values in areas with greater tree cover, which can also mitigate against urban heat and stormwater impacts. The challenge appears to be that, while conceptually LVC is an attractive funding mechanism for infrastructure and urban development, the complexity of trying to define and collect fees from specific project beneficiaries, as opposed to simply using general taxation, can result in transaction costs that exceed the benefits. As such, it is no coincidence that projects such as Mission Rock involved the development of unique, high-value urban locations where the underlying land is of sufficiently high value to justify the approach.

[99] World Bank (n.d.). *PPPRC: PPP Contract Types and Terminology*. Available at: https://ppp.worldbank.org/public-private-partnership/applicable-all-sectors/ppp-contract-types-and-terminology/.

(iv) Climate-related funding

Climate funding is a broad topic, but in this context can be thought of as revenue derived from the achievement of specific, verifiable climate outcomes. This could include, for example, the generation of carbon credits from projects that can achieve verifiable GHG emissions reductions. It could also include wider results-based climate funding not tied to carbon markets (including from governments, multilaterals, or the private sector) that are linked to the generation of specific climate or nature-related outcomes. While this funding generally centers on mitigation impacts (GHG avoided and/or captured), many such investments can, either by design or by extension, generate adaptation co-benefits.

The Vida Manglar Blue Carbon Project in Colombia is just such an example, where 11,000 hectares of mangrove forests are being reforested along Colombia's Caribbean coast, backed by revenues generated from carbon credits. Another even more ambitious example is the Delta Blue Carbon project in Pakistan, a joint venture between Indus Delta Capital and the Government of Sindh seeking to reforest 86,000 hectares. While fewer public details are available on this project, it appears that the Pakistan project has already generated around US$7 million in carbon credit revenue, with scope for this to increase by over 10-fold if the full project results are achieved.

Conceptually, funding projects through the sale of carbon credits offers a very attractive mechanism to internalize the environmental externalities and hence further incentivize the use of NbS in infrastructure projects. While both the Colombia and Pakistan projects mentioned above show this model can be a successful mechanism to finance nature-based infrastructure, there are fewer details on how each of the projects was structured. It appears that projects were developed in a highly localized way, through community partnerships on a large scale, indicating that stakeholder engagement is critical for these types of models to be replicated. However, for this to become a mainstream funding option, it requires the development of robust and transparent carbon markets at scale. When and how this will happen is the subject of considerable efforts and debate that are beyond the scope of this research.[100]

Another example of a performance-based funding model that could be used more widely for climate projects comes from DC Water's Rock Creek project. The project introduced a risk-sharing approach with its bond investors, whereby a 'bonus payment' is paid to investors depending on the success of the project in relation to climate adaptation outcomes. If the investments result in performance greater than an agreed baseline, DC Water makes a one-time performance payment to investors of US$3.3 million. Conversely, if runoff reduced below the minimum threshold, investors make a one-time payment to DC Water of US$3.3 million[101]. However, such an approach does require a relatively high level of sophistication on the part of both investors and issuers, as well as the ability to generate transparent and verifiable data on project outcomes, and therefore might not be feasible in many contexts.

5.2 Financing

Financing refers to the raising of money upfront to cover investment during the early, capital-intensive stages of a project's development. This includes the money used to invest in land,

[100] See for example, the World Bank "State and Trends of Carbon Pricing, 2024". Available at: https://openknowledge.worldbank.org/entities/publication/b0d66765-299c-4fb8-921f-61f6bb979087

[101] USA EPA (2017). *DC Water's Environmental Impact Bond: A First of its Kind.* Available at: https://www.epa.gov/sites/default/files/2017-04/documents/dc_waters_environmental_impact_bond_a_first_of_its_kind_final2.pdf.

construction, equipment or supplies, and other investments that address operating losses until revenue can be generated[102].

On the financing side, the projects reviewed fall into typical categories for infrastructure project finance: (i) PPPs with share of private finance; (ii) capital markets finance (national and sub-national); (iii) own-source financing; and (iv) public finance, including donor grants. Again, these are not mutually exclusive, and in almost all cases, a minimum level of public sector financial support has proven necessary to crowd in private financing. As such, the discussion should arguably focus less on the question of *public versus private* finance, but rather on how these sources can be combined and the minimum subsidy level required to achieve the project objectives.

(i) PPPs with private finance

While there is no universal definition of a PPP, for the purposes of this report, the term is defined as in the World Bank *PPP Reference Guide*, namely, "a partnership between the public and private sector to deliver a public asset or service with full or partial transfer of risks to the private sector"[103]. This does not include, therefore, wider forms of more general collaboration or pooled funding between governments, the private sector, and NGOs that are sometimes referred to as PPPs.

PPPs can be used as an alternative to public sector delivery for almost any infrastructure service. They tend to be more commonly used for projects that generate revenues from user fees (e.g., from passengers on metro systems, toll road users, and water supply customers). As such, projects such as Canal del Dique in Colombia and Tibar Bay in Timor-Leste are typical in representing PPPs that mobilized private finance on the back of the rights to charge users for the service.

Private finance can also be mobilized under government-pays PPPs, although for the government, this is generally a way of deferring rather than reducing fiscal obligations. Since financing costs for the private sector are generally higher than for government, this may be attractive in the short term but will tend to increase rather than decrease long-term funding needs. In such cases, it is therefore important that the use of PPPs is also motivated by other reasons, such as the opportunity for increased efficiency and risk transfer.

The Fargo flood management project and As-Samra WWTP are such examples, where the use of the PPP mechanism was motivated by the complexity of the project and desire to reduce the risk of public management, but with the added benefit that the private partner mobilized a portion of the finance for the upfront capital investment (backed by the availability payment obligations). It is also typical of very large-scale PPP projects, which, out of practical necessity, tend to tap into a wide range of different financing mechanisms (in this case, private finance being used in conjunction with state and national government grants and, in the case of Fargo, publicly issued bonds).

PPPs also tend to be utilized for larger projects given the high transaction cost of PPPs at the project design phase and tend to be more prevalent and successful in countries with strong PPP governance capacity and a track record in PPP project development and oversight. The

[102] Delmon (2010). *Understanding Options for Public-Private Partnerships in Infrastructure*. Available at: https://ppp.worldbank.org/public-private-partnership/sites/default/files/2022-05/WPS5173_0.pdf.
[103] World Bank (2017). *Public-Private Partnerships: Reference Guide Version 3*. Available at: https://ppp.worldbank.org/public-private-partnership/sites/default/files/2024-08/PPP%20Reference%20Guide%20Version%203.pdf.

case studies reviewed in this study generally follow these conclusions, with the majority being over US$100 million in total project costs and coming from countries (such as the US, UK, Colombia, and Jordan) with a relatively good track record in developing and managing PPP projects.

(ii) Capital markets finance

As discussed in the previous chapter, another financing solution commonly used by governments for large-scale public infrastructure is to tap capital markets. Issuing a bond, for example, can allow the government to crowd in private capital for large upfront capital investments, repayable over the long term based on the returns from the project (either direct or indirect, such as via increased growth and hence taxation). For the bondholders, infrastructure projects provide a good investment option for those seeking stable, long-term returns, such as pension funds and other institutional investors.

Within this category, the growing market for climate- and environment-related bonds provides a specific source of finance for infrastructure projects with adaptation and nature goals. Indeed, many of the projects reviewed under this study—including the Delta Programme in the Netherlands, the DC Water Environmental Impact Bond, the Belize Blue Bond, and the BBVA Biodiversity Bond—tapped capital markets via different forms of green or blue finance instruments, unlocking sources of financing that would otherwise not have been available for these projects. The benefits of such approaches include: (i) scale, enabling financing at the program level (as was the case for the Netherlands) rather than sourcing and structuring transactions project-by-project; (ii) providing access to long-term institutional capital that would not otherwise be possible to direct towards adaptation projects; and (iii) creating greater incentives for the issuer to consciously consider climate or nature-related outcomes within capital allocation decisions.

Related to this topic, a further potential financing scenario is for governments to borrow against projected future revenues that will accrue as a direct result of the project in question. This includes, for example, the use of mechanisms such as "tax increment financing", where governments raise bonds or loans against expected future tax increases resulting from infrastructure or urban regeneration projects.[104] While not encountered in the case studies reviews for this report, conceptually this is a model that could be applied to the financing of public investments or government-pays PPPs for climate adaptation infrastructure.

(iii) Own source financing

Many adaptation investments may not be feasible or justifiable in terms of size or returns from a project finance perspective. However, companies may be willing to invest in climate adaptation and nature-based infrastructure from a company's development budget, which, in turn, is financed through the company's own development capital, through general-purpose loans, and/or bonds raised at the corporate level. The benefits that these kinds of investors may derive from such voluntary capital contributions could be direct, in terms of cost savings or risk reduction. However, they can equally be indirect, for example, through increased company value through market capitalization as a result of goodwill-driven value appreciation, ESG compliance, improved market access, and enhanced customer loyalty.

[104] Kerth and Baxandall (2011). *Tax-Increment Financing: The Need for Increased Transparency and Accountability in Local Economic Development Subsidies*. Available at: https://publicinterestnetwork.org/wp-content/uploads/2011/12/Tax-Increment-Financing-vMD.pdf.

In other cases, where there is a need for periodic funding, as opposed to large upfront capital investment, it may become feasible to finance adaptation and nature-based interventions via the corporate budget (private sector) or as part of the regular utility or city government budget (public sector). This is especially true where the business case has become established.

For example, the Itaipú Paraguay Biodiversity Project, linked to the Itaipú hydropower plant, financed a significant proportion of the watershed program through its own budget, justified by the project benefits related to energy generation productivity and efficiency. Given the development and environmental impacts, it was also possible to complement this with a pool of grant funding from the Paraguayan government and the World Bank (through the Global Environment Facility). The Quito Water Protection Fund similarly utilized a mix of annual funding from the utility (on the back of the 2 percent water conservation user surcharge) together with donor contributions from NGOs and private sector stakeholders. The Adelaide Airport heat reduction pilot likewise relied on the corporate budget of the operator to finance the project, an example that demonstrates how companies are willing to invest in resilience and climate adaptation where there is a clear business rationale. Often this might not be of a scale to justify raising project finance but will rather be financed through the company's own development capital, or through general-purpose loans and bonds raised at the corporate level[105].

(iv) Public finance, including donor grants

Grant funding (i.e., immediately available, non-repayable capital) tends to be a more limited source of finance for large-scale infrastructure projects, simply because the year-to-year fiscal demands on most governments tend to limit the availability of capital grant budgets.

Where grant funding can be invaluable, however, is at the project development or pilot stage, especially for projects in EMDEs. The power of government or donor grant capital can be seen, for example, in many of the watershed catchment projects discussed earlier. The Greater Cape Town Water Fund, for example, was catalyzed via the combination of subsidized NGO technical support combined with corporate social responsibility contributions from private partners. This was invaluable during the high-risk pilot phase, allowing the project to now move to the phase where it's possible to develop long-term sustainable financing options. Similarly, the concept for the Msimbazi project in Tanzania was only possible to develop via grant-funded technical support from the World Bank.

In addition to funding, the various EMDE case studies in this report point to the important technical and coordinating role of DFIs and specialist international NGOs at this project development stage. In many of the cases, participation of an international partner helped to offset the high transaction costs related to information and data for projects that had not been tried before. This support was invaluable in creating the confidence needed for private investment, especially when combined with follow-on financial support in the form of loans or guarantees.

[105] The benefits that an investor may derive from such voluntary capital contributions to resilience could include ESG compliance, increased company value through market capitalization, goodwill-driven value appreciation, improved market access, and enhanced customer loyalty.

6 Enabling Environment Priorities

While the preceding discussion on financing and cost recovery helps to break down the different mechanisms through which projects may be financed, the ability to tap into these sources at scale will ultimately rely on the strength of the economic or business case for the underlying investment. For projects requiring government funding, this means a clear economic justification that the project represents an optimal use of scarce fiscal resources. For the private sector, it means access to sources of revenue that will generate a return on investment commensurate with the risks involved in the project. Without a clear business case, project activities are likely to remain small and constrained by the limits of grants or NGO funding.

The preceding review of global experience and project case studies points to a range of different supportive interventions in the enabling environment that can help to strengthen the business case for investment. This final chapter will therefore briefly explore lessons on the enabling conditions that have proven necessary or beneficial to creating a positive business case for investment in adaptation and nature-based infrastructure.

The importance of a strong enabling environment is reinforced by the fact that many of the more successful cases to date come from developed economies, where the financial sector and public administration are sufficiently developed to support the types of capital markets instruments, new tax revenues, and long-term PPP structures utilized by the projects discussed so far. However, while strengthening these fundamentals is clearly important, the case studies also point to three broad enabling environment factors specific to developing the economic and business case for investment in adaptation and nature-based infrastructure projects, namely: (i) improving access to climate data, (ii) creating investment incentives to address market failures, and (iii) strengthening multi-stakeholder organization and governance. These findings closely mirror the conclusions of the 2021 World Bank report, *Enabling Private Investment in Climate Adaptation and Resilience: Current Status, Barriers to Investment and Blueprint for Action*[106], which provides a valuable resource for readers interested in a detailed analysis of these topics.

6.1 Improving Access to Data

There are three essential data building blocks to better, more effective investment decision-making: 1) the metrics that define success, 2) comparable and consistent data, and 3) methodologies to evaluate risk, performance, and impact (Figure 1).

Figure 1: The Role of Data, Metrics, and Evaluation Methods in Making More Informed Investment Decisions

Developing metrics for success

Metrics and indicators play a critical role in articulating the value of climate adaptation and nature-based infrastructure. By making benefits more visible and measurable, they help build demand for these investments. Over time, this can support monetization and strengthen the

[106] https://openknowledge.worldbank.org/entities/publication/6219bf23-87e1-5f30-aaf9-30e0cd793ce3

business case for adaptation, and for nature-based solutions as viable alternatives to traditional grey infrastructure. Currently, the lack of granular data linking interventions to positive adaptation and nature outcomes—especially in the short term—makes it challenging to quantify economic returns on investment[107, 108].

Better impact data is especially needed to scale the use of NbS as an alternative to grey infrastructure. Findings from stakeholder consultations revealed that grey infrastructure is still viewed as the "safe" option, as approaches for deriving the expected benefits for climate adaptation and nature-based infrastructure are less well-known and often require complex models, making them more challenging to implement. As such, there is a strong case for public and donor support in proving the "green business case" for NbS as a way to achieve adaptation and nature-based outcomes.

For example, TNC, a partner in the development and implementation of the Greater Cape Town Water Fund in South Africa, defined their end goal in terms of the following metrics: to yield annual water gains of 55 billion liters per year (equivalent to two months' water supply for the City of Cape Town) during the first six years of the project[109]. TNC worked with several technical consultancies to gather data and develop models to predict water flows in the local area based on different hydrological, climate, and invasive species scenarios. This allowed them to capture and disseminate data on water savings, which ultimately demonstrated the business case for invasive alien plant removal—which was highly effective in augmenting water flows, with benefits similar to desalination but at a fraction of the cost[110]. Data is continually being captured and published online[111].

It is important to note that while Cape Town demonstrated success in this case, these efforts were complex and costly, requiring the use of electronic data loggers to monitor the flow of water[109] during the design and operational phases and extensive coordination of multiple data sets and teams across more than 80 hydrological management units and 54,000 hectares, including rugged mountain terrain accessible only by specialized field crews. Due to the project's scale, each area had its own funders and management teams. While many lessons can be learned from this deployment of metrics, data, and methodologies, the availability of funding and skills (in large part supplied through many strategic partnerships with NGOs and the private sector) were also critical elements in the project's success.

Gathering comparable and consistent data

The ability to aggregate data across projects is crucial for scaling investments in adaptation and nature-based infrastructure. Currently, relevant project data is highly fragmented, reported in inconsistent ways, or, in many cases, not reported at all, or because the adaptation or nature components are being subsumed within larger projects or programs and therefore are not being identified. The inevitable blurring of lines between adaptation activities and

[107] GCA (2023). *Financing NBS for Adaptation*. Available at: https://www.eci.ox.ac.uk/sites/default/files/2023-12/Financing_NbS_for_Adaptation-GCAOxford2023-finalv2.pdf.
[108] World Bank. 2024. *Rising to the challenge*. https://www.worldbank.org/en/publication/rising-to-the-challenge-climate-adaptation-resilience
[109] The Nature Conservancy (2024). *Science Behind the Scenes in Cape Town: A new interactive tool tracks the progress of water-saving activities that can help avoid the next "Day Zero"*. Available at: https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/new-tool-validates-cape-town-water-fund/.
[110] The Nature Conservancy (2020). *Greater Cape Town Water Fund: Securing Water Through Nature*. Available at: https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf.
[111] Greater Cape Town Water Fund (2025). Decision Support System. Available at: https://public.tableau.com/app/profile/waterfunds/viz/GCTWFDSSv1/PublicDSS.

developmental efforts also complicates the tracking and monitoring of progress. While these issues will not be a barrier to the developing projects with a strong underlying economic or business case, the development and tracking of comparable data can assist governments and investors in identifying relevant and impactful projects. This would help open a greater range of financing options, including via dedicated climate or environmental funding, green capital markets sources, and so forth.

For example, under the Delta Programme in the Netherlands, the Dutch Treasury developed and monitored a set of adaptation-related indicators to track progress under the bond, including the percentage and length of operational flood defenses, the reduction in land loss from inundation and coastal erosion, and the reduction in flood damage costs. Furthermore, this enabled the Treasury to finance the adaptation investments under a Green Bond, as they could demonstrate alignment with the EU Green Bond Taxonomy, which included flood mitigation and nature-based solutions as eligible categories. The importance of complementary action at different levels is discussed further under section 6.3 below.

Evaluating risk, performance, and impact

Finally, while there exists widespread concern about the scale of climate risks, how the specific impacts will play out in different geographies, at what magnitudes, and over what timelines, remains a source of considerable uncertainty for both governments and private investors. On a positive note, climate data sets and models that can be used to estimate climate risk are becoming more readily available and more accurate with every year. For initial, early-stage assessments, open-source databases and publicly available statistical models may be used (examples that may be useful can be found in Annex 3). However, it is important to note that more uses, such as detailed assessments to support project design and financial modeling, require more robust models and higher resolution, site-specific data, which can be costly and difficult to come by. Nature-related data and baseline biodiversity scenarios are also limited, which makes it challenging to identify and evaluate the best mitigation solutions for positive outcomes.

The more accurate climate projections become, the more reliable project cost-benefit analysis becomes. This helps governments to justify the allocation of public funding and helps reduce risks for the private sector in cases where returns are tied to climatic factors. For example, in the Fargo-Moorhead project in the USA, historical data and future projections were critical components in the project design. Designs incorporated extensive historical flood data and future climate projections to anticipate the potential increase in flood frequency and severity. This helped in designing infrastructure capable of handling extreme weather events, taking into consideration the local ecosystem, and aided in developing future performance standards for long-term operations that would be feasible for the private sector partner[112]. Meanwhile, in the case of the Rock Creek Project in Washington, DC, the uncertainty surrounding the potential impacts of nature-based solutions was factored into the financing mechanism, with bond payments tiered according to the impact of the project, reducing the risk profile for DC Water.

[112] Metro Flood Diversion Authority (2024). *Fargo-Moorhead Metropolitan Area Flood Risk Management Project: Draft Adaptive Management and Mitigation Plan, May 2024*. Available at: https://fmdiversion.gov/wp-content/uploads/2024/05/FMM_AMMP_Main-Document-May-2024.pdf.

6.2 Creating investment incentives

A recurring message throughout this study relates to the risk of underinvestment in projects that achieve positive climate adaptation and nature outcomes due to the public nature of the benefits. As such, "internalizing the externalities"—bringing the benefits of positive impacts onto the financial cost-benefit ledger of the project—is arguably the key challenge to unlocking greater private investment in these areas.

Policy, planning, and regulation

One of the simpler ways to effect change in this area is to use policy, planning, and regulatory approaches to impose desired standards on public and private project developers. For example, developing national adaptation plans signals investment priorities to the market; updating planning laws and building codes ensures that all new development permits come with a requirement to meet certain flood or heat resilience standards; and integrating minimum adaptation or nature standards within procurement and contract provisions for infrastructure services raises the bar for all investments. Assuming strong monitoring and enforcement exist, such approaches can be effective in mainstreaming minimum levels of climate adaptation and biodiversity protection into all new development.

At the project level, the Tibar Bay Port PPP in Timor-Leste provides an example of regulatory and standards-driven best practice. At the outset, the project was classified by the Government of Timor-Leste as a 'Category A' project with significant potential environmental impacts, and as such it was required under law that an Environmental Impact Assessment and Environmental Management Plan be developed for the project. The project's procurement criteria and subsequent concession agreement also specified compliance with the IFC's E&S Performance Standards, thereby introducing a high minimum baseline, founded in both national law and international standards, for compliance with best practice environmental outcomes. This included, for example, a contractual obligation to provide "biodiversity offsets", which includes planting mangroves to offset biodiversity loss and to establish biodiversity conservation zones.

Another good example comes from the Netherlands. Being situated in a low-lying delta, the Netherlands is highly vulnerable to climate impacts. As such, the country developed a robust policy and regulatory landscape to promote climate adaptation, starting with its National Adaptation Strategy. The strategy sets updated goals in relation to adaptation and imposes criteria and standards to ensure that all development considers and integrates measures to address sea level rise, increasing heat, prolonged periods of drought, and more extreme precipitation[113]. The adaptation strategy also influences public funding priorities to build resilience, such as the Delta Programme discussed in Chapter 2, which focuses on flooding safety, freshwater supply, and spatial adaptation.

Carbon and nature markets

While policy, planning, and regulatory levers can undoubtedly improve adaptation and biodiversity outcomes, linking revenues directly to the achievement of climate and nature-

[113] Kennisportal Klimaat adaptatie (n.d.). *National Climate Adaptation Strategy (NAS).* Available at: https://klimaatadaptatienederland.nl/en/policy-programmes/national-strategy/nas/.

positive impacts can be an even more powerful means to optimize outcomes. The carbon market for nature-based carbon credits is one such example, and includes both the "voluntary" market, where carbon credit transactions are undertaken on a voluntary basis to meet self-imposed emissions targets (for example, those set by corporate social responsibility commitments), and the "compliance" market, where carbon credit purchases are driven by mandatory regimes[114]. While linked primarily to incentivizing climate mitigation outcomes (GHG emissions avoided or captured), the fact that premiums exist for credits related to nature-based (as opposed to technology-based) solutions implies that buyers see positive value in both climate and nature outcomes.

The Vida Manglar project in Colombia is one such example where the project, based on carbon sequestration through mangroves, is incentivized by the sale of blue carbon credits, which sell at a premium in the voluntary carbon market. Similarly, the Delta Blue Carbon Project in Pakistan has been able to sell blue carbon credits at a premium, close to US$30 per carbon credit[115]. This potential for future returns, coupled with a long-term agreement with the Government of Sindh, provided a compelling incentive for a private investor in Pakistan to take on the upfront risk of project development.

While the potential scale of the global blue carbon market (i.e., carbon credits from the carbon sequestration and storage by mangrove, saltmarsh, and seagrass ecosystems) has been projected to be as high as US$190 billion per year[116], nature-based carbon markets currently remain small and fragmented due to the complexities of verification processes, high transaction costs, and maintaining the permanence of these nature-based assets. This implies the need for scale and for long-term partnerships—both of which the Vida Manglar and Delta Blue Carbon projects have benefited from.

Another innovative but very early-stage example in this space is Australia's "Nature Repair Market". The aim of this policy initiative is to establish a world-first national market for tradable biodiversity certificates to incentivize public and private sector actors to restore and protect the environment. This would be similar to the way that carbon credits are traded under a cap-and-trade scheme, which incentivizes actors to find the most cost-effective approach to reducing carbon emissions. Eligible projects include those that re-establish vegetation along waterways and prevent pests and feral species from destroying native ecosystems. Biodiversity certificates will be issued for eligible projects, which can be sold to investors or deposited with the Australian Government. Certificates held by the Australian Government will remain in effect but will not be further transferred or sold. The methods outlining the rules for eligible projects are currently being developed with experts and stakeholders. Although the scheme is still in its early stages, if successful, it has the potential to transform incentives to invest in nature-based solutions[117].

Standards and taxonomies

In conjunction with metrics and indicators, investment standards and taxonomies serve as guidelines for the market in terms of where to direct investment in order to achieve certain

[114] IFC (2022). *A Climate Opportunity for the Private Sector: Designing Investor-Friendly Carbon Markets*. Available at: https://documentsinternal.worldbank.org/search/33943992.
[115] Respira (2022). *Climate Impact X and Respira's landmark auction for blue carbon credits oversubscribed with global demand.* Available at: https://www.respira-international.com/press-release-climate-impact-x-and-respiras-landmark-auction-for-blue-carbon-credits-oversubscribed-with-global-demand/.
[116] Bertram, et al. (2021). The blue carbon wealth of nations. *Nature Climate Change*, 11, 704–709. Available at: https://www.nature.com/articles/s41558-021-01089-4.
[117] Australia Government Clean Energy Regulator (2024). *Nature Repair Market*. Available at: https://cer.gov.au/schemes/nature-repair-market.

outcomes. These can be developed and implemented at all governance levels—international, national, institutional/corporate, or project level. However, the "missing link" in this area is often the development of interoperable and comparable standards and taxonomies that cross sectoral and geographical boundaries[118]. Comparability of standards and taxonomies is especially important for institutional investors looking to invest in EMDEs.

There has been some recent progress in this space. For example, considerable work has been done by the Climate Bonds Initiative (CBI) and the International Capital Markets Association (ICMA) to develop frameworks for eligible climate and environmentally positive projects, including taxonomies and issuance methods. Meanwhile, in 2022, the IFC complemented this with the publication of the *Biodiversity Finance Reference Guide*, which provides an internationally relevant indicative list of investment activities to help financial institutions, investors, and companies identify investment opportunities to protect, maintain, or enhance biodiversity and ecosystem services and enable the sustainable management of natural resources[119]. This framework provides the basis on which financial intermediaries can issue biodiversity-labeled bonds, as demonstrated by the issuance of the world's first biodiversity bond by BBVA in Colombia in 2024.

At the national level, there are several instances of national sustainable or green finance taxonomies developed by central governments. One example is South Africa's Green Finance Taxonomy, which defines the minimum set of assets, projects, activities, and sectors that can be defined as "green" in line with international best practices and national priorities. Economic activities related to climate adaptation are part of this taxonomy. Similarly, in the case of the Netherlands Delta Programme, access to capital markets finance benefited from the Netherlands Green Bond Framework and the EU sustainable finance taxonomy, which was recently updated to include, among other things, flooding protection and nature-based solutions, enabling the government to tap into the Green Bond asset class for investments related to adaptation and nature. And finally, in the US, both the Fargo-Moorhead and DC Water flood management projects benefited from a national regulatory framework that allows municipalities to issue tax-exempt bonds when used for qualified 'public purposes' (which includes various categories linked to green infrastructure and adaptation), which helped to reduce the cost of financing.

6.3 Multi-stakeholder collaboration

A final key feature of the enabling environment, observed for many of the case studies discussed in this report, relates to the existence of effective multi-stakeholder organization and governance mechanisms. Climate adaptation and nature loss are both challenges that require collective action, and several projects responded to this via funding mechanisms that allowed a group of stakeholders to pool their resources rather than engage in individual transactions.

[118] G20 Indonesia (2022). *G20/GI Hub Framework on How to Best Leverage Private Sector Participation to Scale Up Sustainable Infrastructure Investment*. Available at: https://cdn.gihub.org/umbraco/media/4832/g20-gi-hub-framework-to-scale-up-investment-in-sustainable-infrastructure.pdf.

[119] IFC (2023). *Biodiversity Finance Reference Guide*. Available at: https://www.ifc.org/content/dam/ifc/doc/mgrt/biodiversity-finance-reference-guide.pdf. This reference guide builds on the Green Bond Principles and Green Loan Principles as well as related resources, including the ICMA Handbook for Impact Reporting. It also aligns with targets in the recently adopted Global Biodiversity Framework.

In particular, the development and delivery of nature-based infrastructure projects often require multidisciplinary expertise and multi-stakeholder collaboration beyond the typical requirements of core infrastructure projects. For example, the Itaipú Paraguay Biodiversity Project involved a participatory project preparation process that involved extensive consultations with farmers, indigenous communities, government agencies, and NGOs. This approach enabled the project to scale across 55 municipalities, engaging over 20,000 people in restoring the catchment's forests. Similarly, the Vida Manglar project in Colombia comprised local and international NGOs, research institutes, national environmental authorities, and community-based associations, with more than 1,000 local participants trained in sustainable mangrove management.

While multi-stakeholder collaboration is invaluable at the project level, the case studies also point to the importance of complementary action across the local, national, and international levels. Many of the examples in the earlier chapters demonstrate how, when motivated and creative stakeholders come together, impressive innovation and results can be achieved at the level of a single town or region. However, such local innovation is also much more likely to succeed in the context of a conducive national policy and regulatory environment—be it in the form of financial incentives, PPP capacity, capital markets development, etc. As such, national-level stakeholders have an equally important role to play in creating the plans, policies, and regulations that can empower such success. International actors can be another invaluable source of support, whether through channeling of patient capital or guarantees for demonstration projects, or developing the regulatory market infrastructure needed to channel capital towards adaptation and nature-based infrastructure through capital and carbon markets.

7 Conclusions and Recommendations

Many existing studies highlight the significant gap between the growing need for climate adaptation and nature-based infrastructure and the current limited levels of investment (especially private sector investment) being made into these kinds of projects, especially in EMDEs. However, the question of how to fill this gap—and via what practical, project-level financing structures and revenue generation mechanisms—has received less attention to date. This report contributes to addressing this critical question by analyzing the challenges and identifying opportunities to increase private sector participation in adaptation and nature-based infrastructure projects, drawing on evidence from case studies, literature, and expert insights.

The report reaffirms the fact that this is not an easy area to mobilize private sector participation and investment. Climate adaptation and nature-based infrastructure projects are public by nature and do not readily generate the revenue streams needed to attract private investment. Where revenue incentives do exist, such as in the nature-based carbon market, they generally remain nascent and challenging to access at scale. This fundamental revenue challenge is further compounded by other constraints, including, for example, data challenges and the inherent uncertainty surrounding long-term climate impacts, which makes project planning and financing harder; project complexity and the related need for strong governance and multi-stakeholder participation; and capacity and knowledge challenges, such as those related to the design and implementation of green versus grey infrastructure solutions.

Despite these challenges, the report highlights various examples of successful public-private collaborations. The lessons from these case studies and wider market experience point to the following key recommendations:

- **Strengthen the economic case for public investment: A** clear theme throughout the projects reviewed in this study is the importance of government support in project financing and cost recovery. In most of the case studies, even for those involving private finance, the government remained either partially or entirely responsible for funding through the public budget, for example, via grants or availability payments to the private operator. To justify the allocation of scarce public resources, a clear *economic case* for investment is essential. This includes a clear understanding of the benefits generated by a project—specifically, identifying who benefits from the project and how value is created. Such insights can determine who may be willing or obligated to contribute towards project costs. This, in turn, depends on the availability of robust climate adaptation and nature-based metrics, indicators, and data to inform strong national planning processes (e.g., national adaptation plans) and ensure public resources are directed to where they are most needed.
- **Strengthen the business case for private investment:** While in many cases government funding will be a crucial part of the solution, this alone will be insufficient to address the scale of the adaptation and nature challenge. Therefore, a stronger *business case* for private investment is also urgently needed to attract private sector investment at scale. The case studies reviewed point to several ways in which this can be achieved:

- **Understand and explore alternative cost recovery options:** The case studies reviewed demonstrate that a range of alternative cost recovery mechanisms are available and have been proven to be successful in reducing the fiscal burden on governments. As discussed in Chapter 4, this can include the integration of adaptation or nature criteria into PPP projects with a user-pays revenue stream; exploring land value capture revenue streams for projects involving land redevelopment; and leveraging new sources of climate-related funding such as carbon finance or other available results-based financing. While the policy, regulatory, and specific project circumstances will dictate what is possible in terms of cost recovery options, a clear understanding of the options, as well as the benefits and constraints of each, can promote innovation and crowd-in private investment at the project development and implementation stage.
- **Create a supportive enabling environment for private investment:** The potential to apply different cost recovery mechanisms depends both on the creativity of project developers and the wider enabling environment in which the project is being developed. For example, the scope for the private sector to leverage carbon finance opportunities will be heavily contingent on the regulatory environment for carbon markets, both nationally and internationally. Similarly, governments and DFIs will continue to be instrumental in creating the capital markets frameworks and taxonomies needed to allocate "green" finance towards adaptation and nature-based infrastructure projects. And finally, given that adaptation and nature-based infrastructure projects are often geographically complex, governments (and their DFI or NGO partners) will often need to recognize and drive intergovernmental and multi-stakeholder collaboration in order to crowd in private sector participation.

- **Develop bankable project pipelines:** Finally, to reinforce the recommendations above, all stakeholders have a role in developing and promoting the demonstration projects that are urgently needed to accelerate progress. On this topic, a "Blueprint for Action", published under the *Enabling Private Investment in Climate Adaptation and Resilience* report (World Bank, 2021), provides a useful breakdown and sequencing of the wider actions needed, from planning through to project development and financing (see Figure 2 below). While developed specifically in the context of climate adaptation, the same framework could equally be applied to projects intended to support nature outcomes and hence remains very relevant in the context of this study.

Figure 2: Enabling Private Investment in Climate Adaptation and Resilience: A Blueprint for Action

Source: World Bank, *Enabling Private Investment in Climate Adaptation and Resilience: Current Status, Barriers to Investment and Blueprint for Action*, 2021.

In short, a concerted effort is needed to address the financing gap and unlock the potential of private investment in climate adaptation and nature-based infrastructure. While this will not be easy, strengthening the economic and business case, developing innovative financing mechanisms, and creating a supportive enabling environment and robust project pipeline will all be critical in building a more resilient and sustainable future in EMDEs.

Annex 1: Case Studies

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Case Studies—Climate Adaptation Infrastructure
Fargo-Moorhead River Diversion Project (USA)

Context:

The Fargo-Moorhead region, spanning North Dakota and Minnesota, experiences frequent flooding due to melting snow and its flat topography. The Red River has exceeded the flood stage annually from 1992 to 2011, with increasingly severe and frequent flood events over the past 30 years, likely due to climate change. The 1997 flood alone caused damages of approximately US$3.5 billion, displacing over 56,000 residents and affecting nearly 7,900 properties. The risk of a 1-in-100-year flood event, with potential catastrophic damage, made flood protection a critical necessity. The challenge was finding a sustainable, long-term flood mitigation strategy that could protect urban areas, preserve biodiversity, and address increasing climate risks while ensuring economic and social resilience.

The Fargo-Moorhead Area Diversion Project is a large-scale climate adaptation initiative designed to manage flood risks through structural and environmental measures. The US$2.8 billion project includes a 30-mile diversion channel, a southern embankment to regulate water flow, and levees and floodwalls to protect urban areas. The infrastructure is designed to provide protection against a 1-in-100-year flood and mitigate risks from 1-in-500-year floods. To enhance biodiversity, 85,000 trees (spanning 283 acres) will be planted along the diversion channel to restore wetlands and ecosystems.

The project is being delivered through a Public-Private Partnership (PPP), integrating federal, state, and local funding with private investment to ensure sustainability and efficiency. Key performance indicators (KPIs) for the project include:

- Protection of 235,000 residents and US$19 billion in property value from flooding.
- Completion of construction by 2027, delivering flood protection 10 years earlier than traditional procurement methods.
- Projected savings of US$438 million over the life of the low-interest green loan and US$330 million in construction costs through PPP.

Financing Models:

PPP with private finance (project bonds, equity & debt, government loans, grants): This US$2.8 billion project was delivered through a 30-year PPP financed through a combination of public and private sector financing. US$1.2 billion was financed by the private sector, which comprised a mix of tax-exempt municipal bonds (US$470 million), equity from project sponsors (US$48 million), and loans (US$643 million)[1,2]. The project is an example of a PPP that was motivated by the complexity of the project and the desire to reduce the risk of public management, but with the added benefit of private finance for the upfront capital investment (backed by the availability payment obligations). It is also typical of very large-scale projects, which, out of practical bureaucratic necessity, tend to tap into a wide range of different financing mechanisms (in this case, private finance being used in conjunction with state and national government grants and project bonds).

Public finance (including performance-based grants): US$1.6 billion came from various federal and state sources, including two US-specific government support mechanisms: grants from the US Army Corps of Engineers (US$750 million) and the Infrastructure Investment and Jobs Act (US$437 million).

Cost Recovery Models:

Government pays (availability payment) combined with user pays (special sales taxes): Funding for the project was mobilized via a mix of local and, to a lesser extent, national revenue sources, including a dedicated sales tax supplement, annual maintenance district levies, and stormwater maintenance fees.

The PPP's revenue source comprised availability payments based on performance milestones. To fund availability payments, local residents approved multiple sales tax initiatives—two ½-cent local sales taxes and one ½-cent countywide sales tax—until 2084.

[1] Headwaters Economics 2024, *Fargo-Moorhead Economic Resilience Report*, available at: https://headwaterseconomics.org/wp-content/uploads/Fargo-Report-R5.pdf.

[2] World Bank/PPIAF analysis based on Realfin database from the US Army Corps of Engineers (US$750 million) and the Infrastructure Investment and Jobs Act (US$437 million).

Although this might technically be labelled as "government pays," the result was that funding was tied to the specific beneficiaries, in contrast to projects where funding came from central government budgets.

Project Results:

The project has resulted in flood protection for 235,000 residents, safeguarding US$19 billion in property value, and potential environmental improvement. Properties will benefit from the removal of flood insurance requirements upon completion of the project in 2027.

The project integrates biodiversity protection measures, including extensive tree planting and habitat restoration.

Community engagement and transparent governance have been key factors in gaining local support. The project enhances recreational spaces and mitigates displacement risks from future floods while safeguarding homes and infrastructure.

Enabling Environment:

Improving access to data: Historical data and future projections were critical components in the project design. Designs incorporated extensive historical flood data and future climate projections to anticipate the potential increase in flood frequency and severity. This helped in designing infrastructure capable of handling extreme weather events, taking into consideration the local ecosystem, and aided in developing future performance standards for long-term operations that would be feasible for the private sector partner.

Creating investment incentives to capture externalities: A US national regulatory framework, which allows municipalities to issue tax-exempt bonds when used for qualified 'public purposes' (which includes various categories linked to green infrastructure and adaptation), helped to attract investors through capital markets and reduce the cost of financing.

In addition, milestone payments were made during construction, based on the completion of specific sections of work. This incentivized the private partner to adhere to the project schedule, as opposed to "typical" PPPs, whereby payments are only made once construction is complete and the project is in operation.

References:

Federal Environment Management Agency (FEMA) 1997, Grand Forks 1997 Flood Recovery: Facts and Statistics, archived at: https://web.archive.org/web/20090328103430/http://www.fema.gov/hazard/archive/grandforks/statistics.shtm.

Fargo-Moorhead Metro Flood Diversion Authority 2024, Draft Adaptive Management and Mitigation Plan, available at: https://fmdiversion.gov/wp-con¬tent/uploads/2024/05/FMM_AMMP__Main Document-May-2024.pdf.

Fargo-Moorhead Metro Flood Diversion Authority 2024, Fargo-Moorhead Diversion Delivery Structure, available at: https://fmdiversion.gov/newsresources/legaldocuments/.

North Dakota Department of Emergency Services 1997, Disaster Statistics, archived at: https://web.archive.org/web/20090518045635/https://www.fema.gov/pdf/hazard/archive/grandforks/statistics.pdf.

U.S. Geological Survey 2007, A History of Flooding in the Red River Basin, available at: https://pubs.usgs.gov/gip/2007/55/pdf/finalWebGIP55.pdf.

U.S. Department of Transportation 2024, Project Profile: Fargo-Moorhead River Flood Diversion PPP Project, available at: https://www.fhwa.dot.gov/ipd/project_profiles/fargo_moorhead_flood_diversion.aspx.

SMBC Group 2024, SMBC Closes $642 Million Green Loan and $273 Million Private Activity Bonds for FM Area Diversion P3, available at: https://www.smbcgroup.com/news/smbcfargomoorhead-diversion-p3-press-release.

Fargo-Moorhead Metro Flood Diversion Authority 2022, Memorandum of Understanding, available at: https://fmdiversion.gov/wp-con¬tent/uploads/2022/11/071116_MOU.pdf.

City of Fargo 2024, City Sales Tax, available at: https://fargond.gov/citygovernment/departments/finance/city-sales-tax.

U.S. Army Corps of Engineers 2024, FargoMoorhead Flood Risk Management Project, available at: https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll11/id/3370.

U.S. Department of Transportation, Federal Highway Administration 2024, Project Profile: FargoMoorhead River Flood Diversion PPP Project, available at: https://www.fhwa.dot.gov/ipd/project_profiles/fargo_moorhead_flood_diversion.aspx.

Fargo-Moorhead Metro Flood Diversion Authority 2024, How It Is Funded, available at: https://fmdiversion.gov/about/how-it-is-funded/.

Headwaters Economics 2024, Fargo-Moorhead Economic Resilience Report, available at: https://headwaterseconomics.org/wpcontent/uploads/Fargo-Report-R5.pdf.

Broadland Flood Protection (UK)

Context:

The Broadland Flood Alleviation Project took place in an ecologically sensitive and agriculturally significant region in east England, covering 30,000 hectares. Most of the area is below sea level, making it highly vulnerable to flooding, which is expected to worsen due to climate change and sea level rise. The region contains residential communities, endangered species, wetlands, farmland, transportation infrastructure, and archaeological sites, all of which are at risk.

Prior to the project, flood defenses were failing. The local flood protection agency had already spent GBP 10 million (approximately US$12 million) on emergency repairs following multiple levee failures, and more failures were expected without a proactive overhaul of flood protection infrastructure. Additionally, flooding posed a serious threat to biodiversity, damaging wetlands and disrupting natural habitats. Addressing both flood risk and biodiversity loss required an integrated solution combining green and grey infrastructure approaches.

A Public-Private Partnership (PPP) was established between a private partner (Broadland Environmental Services) and the UK Environment Agency to ensure long-term investment in flood protection over a 20-year period (2001–2021), with a contract value of GBP 140 million (approximately US$190 million). The project combined grey infrastructure (flood bank reinforcements) with nature-based solutions to enhance flood resilience and restore wetland habitats.

Source: BAM Nuttall

Financing Models:

PPPs with private finance: The project was delivered through an SPV (Broadland Environmental Services) under the UK Private Finance Initiative (PFI) through a US$190 million 20-year O&M performance-based contract with the UK Environment Agency. The SPV comprised stakes of 90 percent from BAM Nuttall Ltd. and 10 percent from Halcrow Group Ltd. (now CH2M HILL)[1],[2].

Cost Recovery Models:

Government pays (performance-based contract): Payments to the operator came from the Environment Agency based on a performance-based contract. These services were funded through the UK National Budget, and hence there was no project-specific cost recovery mechanism.

Project Results:

The project resulted in the upgrade and maintenance of 240 km of flood banks, protecting 24,000 ha of highly productive farmland and 1,700 properties[3]. The project also achieved the cost-saving goal, with the PPP model providing a more cost-effective solution compared with traditional procurement models.

Environmental results included[3]:

- Restoration of natural floodplain habitats resulting in a 200 percent increase in water vole populations.
- Creation of 125 hectares of wetlands, contributing to improved biodiversity.
- Realization of carbon savings through material reuse and nature-based flood defenses.

Social results included:

- Secured flood protection for 1,700 properties and five previously undefended communities.
- Safeguarded 24,000 hectares of farmland, ensuring agricultural productivity.
- Improved public trust in PPP flood management through transparent stakeholder engagement.

[1] Jacobs. (n.d.) Broadland Flood Alleviation Project. Available at: https://www.jacobs.com/projects/broadland-flood-alleviation-project#:~:text=The percent20Broadland percent20Flood percent20Alleviation percent20Project.

[2] Climate ADAPT (2016). Regional flood management by combining soft and hard engineering solutions, the Norfolk Broadlands. Available at: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/regional-flood-management-by-combining-soft-and-hard-engineering-solutions-the-norfolk-broadlands.

[3] Environment Agency (2021). *Broadland flood alleviation project reaches 20 year landmark*. Available at: https://www.gov.uk/government/news/broadland-flood-alleviation-project-reaches-20-year-landmark.

Enabling Environment:

Improving access to data: Given the size and complexity of the project area, it was unrealistic to expect the private sector to accurately project the scale of investment required to meet the project objectives at the time of bidding. Therefore, the project included an initial two-year survey and modelling phase, which allowed the private partner to gather the detailed data needed to confirm the viability of the project, reimbursed at cost, with the provision of an exit clause. This de-risked the project, allowing the contractor to gain confidence they could deliver on the project's specifications within the allotted budget and schedule.

Multi-stakeholder organization and governance: The project was driven by UK environmental regulations, requiring flood protection for 240 km of embankments and 28 Sites of Special Scientific Interest (SSSI)[3].

The private partner engaged seven key stakeholder groups, including farmers, conservation groups, and local authorities, ensuring community alignment. The project involved wildlife organizations in wetland restoration and biodiversity monitoring, ensuring ecological concerns were addressed alongside flood protection measures.

References:

New Civil Engineer. (2022) Future of Flooding: Broadland Flood Defence Project Underpinned by Long-Term Sustainable Approach. Available at: https://www.newcivilengineer.com/the-future-of/future-of-flooding-broadland-flood-defence-project-underpinned-by-long-term-sustainable-approach-05-01-2022/.

Climate ADAPT (2016). Regional flood management by combining soft and hard engineering solutions, the Norfolk Broadlands. Available at: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/regional-flood-management-by-combining-soft-and-hard-engineering-solutions-the-norfolk-broadlands.

Environment Agency (2021) Broadland Flood Alleviation Project Reaches 20-Year Landmark. Available at: https://www.gov.uk/government/news/broadland-flood-alleviation-project-reaches-20-year-landmark.

European Environment Agency (EEA). (n.d.) Regional flood management by combining soft and hard engineering solutions: The Norfolk Broadlands. Available at: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/regional-flood-management-by-combining-soft-and-hard-engineering-solutions-the-norfolk-broadlands.

Institution of Civil Engineers (ICE). (n.d) Broadland Flood Alleviation. Available at: https://www.ice.org.uk/what-is-civil-engineering/infrastructure-projects/broadland-flood-alleviation.

Jacobs. (n.d.) Broadland Flood Alleviation Project. Available at: https://www.jacobs.com/projects/broadland-flood-alleviation-project#:~:text=The percent20Broadland percent20Flood percent20Alleviation percent20Project.

Marsh, K., Philpot, M., Payne, D., and Russell, D. (2011) Broadland: A Current Model of Future Delivery? White Paper.

Canal del Dique (Colombia)

Context:

Canal del Dique is a 118 km manmade waterway built in the 16th century in Colombia that connects Colombia's two main colonial ports (Cartagena and Santa Marta) and the Magdalena River[1]. The canal has significant social and economic importance. It was one of the first engineering projects undertaken in the Americas, dug by hand using basic tools, and even today, the 1.5 million people living in the area consider it as a key source of their livelihood[2].

The canal has suffered from extensive sedimentation, leading to degraded ecosystems and increased flood risks. The sediment influx has adversely affected water quality and disrupted the natural habitats of numerous species. Additionally, the surrounding communities have been increasingly vulnerable to flooding exacerbated by climate change. In December 2010, the banks along the canal were breached, rendering almost 100,000 people homeless and destroying crops and infrastructure[3].

In response to these events, a 15-year concession was awarded to a private company to design and build infrastructure upgrades, and to operate and maintain the infrastructure, including control of sediment for transit, mitigation of flooding risk by controlling water levels in the canal, and restoration of the surrounding ecosystems[4],[5].

In addition to the infrastructure upgrades, the concessionaire, Ecosistemas del Dique, aimed to rehabilitate 435,000 hectares of both aquatic and terrestrial ecosystems along the canal[6]. The project encompasses 36 targeted interventions (including lock and floodgate infrastructure in the towns of Calamar and Puerto Badel plus 34 minor works)[4] designed to restore degraded habitats, regulate water flow, and reduce sedimentation.

Green measures have been adopted to manage both water and sediment flows as well as mangrove reforestation and biodiversity conservation efforts. For example, controlled water releases from sluice gates mimic natural water cycles and not only control water and sediment flows throughout the channel, but they also manage salinity levels for mangroves along the canal banks. A fish passage allows fish to swim upstream when the water level in the canal drops[7].

Source: Ecosistemas del Dique (2025)

[1] Royal HaskoningDHV (n.d.). *System improvement Canal del Dique*. Available at: https://coastalsolutions.ireport.royalhaskoningdhv.com/12001001A1.

[2] UNESCO (2012). Canal del Dique—Dike Canal. Available at: https://whc.unesco.org/en/tentativelists/5756/.

[3] Dutch Water Sector (2018). Royal HaskoningDHV to design Colombia's first two navigation locks. Available at: https://www.dutchwatersector.com/news/royal-haskoningdhv-to-design-colombias-first-two-navigation-locks.

[4] Ecosistemas del Dique (2025). Proyecto. Available at: https://ecosistemasdeldique.com/proyecto.

[5] Sandoval and Posada (2022). Canal del Dique—Public Bidding for the Second Fluvial Project of the 5G Concessions in Colombia. Available at: https://cms.law/en/col/publication/canal-del-dique-public-bidding-for-the-second-fluvial-project-of-the-fifth-generation-5g-of-concessions-in-colombia.

[6] Sacyr (2023). We signed the Certificate of Commencement over the Canal del Dique Ecosystems P3. Available at: https://sacyr.com/en/-/acta-inicio-ecosistemas-canal-del-dique.

[7] ANI (2017). Final Studies and Designs for the Construction of Works Under the Hydro-Sedimentological and Environmental Management Plan for the Canal del Dique System: Hydraulic Control Operating System. Available at: https://www.ani.gov.co/sites/default/files/apendice_tecnico_2_anexo_1_cd.id_.330.hid_.inf_.00.001_sistema_operativo_control_hidraulico.pdf.

Financing Models:

PPPs with private finance: The Canal del Dique is a US$1.2 billion project (US$680 million of which is for design and construction) financed through a 15-year PPP granted to Ecosistemas del Dique, a Special Purpose Vehicle (SPV) wholly owned by Sacyr Concesiones, which raised the equity and debt needed to finance the project[8]. Under Colombian PPP law, the SPV takes on the risk of design and construction and is reimbursed by the government following completion[9].

Cost Recovery Models:

Government pays + user pays: Project revenue is derived through government availability payments (funded through the Colombian national budget and local government contributions) and transport user fees from navigation of the channel by public/private water transport and cargo barges[10]. In this context, the project serves as an example of how user fees are used within a broader PPP framework to recover costs associated with flood management investments (both green and grey) by integrating these efforts into the overall waterway concession.

Project Results:

It is still early days for the project, and outcomes are still emerging. However, anticipated outcomes include the restoration of 435,000 hectares, which is expected to enhance biodiversity, improve water quality, and reduce sedimentation; the creation of 60,000 jobs; and community development, engagement, and education to ensure the long-term sustainability of conservation efforts and promote living standards.

Enabling Environment:

Creating investment incentives to address market failures: This river initiative is part of the Bicentennial 5G Concessions program, the second infrastructure program under Colombia's PPP scheme, which was established by law in 2012. The programmatic approach, combined with the PPP law, attracts interest from private investors due to the visibility of a long-term project pipeline, legal certainty of concessions, and clarity over risk-sharing responsibilities for concessionaires. For example, in the PPP scheme, the concessionaires take on construction risk, and only when the concessionaire effectively proves that the infrastructure is available will they be entitled to payment[159].

Improving access to climate data: Royal HaskoningDHV was contracted to design the upgraded Canal del Dique system, including the river diversions, and water and sediment flows. To do this, a thorough understanding of the hydrology, hydraulics, and sediment dynamics was developed by gathering localized data and undertaking hydrodynamic and sediment modelling[11].

[8] Realfin (2024). Private infrastructure transactions between 2013-2023. Note: This was derived through World Bank PPIAF analysis of Realfin data.

[9] Agencia Nacional de Infraestructura (ANI) (2022). *The Public-Private Partnerships.* Available at: https://www.as-coa.org/sites/default/files/inline-files/Colombia percent20Infrastructure percent20Presentation percent202022.pdf.

[10] FullAvanteNews (2020). COLOMBIA: *Recover the Canal del Dique may be a reality.* Available at: https://fullavantenews.com/colombia-recover-canal-del-dique-reality/.

[11] RoyalHaskoningDHV (n.d.). *System improvement Canal del Dique.* Available at: https://coastalsolutions.ireport.royalhaskoningdhv.com/12001001A1.

References:

Agencia Nacional de Infraestructura (ANI) (2017). Final Studies and Designs for the Canal del Dique System: Hydraulic Control Operating System. Available at: https://www.ani.gov.co/sites/default/files/apendice_tecnico_2_anexo_1_cd.id_.330.hid_.inf_.00.001_sistema_operativo_control_hidraulico.pdf.

Agencia Nacional de Infraestructura (ANI) (2022). The Public-Private Partnerships. Available at: https://www.as-coa.org/sites/default/files/inline-files/Colombia percent20Infrastructure percent20Presentation percent202022.pdf.

Dutch Water Sector (2018). Royal HaskoningDHV to design Colombia's first two navigation locks. Available at: https://www.dutchwatersector.com/news/royal-haskoningdhv-to-design-colombias-first-two-navigation-locks.

Ecosistemas del Dique (2025). Proyecto. Available at: https://ecosistemasdeldique.com/proyecto.

FullAvanteNews (2020). COLOMBIA: Recover the Canal del Dique may be a reality. Available at: https://fullavantenews.com/colombia-recover-canal-del-dique-reality/.

Highways Today. (2024). Canal del Dique in Colombia set for $835m restoration. Available at: https://highways.today/2024/06/03/canal-del-dique-colombia/.

Realfin (2024). Private infrastructure transactions between 2013-2023. Note: This was derived through World Bank PPIAF analysis of Realfin data.

Royal HaskoningDHV (n.d.). System improvement Canal del Dique. Available at: https://coastalsolutions.ireport.royalhaskoningdhv.com/12001001A1.

Sacyr (2023). We signed the Certificate of Commencement over the Canal del Dique Ecosystems P3. Available at: https://sacyr.com/en/-/acta-inicio-ecosistemas-canal-del-dique.

Sandoval and Posada (2022). Canal del Dique—Public Bidding for the Second Fluvial Project of the 5G Concessions in Colombia. Available at: https://cms.law/en/col/publication/canal-del-dique-public-bidding-for-the-second-fluvial-project-of-the-fifth-generation-5g-of-concessions-in-colombia.

Mission Rock, San Francisco (USA)

Context:

By 2100, global warming is expected to raise sea levels around the San Francisco Bay by 3-6 feet, putting approximately 4 square miles of the city in a high-risk flood zone. This area, known as the Sea Level Rise Vulnerability Zone, threatens over 37,000 residents, 170,000 jobs, and critical infrastructure, including bridges, utilities, roadways, parks, and the Port of San Francisco. Various studies analyzing sea level rise scenarios from 1 to 8.5 feet have highlighted the urgent need for permanent, climate-resilient solutions. Without intervention, flooding could result in significant economic, social, and environmental damage. The Mission Rock Project was initiated as a response to this long-term risk, aiming to protect an underutilized waterfront area through sustainable urban development that integrates climate resilience measures.

The Mission Rock Project is San Francisco's largest mixed-use waterfront neighborhood, designed to mitigate risks from sea level rise, coastal flooding, and seismic activity. The 28-acre development will be resilient to up to 6 feet of sea level rise through elevated infrastructure, on-site wastewater and stormwater treatment systems, and a greenhouse gas-free public power grid. The project includes 1,200 rental housing units (40 percent affordable), 1.4 million square feet of commercial space, the rehabilitation of Pier 48, and expanded public parks and green spaces. The project is executed as a Public-Private Partnership (PPP) under a 30-year development agreement, ensuring that private partners assume long-term performance risks, including climate adaptation obligations.

The project aims to achieve the following objectives:

- Safeguard 37,000 residents, 170,000 jobs, and critical infrastructure from sea level rise and flooding.
- Achieve a 30 percent local hire rate, with 15 percent disadvantaged workers, and allocate US$1 million to workforce training programs.
- Reimburse private developers using special tax districts, bond proceeds, and levies from the Port's net development rights payments.
- Implement green stormwater treatment, energy-efficient building systems, and resilient infrastructure to withstand 6 feet of sea level rise.

Financing Models:

PPP with private financing (project bonds): To finance the infrastructure, "special use districts" were created for the site, which provided the basis for issuing bonds and local tax revenue regulations needed for the project. The budget for the initial horizontal infrastructure improvements was US$265 million. The developer was responsible for constructing these infrastructure improvements, with reimbursement based on completion and satisfactory inspection. As such, the agreement transfers long-term performance risks to the developer.

Cost Recovery Models:

Land value capture (property sales, property taxes, developer fees): The project was funded through development rights payments and special taxes from special use districts.

Project Results:

Approved in 2018, the redevelopment is now largely complete, and the project includes 1,500 flood- resilient housing units (40 percent affordable), 8 acres of new parkland, over 1 million square feet of commercial and office space, and public infrastructure. It is the largest mixed-use waterfront neighborhood in San Francisco.

The project protects key economic assets, including the Port of San Francisco, while creating new commercial opportunities and housing. The project also expands affordable housing, improves public access to waterfront areas, and fosters economic inclusivity by prioritizing local hiring and workforce development programs.

Enabling Environment:

Creating investment incentives to capture externalities: Mission Rock successfully leveraged the latent value of a defunct industrial site to develop a new flood-resilient neighborhood and supporting infrastructure.

References:

The Real Deal 2024, Mission Rock Comes to Life: How an Innovative Partnership is Yielding a Connected Community with Sustainability at its Core, available at: https://therealdeal.com/sponsored/tishman-speyer/mission-rock-comes-to-life-how-an-innovative-partnership-is-yielding-a-connected-community-with-sustainability-at-its-core/.

San Francisco Examiner 2024, Rock Development Team Opens Second Apartment Tower, available at: https://www.sfexaminer.com/news/business/sf-giants-partners-open-second-mission-rock-apartment-tower/article_7718b5d6-6af1-11ef-814c-63697129954c.html.

San Francisco Port Authority 2019, SF Port Memorandum: Mission Rock Phase I Budget, available at: https://www.sfport.com/projects-programs/presentations-and-documents-mission-rock.

San Francisco Office of Resilience and Capital Planning 2022, SF Port 10-Year Capital Plan (FY2022-2031), available at: https://www.sfport.com/projects-programs/presentations-and-documents-mission-rock.

Donnelly-Landolt, W. 2020, Mission Rock Community Facilities Districts 2021 Special Tax Bonds, available at: https://onesanfrancisco.org/sites/default/files/2020-11/Agenda percent20Item percent205 percent20-percent20Mission percent20Rock percent20Presentation.pdf.

San Francisco Planning Department 2024, Sea Level Rise Adaptation, available at: https://sfplanning.org/sea-level-rise-action-plan#assessment.

Port of San Francisco 2021, Mission Rock Development Agreement Fact Sheet, available at: https://www.sfport.com/sites/default/files/2021-07/Mission percent20Rock percent20Fact percent20Sheet_24June2021.pdf.

Msimbazi River Basin (Tanzania)

Context:

The Msimbazi River Basin in Dar es Salaam is an economically, geographically, and environmentally significant region that is home to about 1.6 million people and is strategically important due to critical transportation infrastructure that connects the city and surrounding region to global markets[1],[2]. However, flooding has become increasingly severe over the past decade due to a combination of factors, including rapid and unplanned urbanization, deforestation, and environmental degradation. 70 percent of natural disasters are linked to climate-induced floods or droughts, and Tanzania ranks 145th out of 185 countries on the ND-GAIN index and is therefore considered highly vulnerable to climate change impacts and has low readiness to handle these impacts[2].

The Msimbazi River Basin is particularly prone to flooding due to the rapid urbanization in the watershed increasing runoff and erosion. In addition, settlements have encroached upon riverbanks and buffer zones, destabilizing the river's natural flow and further increasing sedimentation. Critical infrastructure, such as transportation networks and residential areas, has been adversely affected, leading to disruptions in daily life and economic activities. The situation is exacerbated by inadequate stormwater infrastructure and blocked waterways due to sediment and waste accumulation, posing significant challenges to the city's resilience against climate-induced hazards[3]. The economic costs from damages to infrastructure, loss of property, and the interruption of economic activities are immense. One recent study in 2018[4] estimated that household-level losses due to property damage and loss of personal belongings amounted to over US$100 million (2 percent of Dar es Salaam's GDP)[2].

In response to the escalating flood risks, the Government of Tanzania, with support from the World Bank and other international partners, initiated the Msimbazi River Basin Project in 2022. This project has two core objectives: 1) bolster flooding resilience in flood-prone areas, and 2) enhance integrated urban development in economically vital areas to create a safer, more prosperous, and more resilient Msimbazi for its residents and future generations[5]. The project comprises several components, including the development of flooding infrastructure, resettlements of flood-prone communities, and strengthening institutions[2]. The construction of the flood infrastructure is beginning in 2025. As part of the development of this flood infrastructure, the river basin will be recontoured to accommodate flooding, and an area of developable land will be created that has low flood risk. Additionally, nature-based infrastructure will be deployed: the development of the Msimbazi City Park will provide recreational spaces while serving as a natural flood buffer, and watershed interventions will include reforestation, erosion prevention, sediment management, and solid-waste collection and recycling schemes[3].

Source: World Bank (2019)

[1] The United Republic of Tanzania (2022). *Stakeholders Engagement Plan for the Msimbazi Basin Development Project.* Available at: https://www.tamisemi.go.tz/storage/app/media/uploaded-files/Stakeholders percent20Engagement percent20Plan percent20Msimbazi percent20Project.pdf.

[2] World Bank (2022). Project Appraisal Document: *Msimbazi Basin Development Project*. Available at: https://documents1.worldbank.org/curated/en/099815009132223369/pdf/BOSIB0e7180b840870b0d1076ddb9095955.pdf.

[3] World Bank (n.d.). *Msimbazi Basin Development Project*. Available at: https://www.worldbank.org/en/country/tanzania/brief/msimbazi-basin-development-project/.

[4] World Bank Group. 2019. *Wading out the storm: The role of poverty in exposure, vulnerability, and resilience to floods in Dar es Salaam*. Available at: https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/626361565186647096/wading-out-the-storm-the-role-of-poverty-in-exposure-vulnerability-and-resilience-to-floods-in-dar-es-salaam.

[5] Tanzania Rural and Urban Roads Agency (n.d.). *Msimbazi Basin Development Project*. Available at: https://www.msimbazibasin.tz/

Financing Models:

Public finance, including donor funds: The US$260 million Msimbazi Basin Development Project was financed through a US$200 million credit from the World Bank (through the International Development Association, IDA); US$30 million in the form of a credit from the Spanish Agency for International Development Cooperation; and a EUR 30 million (US$35 million) grant from the Netherlands Ministry of Foreign Affairs through Invest International[2].

The project does not directly mobilize private capital, but it will strengthen institutions and capacity building to enable private sector involvement for real estate development in approximately 57 ha of low flood-risk, developable land near the central business district[2].

Cost Recovery Models:

Land value capture and government pays: Land value capture mechanisms are planned to be implemented to recover costs and generate revenues. Potential future revenue streams for the government include developer fees and revenues from the sale of housing units and the government budget. If successful, the project will also increase existing property values and revenue for the city and for the national government.

The resulting high-value land would then be available for development into market-rate housing, driving the financial viability of the project, together with affordable housing to meet social inclusion goals. The low-lying area would then be developed as a large city park, with a mix of green and blue spaces also then doubling as a detention basin for flood management during high rainfall events.

Project Results:

The project will begin construction in 2025 as well as the detailed master planning for the park and developable land. It is expected to provide multiple benefits to citizens by enhancing flood resilience and developing urban infrastructure. Flood control measures will create safer settlements and communities, while upgrades to transport infrastructure will ensure resilient, reliable transport. A new city park will provide recreation and act as a natural flood buffer. Commuters will face fewer disruptions, and overall, buildings, infrastructure, and lives will be better protected from extreme weather[3].

In terms of the potential for land value capture, the planned development near the central business district will have an estimated capacity of 14,500 new housing units over a 10-20-year period. It will include a mix of market-rate and low-income housing units. Additionally, a mixed-use functionality is planned to accommodate commercial, retail, and office developments[6].

Enabling Environment:

Improving access to climate and nature data: Current and past urban operations have been supported by strong advisory services and analytics from donors, including the United Kingdom Foreign Commonwealth and Development Office (FCDO) and the World Bank. In particular, the Tanzania Urban Resilience Program (TURP) provided technical assistance activities related to risk identification, risk reduction, and disaster risk management, including data, plans, and technical studies that informed the Msimbazi Opportunity Plan[2].

Multi-stakeholder collaboration: A participatory planning process, led by the Government of Tanzania and the World Bank, engaged over 200 stakeholders from 59 institutions and communities, facilitating inclusive decision-making and fostering a sense of ownership among local populations. This collaborative framework is essential for the sustainable management and long-term success of the interventions within the Msimbazi River Basin[2].

[6] World Bank (2019). *The Msimbazi Opportunity: Transforming the Msimbazi Basin into a Beacon of Urban Resilience*. Available at: https://documents1.worldbank.org/curated/ru/842751555397752385/pdf/Executive-Summary.pdf.

References:

Tanzania Rural and Urban Roads Agency (n.d.). Msimbazi Basin Development Project. Available at: https://www.msimbazibasin.tz/.

The United Republic of Tanzania (2022). Stakeholders Engagement Plan for the Msimbazi Basin Development Project. Available at: https://www.tamisemi.go.tz/storage/app/media/uploaded-files/Stakeholders percent20Engagement percent20Plan percent20Msimbazi percent20Project.pdf.

World Bank (2019). The Msimbazi Opportunity: Transforming the Msimbazi Basin into a Beacon of Urban Resilience. Available at: https://documents1.worldbank.org/curated/ru/842751555397752385/pdf/Executive-Summary.pdf.

World Bank (2022). Project Appraisal Document: Msimbazi Basin Development Project. Available at: https://documents1.worldbank.org/curated/en/099815009132223369/pdf/BOSIB0e7180b840870b0d1076ddb9095955.pdf.

World Bank (n.d.). Msimbazi Basin Development Project. Available at: https://www.worldbank.org/en/country/tanzania/brief/msimbazi-basin-development-project/.

World Bank Group (2019). Wading out the storm: The role of poverty in exposure, vulnerability, and resilience to floods in Dar es Salaam. Available at: https://documents.worldbank.org/pt/publication/documentsreports/documentdetail/626361565186647096/wading-out-the-storm-the-role-of-poverty-in-exposure-vulnerability-and-resilience-to-floods-in-dar-es-salaam.

As-Samra Wastewater Recycling Plant (Jordan)

Context:

Jordan is one of the most water-scarce countries in the world, with water resources significantly below the threshold that defines severe water scarcity[1]. Climate change, population growth, and overuse of water resources are expected to cause a further 15 percent decline in freshwater resources by 2040[2]. This situation posed risks to public health, environmental sustainability, and the efficient allocation of Jordan's limited water resources, which is vital for agricultural and municipal water supply.

Addressing these capacity constraints became a priority. Jordan's Water Strategy for 2023-2040 shows that around 50 percent of water consumed is used for irrigation. The country is already using a significant proportion of recycled wastewater for irrigation purposes, and the strategy aims to increase the amount of non-conventional water (including recycled wastewater) for irrigation purposes, and increasing private sector participation is one of the key approaches that will help implement the plan.

The As-Samra Wastewater Treatment Plant (WWTP) is one example of a wastewater treatment plant delivering recycled water for irrigation in partnership with the private sector. As-Samra WWTP was initially designed in 2003 to treat wastewater for 2.3 million inhabitants of Amman while also supplying recycled irrigation water to the surrounding region. The Phase 1 plant was constructed in 2008; however, the country's rapid population growth required further expansion sooner than anticipated.

The Government of Jordan, through the Ministry of Water and Irrigation (MWI), accelerated Phase 2 of the As-Samra WWTP. The expansion was constructed by October 2015, increasing the plant's treatment capacity by over 35 percent, from 267,000 cubic meters per day to 365,000 cubic meters per day[3].

The expansion was delivered through a public-private partnership (PPP) under a 25-year build-operate-transfer (BOT) model. This collaborative approach not only enhanced the plant's capacity but also improved the quality of treated wastewater, making it suitable for agricultural irrigation. By reallocating high-quality treated wastewater for irrigation, the project freed up more freshwater resources for municipal use, thereby bolstering Jordan's overall water security and resilience against climate-induced water shortages[170].

Financing Models:

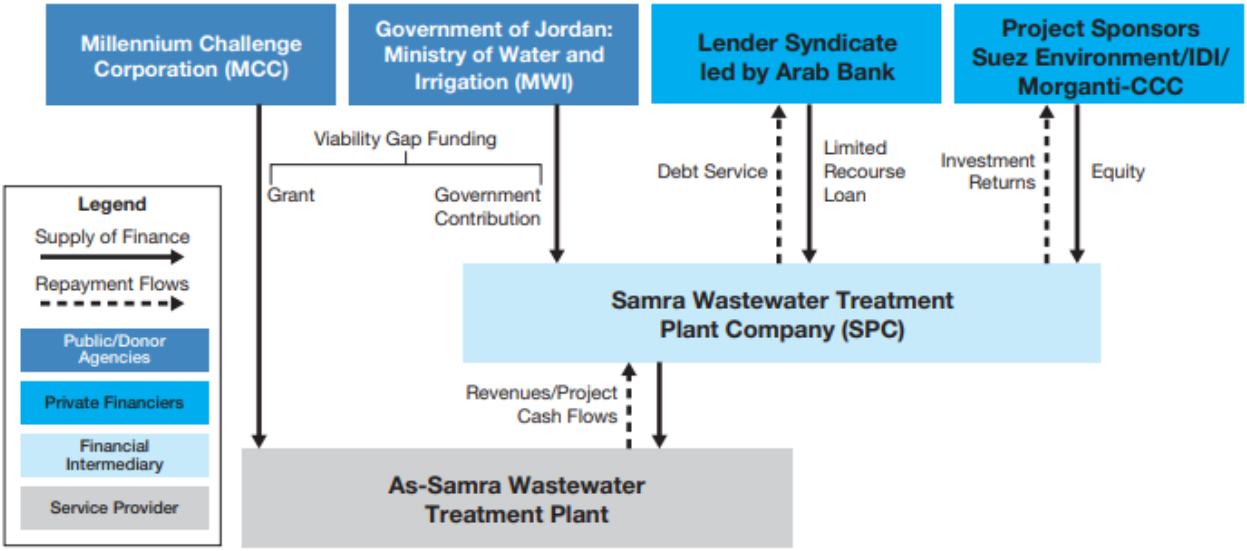
PPP with private financing: A blended financial package was used to finance the US$233 million Phase 2 expansion of the As-Samra Wastewater Treatment Plant. The project was awarded to the Samra Wastewater Treatment Plant Company Limited (SPC), a private operator, to deliver a 25-year Build-Operate-Transfer (BOT) from 2015-2040 to finance, upgrade, and operate the treatment plant. The blended finance package comprised grants (viability gap funding) from the Millennium Challenge Corporation (MCC) and the Government of Jordan (Ministry of Water and Irrigation, MWI) at US$93 million and US$20 million, respectively. This mobilized US$110 million in private financing, including US$102 million in debt (from a syndicate of local banks and financial institutions arranged by the Arab Bank) and US$8 million in equity mobilized by SPC including Morganti, Infilco Degrémont, and Suez Environment[4].

[1] UNICEF (n.d.). Jordan: *Water, sanitation and hygiene.* Available at: https://www.unicef.org/jordan/water-sanitation-and-hygiene#:~:text=Jordan percent20is percent20the percent20second percent20most,which percent20defines percent20severe percent20water percent20scarcity.

[2] Ministry of Water and Irrigation (2023). *Jordan's National Water Strategy 2023-2040.* Available at: https://www.mwi.gov.jo/EBV4.0/Root_Storage/AR/EB_Ticker/National_Water_Strategy_2023-2040_Summary-English_-ver2.pdf.

[3] World Bank (2016). *Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan.* Available at: https://documents1.worldbank.org/curated/ar/959621472041167619/pdf/107976-Jordan.pdf.

[4] World Bank (2016). Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan. Available at: https://documents1.worldbank.org/curated/ar/959621472041167619/pdf/107976-Jordan.pdf.



Source: World Bank (2016)

Cost Recovery Models:

Government pays (availability payment, partially tariff recovered): SPC's revenues come from government payments from MWI and are guaranteed through a reserve account, the replenishment of which is in turn backed by a guarantee from the Ministry of Finance.

Project Results:

Post-expansion, the As-Samra plant treats 70 percent of Jordan's wastewater, producing 133 million cubic meters of high-quality treated water annually for agricultural use. The project freed up more freshwater resources (equivalent to over 10 percent of Jordan's annual water resources[5]) for municipal use, thereby bolstering Jordan's overall water security and resilience against climate-induced water shortages[4]. The As-Samra plant also generates around 80 percent of its own energy needs from biogas (produced from biosolids) and hydropower[5].

The project has positively impacted more than 2 million residents in Amman and Zarqa by ensuring the continuous and efficient treatment of wastewater, thereby safeguarding public health. The increased availability of freshwater for domestic use has enhanced the quality of life, while the provision of treated water for irrigation supports agricultural livelihoods in the Jordan Valley[5].

Enabling Environment:

Creating investment incentives to address market failures: A blended financing approach in local currency was employed, combining a US$93 million grant from the Millennium Challenge Corporation (MCC) and a US$20 million contribution from the Government of Jordan, which mobilized US$110 million in private financing, including from local banks, which offered loan tenors of 13 years, extendible to 20. This tenor marks the longest maturity that Jordanian banks offered to date for a dinar-denominated limited-recourse loan. This brought down the capital costs for the project, which enabled the project to be financially viable[6].

[5] Millennium Challenge Corporation (2018). *As-Samra Wastewater Treatment Plant Expansion Project*. Available at: https://www.mcc.gov/resources/story/section-jor-ccr-as-samra-project/.

[6] Consolidated Contractors Company (2023). *As-Samra Wastewater Treatment Plant*. Available at: https://www.ccc.net/project/as-samra-wastewater-treatment-plant/.

References:

Consolidated Contractors Company (2023). As-Samra Wastewater Treatment Plant. Available at: https://www.ccc.net/project/as-samra-wastewater-treatment-plant/.

Millennium Challenge Corporation (2017) Compact Closeout Report: As-Samra Wastewater Treatment Plant Expansion. Millennium Challenge Corporation. Available at: https://www.mcc.gov/publications-sections/section-jor-ccr-as-samra-project.

Millennium Challenge Corporation (2018). As-Samra Wastewater Treatment Plant Expansion Project. Available at: https://www.mcc.gov/resources/story/section-jor-ccr-as-samra-project/.

Ministry of Water and Irrigation (2023). Jordan's National Water Strategy 2023-2040. Available at: https://www.mwi.gov.jo/EBV4.0/Root_Storage/AR/EB_Ticker/National_Water_Strategy_2023-2040_Summary-English_-ver2.pdf.

PPIAF (2016) Jordan's Experience with Public-Private Partnerships in the Water Sector. Public-Private Infrastructure Advisory Facility. Available at: https://www.ppiaf.org/documents/1991.

UNICEF (n.d.). Jordan: Water, sanitation and hygiene. Available at: https://www.unicef.org/jordan/water-sanitation-and-hygiene#:~:text=Jordan percent20is percent20the percent20second percent20most,which percent20defines percent20severe percent20water percent20scarcity.

World Bank (2016). Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan. Available at: https://documents1.worldbank.org/curated/ar/959621472041167619/pdf/107976-Jordan.pdf.

Paris District Cooling PPP (France)

Context:

Paris faces increasing temperatures due to climate change, leading to heightened demand for air conditioning, which traditionally relies on energy-intensive systems contributing to urban heat islands and elevated greenhouse gas emissions. The city's dense infrastructure and limited green spaces further compound these issues, making it imperative to adopt sustainable cooling solutions that mitigate environmental impacts while addressing the rising cooling needs of residents and businesses.

In 1991, the City of Paris built a district cooling system that utilizes water from the Seine River within cooling generation plants, which then distribute chilled water through underground pipes to various buildings. Today, the system has ten generation plants and four energy storage sites supplying over 700 customers, cooling around six million square meters of space across the city[1]. This system replaces the use of traditional air conditioning units, which not only reduces energy consumption but also eliminates heat discharged into the environment by these units. The cooling network has been running on 100 percent renewable electricity since 2013[1]. This case study demonstrates the combination of grey (the pipework and cooling stations) and green (using water from the Seine) infrastructure solutions to protect against the effects of extreme heat.

The 1991 project was procured through a 20-year Public-Private Partnership (PPP) contract with Climespace, which was a wholly owned subsidiary of ENGIE. In 2022, a new PPP (20-year concession) was awarded to Fraîcheur de Paris, which is also majority-owned by ENGIE. Fraîcheur de Paris aims to expand the network to cover all Parisian arrondissements by 2042, tripling its current length with an additional 158 kilometers of pipelines[1]. Whereas the previous district cooling system served mainly service-sector buildings, the expanded network will serve an additional 300 buildings, including hospitals, childcare centers, retirement facilities, and care homes[1].

Financing Models:

PPPs with private finance: The 20-year PPP is being delivered by a Special Purpose Vehicle (SPV), Fraîcheur de Paris, which is co-owned by ENGIE (85 percent) and RATP (15 percent). The SPV was initially capitalized with US$590 million from its two owners (debt and equity split undisclosed)[2]. The new concession covers the operation and maintenance of the existing district cooling infrastructure as well as investment in the expansion of the district cooling network by 158km by the end of the contract period.

Source: ENGIE, 2022

[1] ENGIE (2022). *What carbon-free solution can we offer for the Paris district cooling system?*. Available at: https://www.engie.com/en/business-case/engie-x-fraicheur-de-paris.

[2] Fraîcheur de Paris (2022). *The City of Paris selects the ENGIE group and its partner, the RATP group, to manage its cold network*. Available at: https://www.fraicheurdeparis.fr/actualite/la-ville-de-paris-retient-le-groupe-engie-et-son-partenaire-le-groupe-ratp-pour-gerer-son-reseau-de-froid.

Cost Recovery Models:

User pays (cooling tariff): The project revenues come from user charges through the district cooling network's customers. 10-year contracts have been established with these customers, and it is estimated that the project revenues will be US$ 2.4 billion by the end of the contract period[3].

Project Results:

The project is expected to 1) reduce CO_2 emissions by 300,000 metric tonnes over the concession's duration, 2) decrease energy consumption by 20 percent compared to traditional air conditioning systems, and 3) save 130,000 m^3 of water each year through the collection of seepage water for cooling[4].

Enabling Environment:

Creating investment incentives to address market failures: The implementation of the Fraîcheur de Paris district cooling system through a PPP was made possible by a robust policy and regulatory framework that encouraged long-term investment and sustainability. The city's 2018 Climate Plan set ambitious carbon reduction targets, including zero local emissions, a 50 percent reduction in energy consumption, and 100 percent renewable energy by 2050. Measures specified in the plan to achieve these targets include energy efficiency in buildings and natural urban cooling. The extension of the existing district cooling network is called out in this plan[5].

[3] Fraîcheur de Paris (n.d.). *REFRESHING PARISIANS, STRENGTHENING THE CITY'S RESILIENCE, ADAPTING PARIS TO GLOBAL WARMING*. Available at: https://www.thegpsc.org/sites/gpsc/files/paris_district_cooling.pdf.

[4] ENGIE (2021). *The City of Paris selects ENGIE and its partner the RATP group to manage its cooling network*. Available at: https://www.engie.com/en/journalists/press-releases/the-city-of-paris-selects-engie-and-its-partner-the-ratp-group-to-manage-its-cooling-network?utm_source=chatgpt.com.

[5] Mairie de Paris (2018). *Paris Climate Action Plan*. Available at: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ae2f905a2f4220ae645f026/5af7316614ad660b652531de/files/Paris_-_Paris_Climate_Action_Plan.pdf?1526890697.

References:

ENGIE (2022). What carbon-free solution can we offer for the Paris district cooling system? Available at: https://www.engie.com/en/business-case/engie-x-fraicheur-de-paris.

ENGIE (2021). The City of Paris selects ENGIE and its partner the RATP group to manage its cooling network. Available at: https://www.engie.com/en/journalists/press-releases/the-city-of-paris-selects-engie-and-its-partner-the-ratp-group-to-manage-its-cooling-network/.

Fraîcheur de Paris (2022). The City of Paris selects the ENGIE group and its partner, the RATP group, to manage its cold network. Available at: https://www.fraicheurdeparis.fr/actualite/la-ville-de-paris-retient-le-groupe-engie-et-son-partenaire-le-groupe-ratp-pour-gerer-son-reseau-de-froid.

Fraîcheur de Paris (n.d.). REFRESHING PARISIANS, STRENGTHENING THE CITY'S RESILIENCE, ADAPTING PARIS TO GLOBAL WARMING. Available at: https://www.thegpsc.org/sites/gpsc/files/paris_district_cooling.pdf.

Mairie de Paris (2018). Paris Climate Action Plan. Available at: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ae2f905a2f4220ae645f026/5af7316614ad660b652531de/files/Paris_-_Paris_Climate_Action_Plan.pdf?1526890697.

Delta Programme (Netherlands)

Context:

The Netherlands faces significant climate adaptation challenges due to its vulnerability to sea level rise, flooding, and reduced freshwater resources. The Netherlands is a low-lying country with 26 percent of its area below sea level, making it highly vulnerable to climate hazards such as sea level rise and flooding. It is estimated that, in the absence of flood defenses, 60 percent of the country would be inundated on a regular basis. These issues pose a threat to the country's infrastructure, ecosystems, and overall resilience.

To address these challenges, in 2011, the 2050 Delta Programme was launched to protect the Netherlands from intensifying flood risk and water scarcity. The Delta Programme allocates substantial resources to flood risk management, including reinforced dikes and storm surge barriers. Similarly, freshwater supply investments focus on securing sustainable water availability through improved water retention, active groundwater management, use of alternative water sources, and more efficient water distribution[1].

For the period 2021-2034, EUR 15 billion (US$15.3 billion) was budgeted for the program, with more than 55 percent of this amount to be invested in new adaptation measures[2,3]. The Netherlands issued a Sovereign Green Bond in 2019, part of which was used to finance the Delta Programme.

Financing Models:

Capital markets finance (green bonds): The Delta Programme is financed through a combination of public financing (through the national budget) and sovereign green bond issuances. Green bond financing is allocated in line with a Green Bond Framework[80], which specifies investment criteria that include adaptation investments such as those being undertaken by the Delta Programme.

All measures in the Delta Programme are financed through a Delta Fund, which enables detailed tracking of green bond proceeds.

The latest issuance of 20-year Dutch sovereign green bonds was in October 2023 for EUR 4.98 billion (US$5.1 billion). In 2023, the Delta Programme spent EUR 1.55 billion (US$1.6 billion), of which EUR 795 million (US$810 million) was financed through Green Bond allocations and the rest through the national budget[4].

Cost Recovery Models:

Government pays (debt service payment on green bonds): Green bond debt service payments are funded through national government budget allocations.

Project Results:

The environmental and social indicators tracked under the green bond include the percentage and length of flood defenses that are operational at safe levels, the reduction in land loss from inundation and coastal erosion, and the reduction in the flood damage costs. As of 2023, 219 km of dykes and 138 flood defenses were improved to adhere to new flood risk standards, which is around 15 percent and 36 percent, respectively, of the program pipeline[236]. Nature-based solutions are being prioritized where feasible.

The use of green bonds also enabled the Dutch Treasury to access long-term private institutional capital at lower rates than would be possible under typical sovereign issuances.

[1] Ministry of Infrastructure and Water Management (2021). Delta Programme 2021: Staying on track in climate-proofing the Netherlands. Available at: https://english.deltaprogramma.nl/documents/publications/2020/09/15/dp2021-eng-printversie.

[2] Government of the Netherlands (n.d.). Delta Programme: flood safety, freshwater, and spatial adaptation. Available at: https://www.government.nl/topics/delta-programme/delta-programme-flood-safety-freshwater-and-spatial-adaptation.

[3] Dutch State Treasury Agency (2023). State of the Netherlands Green Bond Framework. Available at: https://english.dsta.nl/binaries/dsta-english/documenten/publication/2023/09/08/green-bond-framework---updated-8-september-2023/State+of+the+Netherlands+-+Green+Bond+Framework+-+updated+8+September+2023.pdf.

[4] Dutch State Treasury Agency (2024). State of the Netherlands Green Bond Report 2023. Available at: https://english.dsta.nl/documents/publication/2024/05/29/2023-green-bond-report.

Enabling Environment:

Improving access to data: The Dutch State Treasury monitors eligible expenditures annually, providing reports on the allocation of proceeds in line with the Green Bond Framework and the impact generated, with external reviews for verification.

Creating investment incentives to capture externalities: The Netherlands has a nationally coordinated approach to investing in climate adaptation, starting with its National Adaptation Strategy. The strategy sets goals in relation to adaptation and imposes criteria and standards to ensure that all development considers and integrates measures to address sea level rise, increasing heat, prolonged periods of drought, and more extreme precipitation. The adaptation strategy also influences public funding priorities to build resilience, focusing on flooding safety, freshwater supply, and spatial adaptation.

Furthermore, the Netherlands' Green Bond Framework was able to unlock institutional capital for spending on adaptation projects. While the green bonds were not exclusive to the Delta Programme, the 2023 update to the Green Bond Framework (which reflected updates to the EU Taxonomy) included flood risk mitigation and nature-based solutions, including those implemented under the Delta Programme.

References:

Business.gov.nl. (n.d.) Tax schemes for environmentally-friendly investments (MIA and Vamil). Available at: https://business.gov.nl/subsidy/mia-vamil/.

Climate Bonds Initiative. (n.d.) Netherlands Sovereign Green Bond. Available at: https://www.climatebonds.net/certification/netherlands_sovereign.

Dutch State Treasury Agency (2023). State of the Netherlands Green Bond Framework. Available at: https://english.dsta.nl/binaries/dsta-english/documenten/publication/2023/09/08/green-bond-framework---updated-8-september-2023/State+of+the+Netherlands+-+Green+Bond+Framework+-+updated+8+September+2023.pdf.

Dutch State Treasury Agency (2024). State of the Netherlands Green Bond Report 2023. Available at: https://english.dsta.nl/documents/publication/2024/05/29/2023-green-bond-report.

Dutch State Treasury Agency. (2023). Water investments at the heart of the new Dutch Sovereign Green Bond: The Dutch State Treasury Agency announces the new Green DSL to be issued on 17 October 2023. Available at: https://english.dsta.nl/news/news/2023/09/08/water-investments-at-the-heart-of-the-new-dutch-sovereign-green-bond-the-dutch-state-treasury-agency-announces-the-new-green-dsl-to-be-issued-on-17-october-2023.

Dutch State Treasury Agency. (n.d.) Green Bonds. Available at: https://english.dsta.nl/subjects/green-bonds.

Government of the Netherlands (n.d.). Delta Programme: flood safety, freshwater, and spatial adaptation. Available at: https://www.government.nl/topics/delta-programme/delta-programme-flood-safety-freshwater-and-spatial-adaptation.

Ministry of Infrastructure and Water Management (2021). Delta Programme 2021: Staying on track in climate-proofing the Netherlands. Available at: https://english.deltaprogramma.nl/documents/publications/2020/09/15/dp2021-eng-printversie.

World Economic Forum. (2019) Netherlands issues a massive Green Bond – starting the new age of conservation finance. Available at: https://www.weforum.org/agenda/2019/06/netherlands-green-bond-conservation-finance/.

World Resources Institute. (2019) Conservation Finance Takes Off as the Netherlands Issues One of the Largest Green Bonds Ever. Available at: https://www.wri.org/insights/conservation-finance-takes-netherlands-issues-one-largest-green-bonds-ever.

DC Water Rock Creek Project A (USA)

Context:

DC's stormwater infrastructure has been consistently overwhelmed by heavy rainfall events, leading to combined sewer overflow (CSO) and posing significant public health hazards due to wastewater release into rivers. These polluted CSOs introduced bacteria, solid waste, and heavy metals into waterways, negatively impacting DC's water quality, air quality, and natural habitats[1]. Climate change has exacerbated these events, resulting in approximately 3 billion gallons of overflows entering waterways annually. To address this flooding risk, DC Water developed the DC Clean Rivers Project, which included a program of deep tunnels, sewers, and diversion facilities to reduce the frequency and volume of CSOs, including green infrastructure projects using Nature-based Solutions (NbS). The first of these projects was the Rock Creek Project A, which involved the installation of approximately 20 acres of green infrastructure.

The infrastructure solutions for Rock Creek Project A included bioretention (rain gardens) in planter strips and curb extensions, permeable pavement on streets and alleys, and two green infrastructure parks in the Rock Creek sewershed. These solutions diverted stormwater away from the sewer system by allowing rainwater to infiltrate into the ground prior to runoff. This approach was able to reduce the risk of CSO events more cost-effectively than traditional gray infrastructure.

The key performance metric for this was the percentage reduction in rainwater runoff during the evaluation period compared to a 12-month baseline period. Targets were as follows:

- As expected volume reduction—between 18.6 percent-41.3 percent
- Greater than expected volume reduction—greater than 41.3 percent
- Less than expected volume reduction—less than 18.6 percent

DC Water linked a success payment to their investors based on these KPIs, which are detailed further below.

Financing Models:

Capital markets finance: In 2016, DC Water issued US$25 million of tax-exempt Environmental Impact Bonds (EIBs) to finance Rock Creek Project A, the inaugural green infrastructure project under the DC Clean Rivers Project[2]. The EIBs were issued to Goldman Sachs Urban Investment Group and Calvert Impact Capital through a private placement. DC Water was able to leverage a unique public financing mechanism in the USA, which incentivizes investors via a tax exemption on interest payments when the bond proceeds go towards eligible 'public good' activities.

As a further incentive, bonus/risk-share payments were also initiated depending on whether the project met, exceeded, or failed to achieve its targets. If CSO volume reduction was greater than expected, a one-time additional bonus payment of US$3.3 million would be made to bondholders. Conversely, if the volume reduction was less than expected, the bondholders would pay a risk share payment of US$3.3 million to DC Water. If the project performed as expected, no payment would be made to either party.

Cost Recovery Models:

User pays (special water tariff): To cover the cost of the EIB, DC Water generated additional revenue through an incremental fee added to the customers' water bill, calculated based on a property's 'impervious area', which is the area that contributes to rainwater runoff into the district's sewer system. This fee provides an additional funding stream for all stormwater projects under the DC Clean Rivers Project.
Revenue to private investors included the EIB debt service payments plus the bond/risk-sharing payment, which depended on the success of the project in relation to climate adaptation targets (as above).

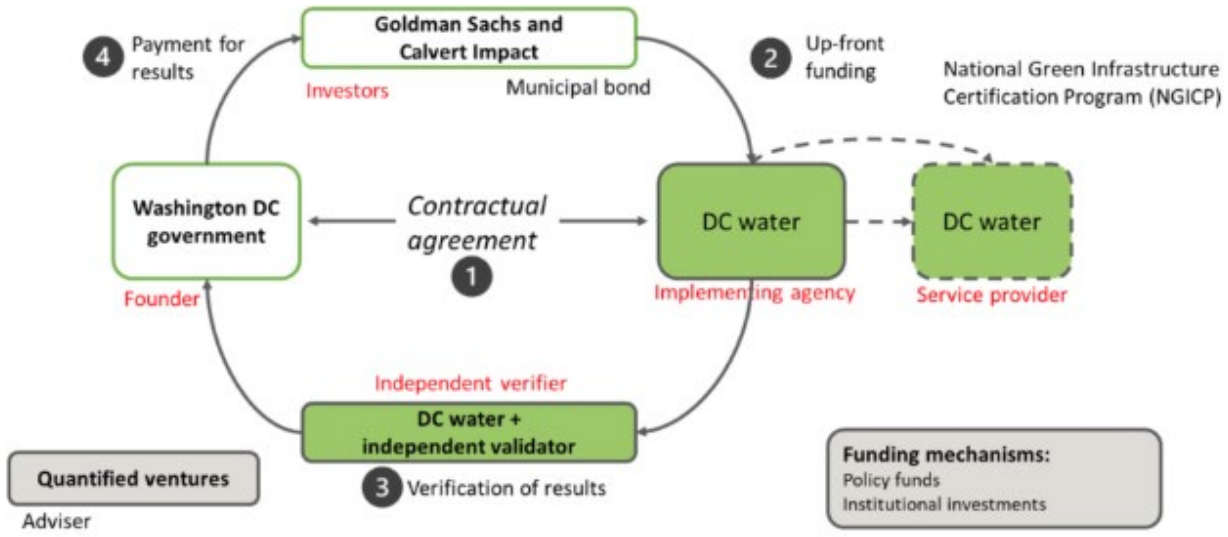
Project Results:

The project reduced the volume of CSOs by nearly 20 percent compared with previous levels. This 'as expected' result meant that no outcome payments or risk-sharing payments were made.

[1] World Economic Forum. Case study: DC Water's Environmental Impact Bond. https://www3.weforum.org/docs/WEF_Urban_Transformation_Case_Study_DC_Water_2022.pdf.

[2] DC Water. *EIB Fact Sheet*. https://www.dcwater.com/sites/default/files/finance/eib-factsheet.pdf.

Financing Structure for the Environmental Impact Bond[3]



Enabling Environment:

Creating investment incentives to address market failures: The US national regulatory framework, which allows municipalities to issue tax-exempt bonds when used for qualified 'public purposes' (which includes various categories linked to green infrastructure and adaptation), helped to attract investors to the project and reduce the cost of financing for DC Water and its customers.

[3] Green Finance Institute (citing the Climate Policy Initiative). *DC Water Environmental Impact Bond.* https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/dc-water-environmental-impact-bond/

References:

Appel, T., Bezak, B. and Lisle, J., 2017. DC Water Green Infrastructure Financing: Pay for Success Can Help Water Utilities Pursue Innovative Solutions. Available at: https://awwa.onlinelibrary.wiley.com/doi/10.5942/jawwa.2017.109.0131.

Conservation Finance Network, 2021. A Pioneering Environmental Impact Bond for DC Water (Updated). Available at: https://conservationfinancenetwork.org/2021/09/27/pioneering-environmental-impact-bond-for-dc-water-updated.

DC Water, 2021. Environmental Impact Bond. Available at: https://www.dcwater.com/environmental-impact-bond.

DC Water, 2021. FACT SHEET: DC Water Environmental Impact Bond Results- Successful. Available at: https://www.dcwater.com/sites/default/files/finance/eib-factsheet.pdf.

DC Water, 2024. Impervious Area Charge. https://www.dcwater.com/customer-center/rates-and-billing/impervious-area-charge.

Green Finance Institute (citing the Climate Policy Initiative). DC Water Environmental Impact Bond. https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/dc-water-environmental-impact-bond/.

US EPA Water Infrastructure and Resilience Finance Center, 2017. DC Water's Environmental Impact Bond: A First of its Kind. https://www.epa.gov/sites/default/files/2017-04/documents/dc_waters_environmental_impact_bond_a_first_of_its_kind_final2.pdf.

World Economic Forum. Case study: DC Water's Environmental Impact Bond. https://www3.weforum.org/docs/WEF_Urban_Transformation_Case_Study_DC_Water_2022.pdf.

Case Studies—Nature-Based Infrastructure
Greater Cape Town Water Fund (South Africa)

Context:

The Greater Cape Town region faces severe water security challenges due to climate change impacts, including temperature rises and prolonged droughts. This situation came to a head in 2018 when, after 3 years of drought conditions, the city was approaching "Day Zero" of no water availability, with dam reservoir storage dropping below 20 percent capacity[1].

In response to the crisis, the City of Cape Town conducted a comprehensive evaluation of various strategies to strengthen its water resource base, including the integration of nature-based solutions. The assessment revealed that invasive alien plants and trees were responsible for an annual reduction of approximately 55 billion liters of water, with these species occupying over 67 percent of the region's catchments[2]. In addition to water loss in the catchment, these invasive species were also found to contribute significantly to biodiversity decline, soil degradation, and heightened wildfire intensity, further disrupting river flows and aquifer recharge. Removing these invasive species was estimated to be around 5x more cost-effective per liter saved vs. available grey infrastructure solutions and therefore became a focus for the city and national governments[3].

In 2018, a multi-stakeholder partnership facilitated by The Nature Conservancy (TNC) came together to establish the Greater Cape Town Water Fund (GCTWF). The fund was used to pool resources from the public and private sectors to increase annual water supply by removing invasive alien plants.

Short-term goals include reclaiming 55 billion liters of water per year within six years, while long-term objectives aim for 100 billion liters annually over 30 years[4].

Financing Models:

Own-source financing: The GCTWF combines grants and corporate funding from public, private, and philanthropic capital to achieve the business case objectives stated above. The fund aims to raise US$25 million over 30 years to 'unlock' 100 billion liters of water in the catchment, equivalent to one-third of Cape Town's water needs. Based on the success of the pilot phase, discussions are underway to further scale the fund and develop a long-term sustainable financing source via an Impact Bond.

Contributors to the fund include:

- Public contributors—including CapeNature (Provincial Conservation Authority), the National Department of Environmental Affairs (Environmental Programmes), the Provincial Department of Environmental Affairs and Development Planning, the South African National Biodiversity Institute, and the City of Cape Town. In 2021, the City of Cape Town committed R 125 million (US$7 million) over five years towards the fund[5].

- Private companies and NGOs—including 12 corporates supporting through foundations and grants as part of their sustainability strategies, as well as several philanthropic supporters and partners such as water user associations, TNC, and WWF SA[6,7].

[1] Jourbert and Ziervogel (n.d.). *Day Zero: Once City's Response to a Record-Breaking Drought*. https://dayzero.org.za/. Note: Day zero was estimated to be on 21 April 2018 and this was cancelled in March 2018.

[2] The Nature Conservancy. (2019) *Greater Cape Town Water Fund: Business Case, April 2019*. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/GCTWF-Business-Case-April-2019.pdf.

[3] The Nature Conservancy. (2020) *Greater Cape Town Water Fund: Fact Sheet, September 2020*. Available at: https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf.

[4] OECD (2021), *Water Governance in Cape Town, South Africa, OECD Studies on Water*, Available at: https://doi.org/10.1787/a804bd7b-en.

[5] City of Cape Town (2021). City invests R62m to secure water by clearing invasive alien plants. Available at: https://www.capetown.gov.za/Media-and-news/City%20invests%20R62m%20to%20secure%20water%20by%20clearing%20invasive%20alien%20plants?.

[6] South African Breweries (SAB). (n.d.*) SAB affirms commitment to water sustainability with over R5 million investment*. Available at: https://www.sab.co.za/article/sab-affirms-commitment-water-sustainability-over-r5-million-investment.

[7] Peninsula Beverage. (n.d.) *Coca-Cola's investment in Cape Town Water Fund*. Available at: https://www.peninsulabeverage.co.za/news-events/coca-cola-s-investment-in-cape-town-water-fund-1/.

Cost Recovery Models:

Corporate and government pays (Corporate and public budget): Rather than generating direct revenue, the investors and municipalities recovered their costs through project benefits, including reducing the pressure on the city to invest in capital-intensive water storage, thereby improving the overall financial health of the city's water supply.

Project Results:

As of March 2025, the project cleared 38,482 initial hectares and 41,832 follow-up hectares of invasive alien plants. As a result of all invasive alien clearing completed in the GCTWF, a total of 34.53 billion liters per year is restored back into the streams. This translates to a water supply yield benefit of 18.17 billion liters per year at a 1:100 year assurance of supply for the City of Cape Town.

The GCTWF has created 1,085 green job opportunities, providing employment and skill development, especially for women (50%) and youth (30%). Economic benefits include cost savings generated via the nature-based solutions.

Enabling Environment:

Improving access to data: TNC, a partner in the development and implementation of the GCTWF, worked with several technical consultancies to develop models to predict water flows in the catchment based on different hydrological, climate, and invasive species scenarios. This allowed them to capture and disseminate data on water savings, which ultimately demonstrated the business case for invasive alien plant removal. Data is continually being captured and reported through a dedicated Decision Support System (DSS,) which is publicly available and published online[8].

Multi-stakeholder organization and governance: The GCTWF aggregated financial and in-kind contributions from a diverse range of private players, including NGOs, food and beverage companies, local financial institutions, and a range of national and sub-national government agencies. Securing local government buy-in was also key to the success of this program. For example, the City of Cape Town committed US$7.7 million (R 125 million) to the fund[9]. Also, partnerships with private and not-for-profit organizations helped to connect downstream users like businesses, utilities, and local governments to contribute to a common goal of upstream conservation initiatives aimed at improving water quality and quantity for the region.

[8] Greater Cape Town Water Fund (2025). *Decision Support System*. Available at: https://public.tableau.com/app/profile/waterfunds/viz/GCTWFDSSv1/PublicDSS.

[9] Infrahub Africa. (n.d.) *Greater Cape Town Water Fund*. Available at: https://www.infrahub.africa/case-studies/greater-cape-town-water-fund.

References:

City of Cape Town (2025). Clearing alien invasive plants restores 48 million liters of water daily. Available at: https://www.capetown.gov.za/Media-and-news/Clearing%20alien%20invasive%20plants%20restores%2048%20million%20litres%20of%20water%20daily.

Infrahub Africa. (n.d.) Greater Cape Town Water Fund. Available at: https://www.infrahub.africa/case-studies/greater-cape-town-water-fund.

Jourbert and Ziervogel (n.d.). Day Zero: Once City's Response to a Record-Breaking Drought. https://dayzero.org.za/. Note: Day Zero was estimated to be on 21 April 2018 and this was cancelled in March 2018.

Greater Cape Town Water Fund (2025). Decision Support System. Available at: https://public.tableau.com/app/profile/waterfunds/viz/GCTWFDSSv1/PublicDSS.

OECD (2021), Water Governance in Cape Town, South Africa, OECD Studies on Water, Available at: https://doi.org/10.1787/a804bd7b-en.

Peninsula Beverage. (n.d.) Coca-Cola's investment in Cape Town Water Fund. Available at: https://www.peninsulabeverage.co.za/news-events/coca-cola-s-investment-in-cape-town-water-fund-1/.

South African Breweries (SAB). (n.d.) SAB affirms commitment to water sustainability with over R5 million investment. Available at: https://www.sab.co.za/article/sab-affirms-commitment-water-sustainability-over-r5-million-investment.

The Nature Conservancy. (2019) Greater Cape Town Water Fund: Business Case, April 2019. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/GCTWF-Business-Case-April-2019.pdf.

The Nature Conservancy. (2020) Greater Cape Town Water Fund: Fact Sheet, September 2020. Available at: https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf.

The Nature Conservancy. (2021) Greater Cape Town Water Fund Sustainable Funding Strategy, March 2021. Available at: https://resilientwatershedstoolbox.org/sites/default/files/documents/library/Greater percent20Cape percent20Town percent20Water percent20Fund percent20Sustainable percent20Funding percent20Strategy percent20March percent202021 percent20 percent281 percent29.pdf.

The Nature Conservancy. (2022) Greater Cape Town Water Fund: Securing Water Through Nature-Based Solutions, December 2022 Update. Available at: https://s3.amazonaws.com/tnc-craft/library/TNC-GCTWF-Fact-Sheet-December-2022.pdf?mtime=20230217072149.

The Nature Conservancy. (2023). Nature-Based Solutions Are Protecting Cape Town's Water Supply. Available at: https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/nature-based-solutions-could-protect-cape-town-s-water-supply/.

Quito Water Protection Fund (FONAG) (Ecuador)

Context:

The upper basin of the Guayllabamba River serves one of the most densely populated areas of Ecuador and includes the city of Quito, home to around 2.6 million people. Quito faces challenges related to both water scarcity and pollution, driven by various activities that threaten the availability of a clean water supply. Key threats include ecosystem conversion for agriculture and cattle farming within protected areas, illegal logging, and deforestation. Many residents in the watershed rely on these water sources for their livelihoods, yet agricultural expansion is contributing to ecosystem degradation, disrupting the natural hydrological regulators of the watershed. While continued agricultural practices reduce the availability of water services for downstream communities, simply restricting these activities would be neither equitable nor sustainable. In the past, the municipality attempted to address the issue through conventional gray infrastructure, but these measures proved insufficient to tackle the root causes of water scarcity and ecosystem loss[1].

This complex problem required time and money that municipal authorities of Quito did not have[1]. Therefore, in 2000, the Municipal Sewer and Potable Water Company of Quito (EPMAPS) partnered with The Nature Conservancy (TNC) to establish the Fondo para la Protección del Agua, 'FONAG', a water conservation fund designed to protect the Guayllabamba watershed through conservation projects and ecological restoration[2,3]. FONAG is a private trust that will be operating for over 80 years to deliver conservation programs and projects, ecological restoration, and environmental education[2]. FONAG receives financial contributions from both public and private entities, including the municipal water utility (EPMAPS), electric companies, private enterprises, and non-governmental organizations.

The programs currently underway include control and monitoring of protected areas, restoration of natural vegetation, environmental education and outreach, training in watershed management, productive projects with local communities, and a hydrological monitoring program[1]. These initiatives aim to enhance the health and functionality of the watershed, thereby securing water quality and availability for Quito's population.

Source: PROAmazonia; Diego Ribadeneira

Financing Models:

Own source financing: FONAG was created in 2000 with an initial investment of US$1,000 from TNC and US$20,000 from EPMAPS. To ensure a sustainable revenue source for long-term investment, EPMAPS allocates 2 percent of its annual revenue to the fund. Over time, additional contributors have joined, including the Quito electric company and private sector partners such as Cervecería Nacional (a beer company), Tesalia Springs Co. (a water bottling company), CAMAREN, and the Swiss Cooperation (COSUDE). By the end of 2018, cumulative investments through FONAG had surpassed US$22 million, reinforcing its role as a key financial mechanism for watershed conservation and sustainable water management in Quito[1,2].

[1] Arias et al. (2010). Water fund for catchment management in Quito, Ecuador. Available at: https://www.cbd.int/financial/pes/ecuador-peswater.pdf.

[2] Latin American Water Funds Partnership (n.d.). Fondo para la protección del agua – FONAG. Available at: https://www.fondosdeagua.org/content/dam/tnc/nature/en/documents/latin-america/wfquito.pdf.

[3] The Nature Conservancy (n.d.). Ecuador Water Funds. Available at: https://www.nature.org/en-us/about-us/where-we-work/latin-america/ecuador/our-work-in-ecuador-water/.

Cost Recovery Models:

Corporate and government pays (corporate and public budget) + User pays (water tariffs): Private companies recover the cost of their contributions through the project benefits, including avoided losses and increased productivity. EPMAPS recovers their costs through water tariffs.

Project Results:

As of 2018, the annual budget is around US$2.5 million, and to date, more than 28,000 ha of land has been restored, and more than 3,500 households have participated in projects. These efforts have led to improved water quality and sustained water flows. Socially, FONAG's programs have engaged local communities in environmental stewardship, fostering a culture of conservation and enhancing livelihoods through sustainable practices[2].

Enabling Environment:

Improving Access to Climate and Nature Data: FONAG created a research program to generate key data and information that contributes to impact monitoring. Water flows, and water quality monitoring is being undertaken in the watersheds and in wetlands, which includes 11 weather stations, 7 rain gauges, 1 hydrological station, and 4 more in small sources. All operate with high-quality standards, and an integrated information system is under development owned by EPMAPS-FONAG[2].

Multi-stakeholder collaboration: FONAG pools together a mix of funding from the public and private sectors to achieve a policy objective. Additionally, the programs include environmental education and outreach, training in watershed management, productive projects with local communities, and a hydrological monitoring program[1].

References:

Arias et al. (2010). Water fund for catchment management in Quito, Ecuador. Available at: https://www.cbd.int/financial/pes/ecuador-peswater.pdf.

Latin American Water Funds Partnership (n.d.). Fondo para la protección del agua – FONAG. Available at: https://www.fondosdeagua.org/content/dam/tnc/nature/en/documents/latin-america/wfquito.pdf.

The Nature Conservancy (n.d.). Ecuador Water Funds. Available at: https://www.nature.org/en-us/about-us/where-we-work/latin-america/ecuador/our-work-in-ecuador-water/.

Itaipú Paraguay Biodiversity Project (Paraguay)

Context:

The Itaipú Hydroelectric Dam, located on the Paraná River, was developed in the 1980s as a US$17 billion joint venture between Brazil and Paraguay to provide hydroelectric power to both countries' industrializing economies. The dam spans 170km in length, provides 78 percent of Paraguay's electricity and 17 percent of Brazil's electricity, and is the world's largest generator of renewable energy[1]. Itaipú Binacional is the company responsible for the construction and operation of the dam, which is owned by the governments of Brazil and Paraguay, with each having a 50 percent share of the company equity.

Water quality and water security are of strategic and operational importance to Itaipú Binacional. During a more recent planning phase of development for the hydroelectric dam, it was determined that the dam would face significant sedimentation and unreliable flows during dry weather periods, leading to expensive dredging, poor water quality and water flows, and ultimately reduced generation productivity. In parallel, the runoff from the watershed containing sediment and agricultural chemicals (driven by erosion, pesticide use, and excess fertilizer) has led to pollution and algal growth, further threatening biodiversity.

Recognizing these challenges, Itaipú Binacional has continued to invest in watershed restoration programs as a core part of its business plan. The Paraguay Biodiversity Project is part of this program and aims to combat deforestation in the Atlantic Forest, which is considered Latin America's most important biome for biodiversity after the Amazon Forest. Today, only about 7 percent of the original Atlantic Forest remains in Paraguay[2]. Itaipú Binacional worked with the Ministry of Environment, the Ministry of Agriculture, the National Indigenous Peoples Institute (INDI), farmers, and NGOs to develop this large-scale restoration program to provide refuge for many threatened species displaced by the conversion of forest into agricultural land[2].

Source: World Bank (2017)

Financing Models:

Public finance, including donor grants: To finance the Paraguay Biodiversity Project, US$18.5 million of grant financing was pooled from various sources, including the Global Environment Facility (US$4.5 million), Itaipú Binacional (US$9.7 million), the Paraguayan government (US$3.5 million), and local beneficiaries and NGOs (US$830,000). Itaipú Binacional funded their share of the project through their corporate budget, justified by the project benefits related to energy generation productivity and efficiency.

Cost Recovery Models:

User pays (project benefits—avoided losses and efficiency gains): Itaipú Binacional funded its contribution through its budget, recovered through user fees, and justified by the project benefits, which would result in greater water flows, better water quality, and therefore better energy yields.

Project Results:

A cost-benefit analysis undertaken by the United Nations Environment Programme (UNEP) and the Inter-American Development Bank (IDB) in 2020 for Itaipú's watershed conservation as a whole (including the Paraguay project) estimated the Net Present Value of conservation efforts to be around US$45 million in direct financial benefits[3].

[1] United Nations Climate Change, 2017. *Itaipu Dam Works to Combine Energy, Environment and Biodiversity*. Available at: https://unfccc.int/news/itaipu-dam-works-to-combine-energy-environment-and-biodiversity.

[2] World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. Available at: https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

[3] International Finance Corporation (2022) *Catalogue of Nature-Based Solutions for Infrastructure Projects*. Available at: https://www.ifc.org/content/dam/ifc/doc/2023/catalogue-of-nature-based-solutions-for-infrastructure-projects.pdf.

In terms of the environmental impact, the Paraguay Biodiversity Project restored more than 230,000 ha of land, which supported the protection of nearly 300 bird species, including endangered and endemic species such as the Gray-bellied Hawk, Saffron Toucanet, Bare-throated Bellbird, Helmeted Woodpecker, Vinaceous Parrot and Rusty-barred Owl[4].

A total of 130 staff from the Ministry of Environment and the Ministry of Agriculture received specialized training in managing protected areas, certifying forest production, monitoring biodiversity, and environmental safeguards policies. They also studied environmental economics, agroforestry, apiculture, integrated pest management, and watershed conservation[2].

Additionally, 5,445 teachers from 180 schools in the corridor area participated in an environmental education program. This program provided materials on the threats to the Atlantic Forest, inspiring teachers and students to plant trees and promote environmental awareness campaigns[2].

Enabling Environment:

Multi-stakeholder collaboration: The Paraguay Biodiversity Program used Itaipú Binacional as the executing agency to pool together grant financing from development finance institutions (DFIs) and the Paraguayan government. This arrangement helped to channel these funds towards a common policy objective.

Project preparation followed a highly participatory process, which also allowed the project to achieve scale in implementation. The participatory preparation process convened rounds of consultations with the participation of a wide range of stakeholders and beneficiaries, including: (i) farmers (large and medium-sized as well as 2,500 small campesinos), (ii) 2,283 indigenous families, representing approximately 10,636 indigenous people, (iii) government agencies, and (iv) local and international NGOs. The project resulted in the formation of a trusted civil society—government network encompassing 55 municipalities, 30 regional implementing groups, and more than 20,000 people working toward restoration of the Atlantic Forest[2].

[4] World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

References:

Frontiers in Climate, 2023. International law and transboundary dams: lessons learned from the Binational Entity ITAIPÚ (Brazil and Paraguay). Available at: https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2023.1272254/full.

Global Infrastructure Hub, 2020. Itaipú hydroelectric dam case study report. https://cdn.gihub.org/umbraco/media/3265/itaipu-hydroelectric-dam-case-study-report.pdf.

Inter-American Development Bank, 2024. Itaipú Hydro-Electric Complex. Available at: https://www.iadb.org/en/project/TC7408174.

International Finance Corporation (2022) Catalogue of Nature-Based Solutions for Infrastructure Projects. Available at: https://www.ifc.org/content/dam/ifc/doc/2023/catalogue-of-nature-based-solutions-for-infrastructure-projects.pdf.

Itaipú Binacional, 2023. Itaipú Binacional clears historical debt for construction of the Plant. Available at: https://itaipu.energy/news/itaipu-binacional-clears-historical-debt-for-construction-of-the-plant/.

Power Technology, 2020. The Itaipú Hydroelectric Dam Project, Brazil. Available at: https://www.power-technology.com/projects/itaipu-hydroelectric/?cf-view&cf-closed.

Resilience Rising, 2020. The Itaipú Dam: how natural ecosystems support this modern technological wonder. Available at: https://resiliencerisingglobal.org/the-itaipu-dam-how-natural-ecosystems-support-this-modern-technological-wonder/.

Resilience Shift, 2020. Itaipú Dam case study Resilience Shift. Available at: https://www.resilienceshift.org/wp-content/uploads/2020/08/Itaipu-Dam-case-study-Resilience-Shift.pdf.

Springer, 2010. Water Worth Gold: The Itaipú Hydroelectric Project. Available at: https://link.springer.com/chapter/10.1007/978-90-481-9920-4_92 9.

UNFCCC, 2017. Itaipú Dam Works to Combine Energy, Environment and Biodiversity. Available at: https://unfccc.int/news/itaipu-dam-works-to-combine-energy-environment-and-biodiversity.

United Nations Climate Change, 2017. Itaipú Dam Works to Combine Energy, Environment and Biodiversity. Available at: https://unfccc.int/news/itaipu-dam-works-to-combine-energy-environment-and-biodiversity.

Valor International, 2023. Itaipú Dam settles decades-long debt from construction works. Available at: https://valorinternational.globo.com/business/news/2023/02/28/itaipu-settles-decades-long-debt-from-construction-of-itaipu-dam.ghtml.

World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. Available at: https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

Vida Manglar Blue Carbon Project (Colombia)

Context:

Colombia is one of the world's most biodiverse countries. It is home to 14 percent of known plant species in the world, one-third of the world's bird species, and over 1,400 species of mammals[1]. However, this biodiversity is under threat due to economic activity, notably deforestation, and climate change, which is impacting not only animal species but also the ecosystem services that help regulate droughts, water security, and flooding.

More specifically, hotel development and cattle ranching have drained mangrove forests, which have in turn destroyed the habitats of otters, dolphins, manatees, and crocodiles. The Gulf of Morrosquillo is home to some of the most important mangroves and marine-coastal protected areas of the Caribbean coast, but despite the government declaring the region a marine protected area in 2006, mangroves continued to be cleared for cattle and agriculture. These activities have had a negative impact on the ecosystem services that local communities rely on for income and livelihoods[2].

The Vida Manglar Blue Carbon Project aims to protect and restore 11,000 ha of mangrove forests along the Cispatá Bay on Colombia's Caribbean coast over a span of 30 years[2],[3]. This initiative employs a "blue carbon" approach, monetizing the carbon sequestration capacity of mangroves by generating high-quality carbon credits for sale in the voluntary carbon market. The project began in 2015, and activities are related to four strategic lines: strengthening of governance, alternative productive projects, recovery and rehabilitation of mangrove areas, and monitoring[4].

The Vida Manglar project has set specific targets to measure its success[5]:

- Carbon Sequestration: Aim to sequester close to 1 million metric tons of CO_2 over 30 years, equivalent to removing approximately 184,000 cars from the road annually.
- Mangrove Conservation: Protect and restore 7,500 hectares initially, expanding to 11,000 hectares of mangrove ecosystems over 30 years.
- Biodiversity Protection: Monitor and protect habitats for endangered species such as the Caribbean manatee (Trichechus manatus), neotropical otter (Lontra longicaudis), and American crocodile (Crocodylus acutus)[6].
- Deforestation Reduction: Reduce unplanned deforestation.

Financing Models:

Own source financing: The upfront project costs will be financed by the community and/or project developers and revenue derived through the future sale of blue carbon credits. The Vida Manglar project is an "umbrella" project that aggregates local community projects under a coalition comprised of Conservation International, Colombia's Marine and Coastal Research Institute (INVEMAR), national environmental authorities—Corporación Autónoma Regional del Valle del Sinú (CVS) and Corporación Autónoma Regional de Sucre (CARSUCRE), the local NGO Fundación Omacha, and community-based associations of mangrove workers. The combined carbon stores across Vida Manglar projects were certified using Verra methodologies, and these blue carbon credits were issued in 2021, with most having been committed by 2022 in anticipation of future carbon sequestration potential[7].

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[1] BBVA (2024). *BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue.* Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.

[2] Natural Climate Solutions Alliance (2024). *Vida Manglar*. Available at: https://www.wbcsd.org/wp-content/uploads/2024/08/Vida-Manglar.pdf.

[3] South Pole Carbon Asset Management (2020). *Blue Carbon Project Gulf of Morrosquillo "Vida Manglar".* Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

[4] Verra (n.d.). *Blue Carbon Project Gulf of Morrosquillo "Vida Manglar".* Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

[5] Conservation International (n.d.). *Vida Manglar Carbon Project*. Available at: https://www.conservation.org/projects/vida-manglar-carbon-project.

[6] Vida Manglar (n.d.). *Vida Manglar*. Available at: https://www.vidamanglar.co/#proyecto.

[7] Conservation International (2022). *Vida Manglar Impact Report*. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/cispata-bay-mangroves-2022-impact-report.pdf?sfvrsn=2b5b6f4d_3.

Source: Conservation International (2022)

Cost Recovery Models:

Climate-related funding: The sale of blue carbon credits on the voluntary carbon market provides the revenue to justify investment in mangrove rehabilitation and reforestation[8]. The volume of carbon credits issued is not disclosed in the literature; however, around 92 percent of these revenues are planned to go back to community groups to invest in the conservation management plan[59].

Project Results:

Project beneficiaries include more than 12,000 inhabitants, 435 families, and 14 community organizations. Between 2015 and 2018, the project sequestered 69,000 tons of carbon dioxide and aims to remove a further 930,000 tons of CO_2 over the next 20 years[60]. Within the project's first monitoring period, Vida Manglar reported a 69 percent reduction in unplanned deforestation compared with the projected annual deforestation rate in the project area[5]

Enabling Environment:

Creating investment incentives to capture externalities: The premiums associated with the sale of blue carbon credits provided incentives for community-based investments in mangroves.

Multi-stakeholder collaboration: The project's success is underpinned by robust institutional collaborations and community engagement. Key partners include Conservation International, Colombia's Marine and Coastal Research Institute (INVEMAR), national environmental authorities—Corporación Autónoma Regional del Valle del Sinú (CVS) and Corporación Autónoma Regional de Sucre (CARSUCRE), the local NGO Fundación Omacha, and community-based associations of mangrove workers. These organizations facilitated over 100 workshops, engaging more than 1,000 local participants (42 percent of whom were women) in training sessions focused on sustainable mangrove management and conservation[9].

Improving access to data: The project also employs methodologies developed with Verra[4] for accurately measuring and monetizing blue carbon, ensuring transparency and credibility in carbon credit generation.

[8] OCTO (2024). *Vida Manglar Project: Certifying conservation actions to reduce carbon emissions and benefit local communities*. Available at: https://octogroup.org/vida-manglar-project-certifying-conservation-actions-to-reduce-carbon-emissions-and-benefit-local-communities/.
[9] World Economic Forum (2024) *Pioneering Climate-Positive Approach to Mangrove Ecosystems*. Available at: https://www.weforum.org/stories/2024/11/how-colombia-mangrove-stewards-are-pioneering-a-climate-and-nature-positive-approach/.

References:

BBVA (2024). BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.

Conservation International (2022). Vida Manglar Impact Report. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/cispata-bay-mangroves-2022-impact-report.pdf?sfvrsn=2b5b6f4d_3.

Conservation International (n.d.) Vida Manglar Carbon Project. Available at: https://www.conservation.org/projects/vida-manglar-carbon-project.

Natural Climate Solutions Alliance (2024). Vida Manglar. Available at: https://www.wbcsd.org/wp-content/uploads/2024/08/Vida-Manglar.pdf.

OCTO (2024). Vida Manglar Project: Certifying conservation actions to reduce carbon emissions and benefit local communities. Available at: https://octogroup.org/vida-manglar-project-certifying-conservation-actions-to-reduce-carbon-emissions-and-benefit-local-communities/.

South Pole Carbon Asset Management (2020). Blue Carbon Project Gulf of Morrosquillo "Vida Manglar". Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

Verra (n.d.) The Blue Carbon Project Gulf of Morrosquillo: Protecting Mangroves and Marshes in Colombia. Available at: https://verra.org/programs/verified-carbon-standard/the-blue-carbon-project-gulf-of-morrosquillo/.

Verra (n.d.). Blue Carbon Project Gulf of Morrosquillo "Vida Manglar". Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

Vida Manglar (n.d.) Background. Available at: https://www.vidamanglar.co/indexEn.html.

Vida Manglar (n.d.). Vida Manglar. Available at: https://www.vidamanglar.co/#proyecto.

World Business Council for Sustainable Development (n.d.) Vida Manglar. Available at: https://www.wbcsd.org/wp-content/uploads/2024/08/Vida-Manglar.pdf.

World Economic Forum (2024) Pioneering Climate-Positive Approach to Mangrove Ecosystems. Available at: https://www.weforum.org/stories/2024/11/how-colombia-mangrove-stewards-are-pioneering-a-climate-and-nature-positive-approach/.

Quintana Roo Coral Reef Restoration (Mexico)

Context:

Quintana Roo's coral reefs, spanning approximately 100 miles along the Yucatan Peninsula, have faced significant degradation since 1980 due to climatic impacts from storms, disease, pollution, and overfishing. This has led to the loss or degradation of 80 percent of the living coral along Mexico's Caribbean coast. The decline of coral reefs is causing beach erosion, which threatens the region's main income source, which is tourism. The tourism industry on the Mexican Caribbean coast is worth around US$10 billion in assets.

The reef absorbs 97 percent of a wave's energy before it hits the shore, which mitigates both storm-related damages and daily coastal erosion. However, the loss of coral reefs due to rising sea temperatures is leading to beach erosion, threatening the region's key income source. In 2005, two hurricanes caused US$8 billion in damages. The Nature Conservancy's economic risk analysis revealed that storm damage to buildings along the coastline could triple from future storms with anticipated further reef loss.

It was observed that areas with intact reefs suffered significantly less damage; therefore, in 2019, a proof-of-concept was initiated in Quintana Roo, Mexico, where The Nature Conservancy (TNC) and several other partners launched the world's first post-storm response and parametric insurance financing program for coral reefs and beaches. In 2020, Hurricane Delta triggered a payout from the Quintana Roo insurance policy. This payout was used to finance coral reef restoration. The nearly US$850,000 payout was the first time that funding from an insurance policy was available to help a natural asset recover[1].

The project aimed to strengthen the economic resilience of the region, protect the tourism industry, encourage the conservation of a valuable natural asset, and create a scalable new market for the insurance industry. This was achieved through the reef insurance policy: a parametric insurance policy that triggers a payout when wind speeds in a designated area are recorded in excess of 100 knots, with the maximum payout over the 12 months being US$3.8 million.

Financing Models:

Public finance, including donor grants: The reef and beach restoration activities were financed via a dedicated implementing agency for the project, the Coastal Zone Management Trust (CZMT). The CZMT is a trust fund established by the State of Quintana Roo in 2018 to receive taxes from the local tourism industry to fund ongoing coral reef restoration works. Part of the funding received by CZMT is used to pay the premiums required for the parametric reef insurance policy. The insurance payouts are also channeled via CZMT, which allocates the funds towards restoration activities.

The parametric reef insurance policy was designed by Swiss Re and The Nature Conservancy (TNC). The policy protects the nature investments by insuring the reef and adjacent beaches along the Yucatan Peninsula against climatic weather events.

Cost Recovery Models:

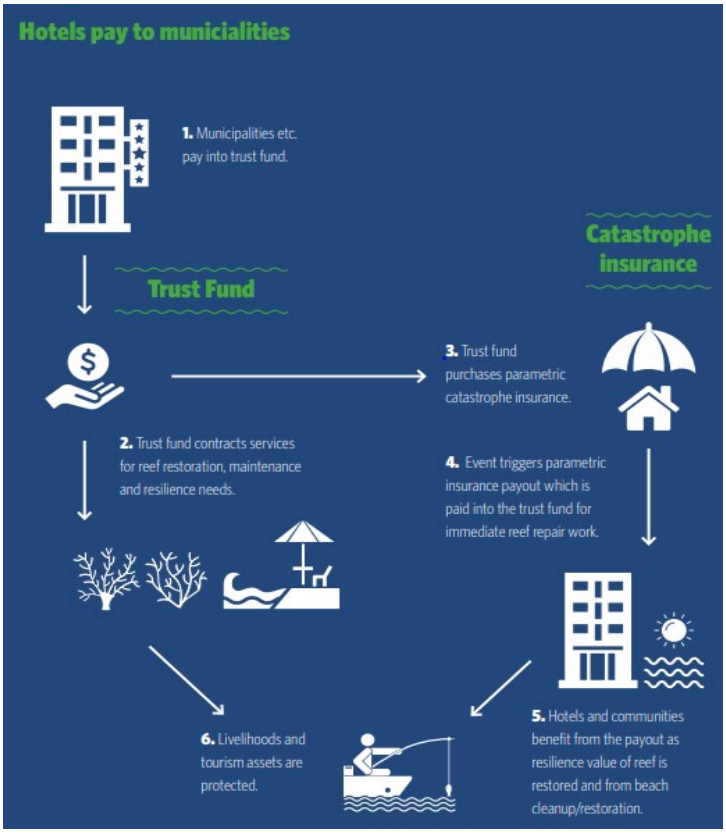
Government pays (public budget, special tourism taxes): The CZMT is funded through special tourism taxes paid to the municipal government by tourism companies, hotels, and coastal landowners.

Project Results:

In 2020, Hurricane Delta hit the Quintana Roo coverage area, breaking up substantial coral structures[2]. An insurance payout of US$850,000 was paid to the CZMT, which funded a team to assess damage, carry out immediate repairs, and plan and implement longer-term restoration of the beaches and reef for the following 2 to 3 years. In the first 11 days, the brigades collected more than 8,000 coral fragments broken by the hurricane and planted them in the reef. These actions enhanced the reef's recovery process, thus helping to maintain the valuable benefits the reefs provide to coastal communities and the creatures that depend on the reefs for food and shelter[2].

[1] The Nature Conservancy. (2024) 'Insuring Nature to Ensure a Resilient Future'. Available at: https://www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future/.

[2] The Nature Conservancy. (2024) 'Urban Water Blueprint - About'. Available at: https://water.nature.org/waterblueprint/about/.



Source: The Nature Conservancy, 2020

The project led to increased speed of reef recovery and business continuity following storm events. It has strengthened the economic resilience of the region, helped protect a US$10 billion tourism industry, and encouraged the conservation of a valuable natural asset. The involvement of the local business community has also been instrumental in engaging stakeholders and securing financial support and building capacity for conservation efforts.

Enabling Environment:

Creating investment incentives to capture externalities: Parametric insurance was designed to protect 100 miles of the Yucatan coastline. Payments are triggered when hurricane wind speeds reach pre-agreed levels in a pre-defined area, enabling funds to be deployed quickly to support recovery efforts and minimize further economic and ecological damage. This type of policy avoids the longer wait times typical of traditional indemnity insurance, which requires verification of losses before claims can be made.

The insurance was underwritten by Swiss Re, with premiums funded by the Coastal Management Zone Trust (CMZT). The policy helps to protect the reef investments and, by extension, helps maintain the security of the community that relies on it[3]

Multi-stakeholder organization and governance: The Coastal Zone Management Trust (CZMT), an independent trust established by the State of Quintana Roo in 2018, was used to pool together tourism taxes from municipalities with donor contributions to fund the insurance premiums and oversee work related to ongoing coral reef restoration.
The trust is governed by a technical committee comprised of government officials, scientific experts, NGOs, and hotel association representatives. This committee decides how best to allocate funds to protect the reef and its beaches. The CZMT, together with partners, also delivers training to coastal and reef managers to ensure that conservation and restoration efforts are sustained in the future.

[3] Green Finance Institute, 2024. *Quintana Roo Reef Protection (Parametric Insurance).* Available at: https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/quintana-roo-reef-protection-parametric-insurance/.

References:

Green Economy Coalition, 2018. Insuring coral reefs in Mexico. Available at: https://www.greeneconomycoalition.org/news-and-resources/insuring-coral-reefs-in-mexico.

Green Finance Institute, 2024. Quintana Roo Reef Protection (Parametric Insurance). Available at: https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/quintana-roo-reef-protection-parametric-insurance/.

InsuResilience, 2024. Global Parametrics - Mexican Reef Protection Program Blending Parametric Insurance and Nature-based Solutions. Available at: https://annualreport.insuresilience.org/global-parametrics-mexican-reef-protection-program/.

Swiss Re, 2021. How insurance is protecting the world's second biggest coral reef. Available at: https://www.swissre.com/risk-knowledge/mitigating-climate-risk/insurance-protecting-coral-reef.html.

Swiss Re, 2024. Mexico: Windstorm. Available at: https://www.swissre.com/our-business/public-sector-solutions/mexico-windstorm.html.

The Nature Conservancy, 2018. Bracing for Impact. Available at: https://www.nature.org/en-us/magazine/magazine-articles/bracing-for-impact/.

The Nature Conservancy, 2020. Reducing Caribbean Risk: Opportunities for Cost-Effective Mangrove Restoration and Insurance. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_MangroveInsurance_Final.pdf.

The Nature Conservancy, 2024. Launch Of The Coastal Zone Management Trust Quintana Roo, Mexico. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_Mexico_CoastalManagementTrust_Factsheet.pdf.

The Nature Conservancy. (2024) 'Insuring Nature to Ensure a Resilient Future'. Available at: https://www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future/.

The Nature Conservancy. (2024) 'Urban Water Blueprint - About'. Available at: https://water.nature.org/waterblueprint/about/.

Tibar Bay Port (Timor-Leste)

Context:

The development of Tibar Bay Port in Timor-Leste addressed major challenges related to port congestion, inefficiencies, and high operating costs associated with Dili Port. The existing port had limited capacity, being too shallow for ships above 500 Twenty-Foot Equivalent Units (TEU), restricting trade expansion[1]. With economic activity and container traffic projected to increase by 2040, a new port was essential to accommodate larger ships and growing demand.

The Tibar Bay Port project, the first Public-Private Partnership (PPP) and largest private investment in Timor-Leste, became operational in 2022. It was designed to replace the congested Dili Port and improve shipping efficiency. Environmental and social considerations were integrated into the project, including habitat restoration for mangroves, biodiversity conservation initiatives, and an Environmental Management Plan (EMP) for continuous monitoring. To mitigate marine and coastal ecosystem disturbances, the project implemented reforestation efforts and seagrass preservation programs. The PPP structure also transferred environmental and biodiversity-related risks to the private partner, Timor Port, which established mangrove conservation areas to ensure the long-term protection of natural assets.

The chosen project site, while strategically located, posed environmental concerns, including hydrodynamic disruptions to the bay, loss of mangroves, tidal flats, coral, terrestrial habitats, and seagrass ecosystems. Social concerns included resettlement issues, the displacement of cultural heritage, and the impact on livelihoods, such as fishing and salt production. Addressing these environmental and social risks was essential to ensure sustainable development.

The project's key objectives included operational improvements such as reducing congestion and enhancing trade efficiency. From a biodiversity perspective, the initiative aims to conserve 20 hectares of mangroves, 15 hectares of seagrass beds, sea turtle habitats, and 23 hectares of seabed[2]. Biodiversity offsets, including mangrove reforestation, were incorporated into the contract in alignment with the IFC Performance Standards.

Financing Models:

PPPs with private finance: The 30-year PPP is being delivered through a Special Purpose Vehicle (SPV) (Timor Port) at a project cost of US$280 million, which comprised US$45 million equity from Bolloré, US$105 million from loans, and viability gap funding (VGF) from the Government of Timor-Leste (US$130 million) as a capital subsidy (minimum subsidy bidding criteria)[3]. The private partner issued a performance bond to mitigate against performance failures associated with the project, including social, environmental, and biodiversity.

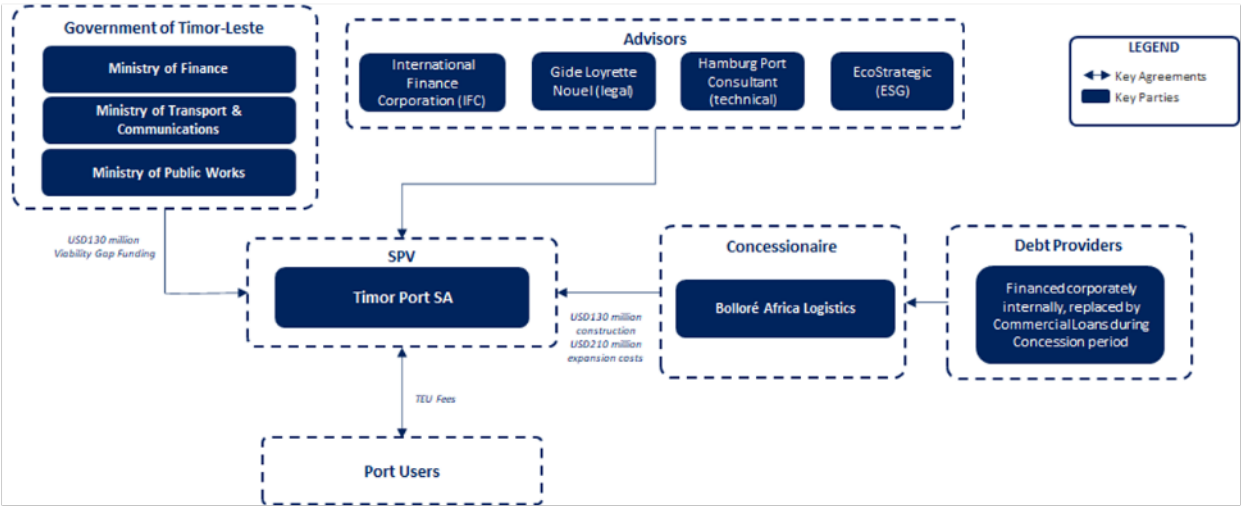
Cost Recovery Models:

User pays (transport tariff) and government pays: The SPV generates revenue through user charges for port services based on a tariff schedule defined in the PPP concession agreement. The government receives royalty fees from the SPV based on the volumes of cargo passing through the port. The private partner bears the traffic and performance risk for the project.

[1] La'o Hamutuk (2013). Tibar Bay Port: Summary of Environment and Social Scoping Study. Available at: https://www.laohamutuk.org/econ/PPP/Tibar/scoping-summary-w-site-selection-annex-december-2013-english.pdf.

[2] La'o Hamutuk (2017). Tibar Bay Port – Environmental Management Plan. Available at: https://www.laohamutuk.org/Env/TibarPort/EMP_301320-13728-MA-REP-1300_Rev2DOct2017.pdf.

[3] Global Infrastructure Hub (2022). Tibar Bay Port. https://www.gihub.org/innovative-funding-and-financing/case-studies/tibar-bay-port/.



Source: Global Infrastructure Hub, 2022

Project Results:

So far, this investment has restored 20 ha of mangroves to mitigate the impact of coastal floods and erosion; 15 ha of seabed grass protection to reduce sedimentation and improve water clarity, which can reduce the need for dredging; and 23 ha of coral reef conservation, which helps maintain a natural barrier against waves and storm surges.

Timor Port was awarded the BiodiverCity label at the end of construction works by the International Biodiversity & Property Council following audits carried out by a third party.

In April 2022, Timor Port launched the mangrove conservation area in Tibar Bay, which is part of their action plan for biodiversity and ensures the protection of a 20-hectare area of mangroves in the immediate vicinity of the port[4].

Enabling Environment:

Creating investment incentives to capture externalities: Tibar Bay Port was classified by the government of Timor-Leste as a 'Category A' project with significant potential environmental impacts, and as such it was required under law that an Environmental Impact Assessment and Environmental Management Plan be developed for the project. The project's procurement criteria and subsequent concession agreement also specified compliance with the International Finance Corporation's (IFC) Environmental and Social (E&S) Performance Standards, thereby introducing a high minimum baseline, found in both national law and international standards, for compliance with best practice environmental outcomes. This included, for example, a contractual obligation to provide "biodiversity offsets", which includes planting mangroves to offset biodiversity loss and to establish biodiversity conservation zones.

Technical assistance grants and support from DevCo, the Public-Private Infrastructure Advisory Facility (PPIAF), the World Bank, the Asian Development Bank (ADB), and Australia's Department of Foreign Affairs and Trade (DFAT).

[4] Kapital Afrik (2022) *Timor Port protects mangroves in Tibar Bay.* Available at: https://www.kapitalafrik.com/2022/05/10/timor-port-protects-mangroves-in-tibar-bay- percentEF percentBF percentBC/.

References:

AGL Group. (2023) Timor Port awarded "Green Terminal" label. Available at: https://www.aglgroup.com/en/timor-port-awarded-green-terminal-label/.

AGL Group. (2024) Timor Port strengthens its environmental commitment with the release of 150 sea turtles at Kaitehu. Available at: https://www.aglgroup.com/en/timor-port-strengthens-its-environmental-commitment-with-the-release-of-150-sea-turtles-at-kaitehu/.

Asian Development Bank. (2024) (AP3F033-PM002) Project Monitoring Assistance: Tibar Bay Port PPP Project. Available at: https://ap3f.adb.org/our-activities/ap3f033-pm002-project-monitoring-assistance-tibar-bay-port-ppp-project.

Global Infrastructure Hub. (2024) Tibar Bay Port. Available at: https://www.gihub.org/innovative-funding-and-financing/case-studies/tibar-bay-port/.

Government of Timor-Leste (2014) Draft Concession Agreement relating to the Tibar Bay Port Project. Available at: https://www.laohamutuk.org/econ/PPP/Tibar/2016/DraftConcessionAgreement19Dec2014.pdf.

Kapital Afrik (2022) Timor Port protects mangroves in Tibar Bay. Available at: https://www.kapitalafrik.com/2022/05/10/timor-port-protects-mangroves-in-tibar-bay-percentEF percentBF percentBC/.

La'o Hamutuk (2013). Tibar Bay Port: Summary of Environment and Social Scoping Study. Available at: https://www.laohamutuk.org/econ/PPP/Tibar/scoping-summary-w-site-selection-annex-december-2013-english.pdf.

La'o Hamutuk (2017). Tibar Bay Port – Environmental Management Plan. Available at: https://www.laohamutuk.org/Env/TibarPort/EMP_301320-13728-MA-REP-1300_Rev2DOct2017.pdf.

La'o Hamutuk. (2018) Public-Private Partnership for Tibar Port: Helping economic growth or limiting sustainability? Available at: https://www.laohamutuk.org/econ/PPP/Tibar/TibarIndexEnTe.htm.

MSC Mediterranean Shipping Company SA. (2023) 2023 Sustainability Report. Available at: https://www.loginlogistica.com.br/wp-content/uploads/2024/10/relatorio-de-sustentabilidade-msc-2023.pdf.

Timor Port. (2022) Wärtsilä visits Timor Port for Vessel Traffic System (VTS) installation. Available at: https://www.timorport.com/2022/10/25/wartsila-visits-timor-port-for-vessel-traffic-system-vts-installation-2/.

Timor Port. (n.d.) Sustainability. Available at: https://www.timorport.com/sustainability/.

World Bank. (2018) Public-Private Partnership Stories: Timor-Leste - Tibar Bay Port. Available at: https://documents1.worldbank.org/curated/en/470341542225495367/pdf/132059-BRI-PUBLIC-PPP-Stories-Tibar-Bay-Port.pdf.

Adelaide Airport Heat Reduction Trial (Australia)

Context:

Airports, with their extensive hard surfaces and open spaces, are particularly vulnerable to the urban heat island effect, resulting in elevated ambient temperatures[1]. In fact, airport data is often used as a proxy for studying heat island effects due to the similar characteristics shared with dense urban environments—minimal vegetation, vast impermeable surfaces, and rapid water runoff[2]. These elevated temperatures can significantly impact airport operations. As hotter air is less dense, aircraft engines must generate more thrust for takeoff, which can lead to operational constraints. Extreme heat conditions can reduce an aircraft's maximum takeoff weight by up to 5 percent and decrease payload capacity by approximately 1 percent (as a global average)[3]. Additionally, airports experience increased energy demand for cooling systems and a higher risk of heat-induced flight disruptions, including delays and cancellations, further compounding economic and operational challenges.

Adelaide, in Australia, is a dry capital city with very high temperatures being reached during summer and early autumn. It is predicted that there will be a significant increase in the number of days exceeding 40 degrees Celsius in the next few decades as a consequence of climate change[4]. Adelaide Airport is therefore susceptible to these extremes in temperature, which will impact both the terminal and airside operations[1].

To address these challenges, Adelaide Airport, in collaboration with SA Water, the local water utility, initiated a heat reduction trial in 2015 by irrigating airport land to lower ambient temperatures. The trial involved irrigating a 4-hectare area within the airport using recycled water from a nearby wastewater treatment plant.

Irrigation was undertaken two nights each week, which led to a cooling effect and also led to the planting of a crop (lucerne), which provided secondary cooling benefits through evapotranspiration as well as a source of revenue[1,4].

Source: CRC for Water Sensitive Cities

Financing Models:

Own-source financing: The project was a joint venture between the privately owned Adelaide Airport and the state-owned company (water utility) SA Water to trial the cooling infrastructure solution. A cost-benefit analysis developed for the project estimated CAPEX for irrigation and crop planting to be at AUD 2.88 million (US$1.8 million). The investment was co-financed by Adelaide Airport and the local water utility[5].

Cost Recovery Models:

User pays (airport fees and revenues): Adelaide Airport recovered their costs through the project benefits, including avoided losses from urban heat management. The outcome from this trial was that the financial benefits for the airport would create a positive cash flow after 7 years of operation (which included the capital cost of the infrastructure to irrigate and crop the land)[6].

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[1] Airport Technology (2019). *Adelaide Airport in Australia trials heat mitigation methods.* Available at: https://www.airport-technology.com/news/adelaide-airport-heat-mitigation/?cf-view.

[2] William and Leung (2022). *Do Airports Have Their Own Climate?. Meteorology, 2022, 1(2), 171-182.* Available at: https://doi.org/10.3390/meteorology1020012.

[3] Qian et al. (2020). *Investigation on Airport Landscape Cooling Associated with Irrigation: A Case Study of Adelaide Airport, Australia. Sustainability, 2020, 12(19),* Available at: https://doi.org/10.3390/su12198123.

[4] Ingleton et al. (2019). *Adelaide Airport Heat Reduction Trial.* Available at: https://www.sawater.com.au/__data/assets/pdf_file/0019/419203/Airport-Case-Study.pdf.

[5] Stantec (2017). *Adelaide Airport irrigation project: Financial and Economic Analysis.* Available at: https://www.sawater.com.au/__data/assets/pdf_file/0008/424727/Adelaide-Airport-irrigation-project.pdf.

[6] CRC for Water Sensitive Cities (n.d.). *Adelaide Airport Irrigation Trial.* Available at: https://watersensitivecities.org.au/wp-content/uploads/2018/10/13-Adelaide-Airport_FINAL.pdf.

Project Results:

The trial demonstrated a 2.4-to-3.8-degree Celsius reduction in temperature in the irrigated area compared with the non-irrigated area on hot days. The cost-benefit assessments showed favorable results in using irrigation to support lucerne crops instead of grass on the airport site[4,6].

Enabling Environment:

Improving Access to Climate and Nature Data: The availability of surface temperature across the two-year trial period enabled the project benefits to be modeled to understand the potential impacts on aircraft operations and energy savings in adjacent buildings[6].

Multi-stakeholder collaboration: Adelaide Airport partnered with the local water utility, SA Water, for the provision of recycled water for cooling, sourced from a nearby wastewater treatment plant.

References:

Airport Technology (2019). Adelaide Airport in Australia trials heat mitigation methods. Available at: https://www.airport-technology.com/news/adelaide-airport-heat-mitigation/?cf-view.

CRC for Water Sensitive Cities (n.d.). Adelaide Airport Irrigation Trial. Available at: https://watersensitivecities.org.au/wp-content/uploads/2018/10/13-Adelaide-Airport_FINAL.pdf.

Ingleton et al. (2019). Adelaide Airport Heat Reduction Trial. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0019/419203/Airport-Case-Study.pdf.

Qian et al. (2020). Investigation on Airport Landscape Cooling Associated with Irrigation: A Case Study of Adelaide Airport, Australia. Sustainability, 2020, 12(19), Available at: https://doi.org/10.3390/su12198123.

Stantec (2017). Adelaide Airport irrigation project: Financial and Economic Analysis. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0008/424727/Adelaide-Airport-irrigation-project.pdf.

William and Leung (2022). Do Airports Have Their Own Climate? Meteorology, 2022, 1(2), 171-182. Available at: https://doi.org/10.3390/meteorology1020012.

Blue Bonds for Ocean Conservation (Belize)

Context:

Belize is highly vulnerable to climate change due to its extensive coastal and marine ecosystems. The country has experienced increasingly intense hurricanes, such as Eta and Iota in 2020, which led to massive flooding and infrastructure damage. Other climate-related threats include sea level rise, coral bleaching, and coastal erosion, all of which negatively impact Belize's marine biodiversity and economy, particularly its tourism and fisheries sectors.

Following the 2020 hurricanes, combined with other economic factors, Belize experienced a 16.7 percent reduction in GDP and increased national debt to 133 percent of gross domestic product. As a result, the country suspended payments to bondholders, and a US$553 million Eurobond ("Superbond"), which represented a quarter of its total debt, was trading at a deep discount of approximately US$0.38 on the dollar[1]. In response, Belize sought a solution that would both restructure its debt and provide sustainable funding for marine conservation. This led to the development of the Blue Bonds for Ocean Conservation, a debt-for-nature swap designed to address financial and nature challenges simultaneously.

In 2021 the government of Belize worked with The Nature Conservancy (TNC) to establish a subsidiary LLC named the Belize Blue Investment Company (BBIC). BBIC worked with Credit Suisse to issue highly rated blue bonds and then to provide a "blue loan" to the Government of Belize, enabling the government to buy back the US$553 million Superbond at 55 cents on the dollar[2]. This reduced Belize's debt by 12 percent of GDP and saved the government US$189 million in principal outstanding. In return for these savings, the government of Belize agreed to spend approximately US$4 million per year on marine conservation until 2041[91].

The project has specific conservation targets. Belize pledged to protect 30 percent of its ocean territory by 2026, with 15 percent designated as high-protection Replenishment Zones and 15 percent as Multi-Use Zones. It also committed to finalizing a Marine Spatial Plan and protecting public lands within the Belize Barrier Reef Reserve System.

The project includes accountability measures under the Conservation Funding Agreement between BBIC and the government of Belize. Failure to meet conservation milestones triggers increased payments; the annual conservation payment will increase by US$1.25 million per year for the first missed milestone and an additional US$250,000 for each additional missed milestone. These KPIs ensure both financial and environmental commitments are upheld[90].

Financing Models:

Capital markets finance: The transaction had two key components: 1) the Blue Loan used by the Government of Belize to repurchase and retire the Superbond, and 2) the conservation financing (based on the Conservation Funding Agreement) of long-term marine conservation activities.

To provide the government of Belize with the Blue Loan, TNC formed BBIC to act as the lender of record of the Blue Loan[90]. BBIC was financed by issuing Blue Bonds in a sale arranged and underwritten by Credit Suisse, also made possible through the provision of political risk insurance by the United States International Development Finance Corporation (DFC). This political risk insurance covers Belize's Blue Loan payments to BBIC, which allowed the loan to have a low interest rate, a 10-year grace period during which no principal is paid, and a long maturity of 19 years[91].

BBIC then provided US$364 million to the Government of Belize via the Blue Loan. US$301 million was used to retire the Superbond, US$24 million comprised the endowment for future conservation activities, and US$39 million comprised liquidity reserves, transaction costs, and original issue discount. The debt conversion resulted in a US$189 million reduction in principal outstanding, the savings from which allowed Belize to invest an estimated US$ 4 million per year in conservation funding over 20 years[90].

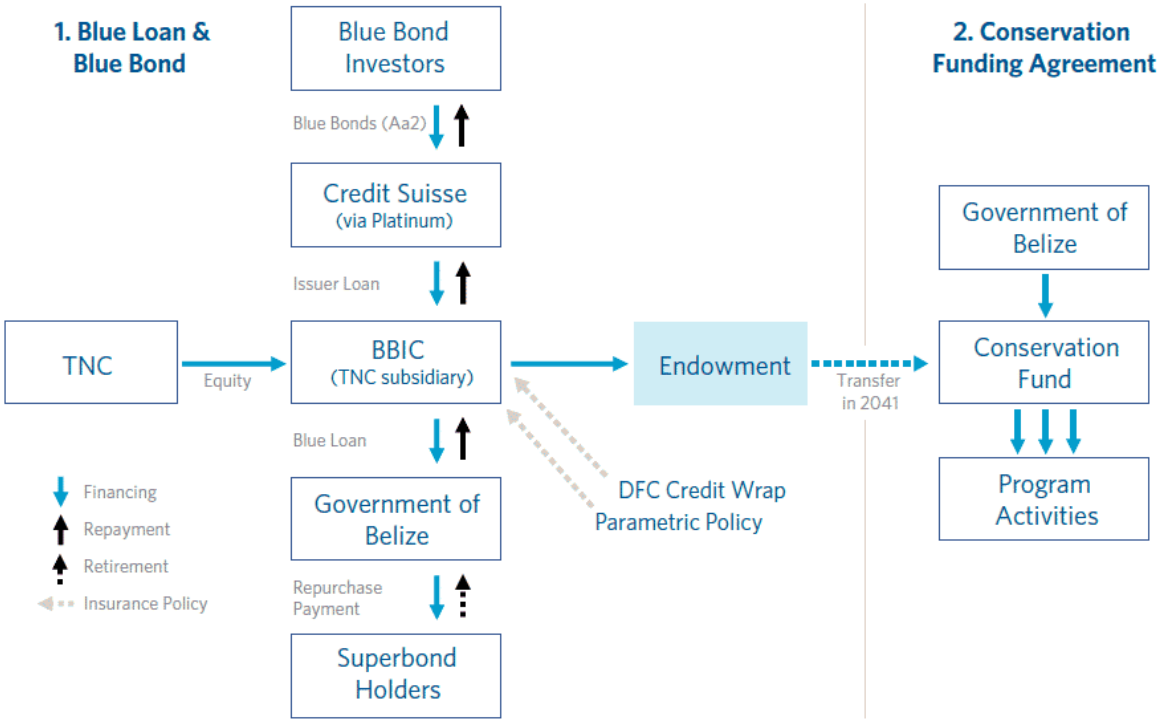
[1] The Nature Conservancy (2022). *Case Study: Belize Blue Bonds for Ocean Conservation*. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Belize-Debt-Conversion-Case-Study.pdf.

[2] IMF (2022). *Belize: Swapping Debt for Nature*. Available at: https://www.imf.org/en/News/Articles/2022/05/03/CF-Belize-swapping-debt-for-nature.

To channel the various sources of funding, the Belize Fund for a Sustainable Future (BFSF) was established in 2022 to pool together these governments' contributions. The BFSF issues grants to government and non-government partners that are developing projects for the sustainable use of coastal and marine resources[3]. After 2040, BFSF's grants will be financed exclusively through the US$24 million endowment, which is expected to grow to US$92 million by 2041.

Credit enhancement: In addition to the political risk insurance from the US DFC, the Blue Loan also incorporates a parametric insurance policy that covers Blue Loan debt payments (coupon and principal) following an eligible hurricane event in Belize. The payment can be triggered: 1) based on the intensity of the hurricane (minimum of Category 3) and proximity to economic hubs; 2) the occurrence of two hurricanes of any intensity in the same 12-month period; or, 3) a hurricane of any intensity accompanied by very heavy rainfall[90].

Belize Blue Loan/Blue Bond & Conservation Funding Agreement Structure



Source: The Nature Conservancy (2022)

[3] Belize Funds for a Sustainable Future (BFSF) (2025). *About the Belize Fund for a Sustainable Future*. Available at: https://belizefund.bz/.

Cost Recovery Models:

Government pays (debt service payments on blue loan): The government contributions to BFSF are funded through the national government budget based on the savings generated from the Blue Loan and the project benefits from investing in nature, which will be good for the Belize economy and hence future tax revenues. Coral reefs and mangroves significantly boost the economy through tourism, fisheries, and coastal protection. Tourism alone contributes over US$150 million annually, making up over 12 percent of GDP. Fisheries add another US$14 million to US$16 million per year, supporting local livelihoods. Additionally, these ecosystems provide coastal protection valued at US$231 million to US$347 million annually by preventing erosion and storm damage.

Project Results:

The debt restructuring reduced Belize's debt-to-GDP ratio by 12 percent and provided US$189 million in debt service savings, attracting international institutional investors to conservation finance.

As of 2023, the government of Belize had completed the first three of eight milestones contained in Belize's conservation commitments. This has included expansion of the area of Belize's ocean in Biodiversity Protection Zones, the designation of public lands as Mangrove Reserves, and the initiation of a Marine Spatial Planning process. As of 2023, the BFSF approved over BZ$18 million (around US$9 million) in government allocations and grants for marine conservation across 14 projects[4].

Enabling Environment:

Creating investment incentives to address market failures: The success of the Blue Bonds initiative was supported by key institutional and policy interventions.

- The BFSF ensures transparent management of conservation financing, with a board representing both government and non-government entities.
- The Marine Spatial Plan, initiated in 2022, supports evidence-based decision-making for ocean management. Belize has also committed to aligning its fisheries governance framework with international best practices.
- Stakeholder engagement was a fundamental part of the project, involving civil society, academia, and the private sector in conservation planning.
- Credit enhancement mechanisms, including political risk insurance and parametric insurance for hurricane protection, improved investor confidence, enabling the successful issuance of blue bonds.

The benefits of such approaches included: 1) scale, enabling financing at the program level rather than sourcing and structuring transactions project-by-project; 2) providing access to long-term institutional capital that would not otherwise be possible; and 3) creating incentives to invest in nature conservation.

[4] Belize Funds for a Sustainable Future (BFSF) (2023). *Annual Impact Report 2023*. Available at: https://belizefund.bz/download/annual-impact-report-2023/?wpdmdl=54276&refresh=67bbb2b8ef9ff1740354232.

References:

Belize Funds for a Sustainable Future (BFSF) (2025). About the Belize Fund for a Sustainable Future. Available at: https://belizefund.bz/.

Green Finance Institute (n.d.) Government of Belize Debt Conversion for Marine Conservation. Available at: https://hive.greenfinanceinstitute.com/gfihive/case-studies/government-of-belize-debt-conversion-for-marine-conservation.

International Monetary Fund (IMF) (2022) Belize: Swapping Debt for Nature. Available at: https://www.imf.org/en/News/Articles/2022/05/03/CF-Belize-swapping-debt-for-nature.

The Nature Conservancy (2022) Case Study: Belize Blue Bonds for Ocean Conservation. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Belize-Debt-Conversion-Case-Study.pdf.

The Nature Conservancy (2023) Belize Blue Bonds 2023 Impact Report. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/Belize-Blue-Bonds-2023-Impact-Report.pdf.

Biodiversity Bond (Colombia)

Context:

Colombia is one of the world's most biodiverse countries. It is home to 14 percent of known plant species in the world, one-third of the world's bird species, and over 1,400 species of mammals[1]. However, this biodiversity is under threat due to economic activity, notably deforestation, and climate change, which is impacting not only animal species but also the ecosystem services that help regulate droughts, water security, and flooding. Addressing these issues is imperative, as biodiversity loss not only undermines the ability to meet climate goals but also impacts local communities' livelihoods and the country's long-term sustainable development.

In response to the pressing need for biodiversity conservation, BBVA Colombia, in collaboration with the International Finance Corporation (IFC) and the Inter-American Development Bank (IDB) Invest, pioneered the issuance of the world's first biodiversity bond. This innovative financial instrument, totaling up to US$70 million, is dedicated exclusively to financing projects that combat biodiversity loss in Colombia[248],[2]. The bond proceeds are earmarked for projects focusing on reforestation, the regeneration of natural forests on degraded land, mangrove conservation or restoration, climate-smart agriculture, and wildlife habitat restoration, among others[244,248]. The project categories and criteria are aligned with the IFC's Biodiversity Finance Reference Guide[3] and aligned with the objectives of the Kungming-Montreal Global Biodiversity Framework[4],[245].

By channeling private capital into these nature-based solutions, the bond aims to enhance the preservation of Colombia's diverse ecosystems while promoting sustainable economic development.

Financing Models:

Capital markets finance: BBVA Colombia is the largest foreign investor in the Colombian financial system and the fifth-largest in the country[5]. With BBVA acting as the issuing bank and the IFC and IDB Invest as the main investors (each subscribed up to US$35 million), the US$ 70 million bond will be utilized for green projects that address the key drivers of biodiversity loss.

Cost Recovery Models:

User pays (commercial loan repayments): As a commercial bank, the proceeds from the bond will be reinvested via loans to the private sector, which will generate the revenue stream to service the bond payments.

Project Results:

The first tranche of biodiversity bonds was issued in 2024. While too early to report specific results, the bond is expected to increase access to finance for investments that address key drivers of biodiversity loss, as well as more broadly increasing attention on the biodiversity impacts of commercial investments in the country. Furthermore, as the first issuance of its kind, it is hoped the bond will have a demonstration effect, encouraging other financial intermediaries to explore the use of similar instruments.

Enabling Environment:

Creating investment incentives to address market failures: The project included technical advisory from IDB Invest, who will support BBVA Colombia in defining a model for managing risks related to nature and supporting the development of its biodiversity strategy[245]. BBVA Colombia also worked with IFC, who acted as structurer and provided advice to establish eligibility criteria and reporting indicators for activities in line with the IFC BiodiversityFinance Reference Guide. Additionally, IFC will build technical capabilities within BBVA to raise awareness among its clients about financing opportunities for biodiversity in Colombia[248].

[1] BBVA (2024). BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.

[2] IDB Invest (2024). IDB Invest and BBVA Colombia Announce Successful Placement of First Biodiversity Bond by a Financial Institution in LAC. Available at: https://www.idbinvest.org/en/news-media/idb-invest-and-bbva-colombia-announce-successful-placement-first-biodiversity-bond.

[3] IFC (2023). Biodiversity Finance Reference Guide. Available at: https://www.ifc.org/content/dam/ifc/doc/mgrt/biodiversity-finance-reference-guide.pdf.

[4] UNEP (2024). Kungming-Montreal Global Biodiversity Framework. Available at: https://www.cbd.int/gbf.

[5] IFC (2024). BBVA Colombia and IFC issue the world's first biodiversity bond in the financial sector. Available at: https://www.ifc.org/en/pressroom/2024/28298.

References:

BBVA (2024). BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue.

IDB Invest (2024). IDB Invest and BBVA Colombia Announce Successful Placement of First Biodiversity Bond by a Financial Institution in LAC. Available at: https://www.idbinvest.org/en/news-media/idb-invest-and-bbva-colombia-announce-successful-placement-first-biodiversity-bond.

IFC (2023). Biodiversity Finance Reference Guide. Available at: https://www.ifc.org/content/dam/ifc/doc/mgrt/biodiversity-finance-reference-guide.pdf.

IFC (2024). BBVA Colombia and IFC issue the world's first biodiversity bond in the financial sector. Available at: https://www.ifc.org/en/pressroom/2024/28298.

UNEP (2024). Kungming-Montreal Global Biodiversity Framework. Available at: https://www.cbd.int/gbf.

Annex 2: Project list

	Country	Project name
Shortlist (18)	Australia	Adelaide Airport heat reduction trial
	Belize	Belize Blue Bonds for Ocean Conservation
	Colombia	Biodiversity Bond
		Canal del Dique
		Vida Manglar Blue Carbon Project
	Ecuador	Quito Water Protection Fund
	France	Paris District Cooling PPP
	Jordan	As Samra Wastewater Recycling Plant
	Mexico	Quintana Roo Coral Reef Restoration
	Netherlands	Delta Programme
	Paraguay	Itaipú Paraguay Biodiversity Project
	South Africa	Greater Cape Town Water Fund
	Tanzania	Msimbazi River Basin
	Timor-Leste	Tibar Bay Port
	UK	Broadland Flood Protection
	USA	DC Water Rock Creek Project A
		Fargo-Moorhead River Diversion Project
		Mission Rock, San Francisco
Long-list (35)	Australia	Centenary Square heat reduction
		Climate Resilient by Nature (CRxN) Australia-Pacific Nature-based Solutions Challenge
		Nature Repair Market
	Bangladesh	Bangladesh Climate Risk Fund
	Cameroon	Green Commodity Landscape Cameroon Project
	China	Erhai Lakeside Ecological Restoration & Wetlands (China)
	Egypt	Bahr El Baqar Agricultural Wastewater Treatment Plant
	France	Aubervilliers schoolyard cooling
	Germany	Climate and Transformation Fund
	Ghana	Blue Economy for Resilient Africa Program - Mangrove Blue Carbon Pilot Program
	International	African Conservation and Community Tourism Fund
		Breathe Better Bond
	Malaysia, Nepal, the Philippines, Suriname, and Ukraine	GEF Greening Transportation Infrastructure Development Integrated Program
	Mexico	Livelihoods Fund for Family Farming
		Monetising Water Savings (MWS) in Mexico
		Sistema de Acción por Cooperación en Tacubaya (Mexico)
	Pakistan	Delta Blue Carbon
	Peru	Microcredit: strengthening local banks to promote biodiversity
		Peru Water Utility funding NbS
	Philippines	Restoration Insurance Service Company (RISCO)
		RISCO (Restoration Insurance Service Company)
	PNG	Blue Carbon Accelerator Fund

	Country	Project name
	Seychelles	Seychelles Sovereign Blue Bond
	South Africa	Cape Town Green Bond
	UK	Natural Environment Investment Readiness Fund
	USA	Central Arkansas Green Bond (for water and sanitation)
		Connecting Canoga Park
		Embarcadero Seawall Program (Phase 1), San Francisco (USA)
		Forest Resilience Bond
		Pier 70, Port of San Francisco
		SRC Trading Program – DC Green Bank
		TNC insurance policy for coral reefs, Hawai'i
	Vietnam	Emission Reduction-linked Bond for water purification projects
		GuarantCo partial credit guarantee to EVNFinance, Vietnam for alternative/ renewable energy sector
	Zanzibar	Chumbe Island Coral Park (CHICOP), established in 1991 in Zanzibar

Annex 3: Open-source climate data and models

Examples of open-source climate data and models to support climate risk screenings and subsequent detailed assessments

Category	Tool	Source
Flood risk management	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)
	Open-Source Data Sets for heat/drought Risk	Source
	Drought Risk Atlas	NOAA
	Drought Risk - Real-time	NOAA
	National Risk Index Annualized Frequency Heat Wave	FEMA
Coastal flooding and resilience	DINAS-COAST	Climate Adapt
	Global Tide and Surge Reanalysis (GTSR)	Vrije Universteit Amsterdam
	Global Dataset of Extreme Sea Levels and Coastal Flood Impacts over the 21st Century	University of Melbourne
	Extreme Sea level - RCP45	European Commission
	Global Flood Mapper	Geospatial Lab, Indian Institute for Human Settlements, Bengaluru
Cyclones	Global Storm Surge Reconstructions (GSSR)	Global Storm Surge Reconstructions (GSSR)
	Tropical Cyclones in Global Storm-Resolving Models	UCAR/NCAR - GDEX
	Historical Hurricane Tracks	NOAA
	Hurricane Satellite (HURSAT) Data	NOAA
	STORM Climate Change synthetic tropical cyclone tracks	4TU.ResearchData
	Global sea level change time series from 1950 to 2050	Copernicus (EU)
Climate models - open source	HEC-HMS	US Army Corps of Engineers
	Hazus	US Federal Emergency Management Agency (FEMA)
Climate data - open access	GBIF	Global Biodiversity Information Facility
	UNBL	UN Biodiversity Lab
	Open-source Biodiversity Data Platform Initiative	Nature Finance
	National Centers for Environmental Information	NOAA
	Climate Data Online	NOAA
	Oasis Hub	Oasis Hub
	ESA Climate Change Initiative	European Space Agency
	WorldClim	World Clim
	Global risk data collection	UNDRR

	Climate Mapping for Resilience & Adaptation	U.S. Federal government
Biodiversity and climate	Climate Resilience Evaluation and Awareness Tool (CREATE)	US Environmental Protection Agency
	National Risk Index for Natural Hazards	FEMA
	Indicators of Biodiversity and Ecological Services	World Resources Institute
	The Blue Guide to Coastal Resilience	USAID & TNC
		Source
Biodiversity loss	Living Planet Index	World Wildlife Fund
	IUCN Red List of Threatened Species	IUCN
	GLOBIO model	PBL Netherlands Environmental Assessment Agency
	Guidelines for Coastal and Marine Ecosystem	WAVES Partnership
	Accounting	
	Biodiversity and nature loss	World Economic Forum
	Our World in Data - Biodiversity	Oxford Martin School
	Global trends and scenarios for terrestrial biodiversity and ecosystem services from 1900 to 2050	Science

References

ANI (2017). Final Studies and Designs for the Construction of Works Under the Hydro-Sedimentological and Environmental Management Plan for the Canal del Dique System: Hydraulic Control Operating System. Available at: https://www.ani.gov.co/sites/default/files/apendice_tecnico_2_anexo_1_cd.id_.330.hid_.inf_.00.001_sistema_operativo_control_hidraulico.pdf.

Agencia Nacional de Infraestructura (ANI) (2022). The Public-Private Partnerships. Available at: https://www.as-coa.org/sites/default/files/inline-files/Colombia%20Infrastructure%20Presentation%202022.pdf.

Airport Technology (2019). Adelaide Airport in Australia trials heat mitigation methods. Available at: https://www.airport-technology.com/news/adelaide-airport-heat-mitigation/?cf-view.

Anglian Water. (n.d.). Working together to Get River Positive. Available at: https://www.anglianwater.co.uk/environment/river-health/working-together-to-get-river-positive/.

Appleton, A.F. (2002) How New York City Used an Ecosystem Services Strategy Carried out Through an Urban-Rural Partnership to Preserve the Pristine Quality of Its Drinking Water and Save Billions of Dollars and What Lessons It Teaches about Using Ecosystem Services. Available at: https://www.cbd.int/financial/pes/usa-pesnewyork.pdf.

Arias et al. (2010). Water fund for catchment management in Quito, Ecuador. Available at: https://www.cbd.int/financial/pes/ecuador-peswater.pdf.

Australia Government Clean Energy Regulator (2024). Nature Repair Market. Available at: https://cer.gov.au/schemes/nature-repair-market.

BBVA (2024). BBVA Colombia and IFC announce the financial sector's first biodiversity bond issue. Available at: https://www.bbva.com/en/sustainability/bbva-colombia-and-ifc-announce-the-financial-sectors-first-biodiversity-bond-issue/.

Belize Funds for a Sustainable Future (BFSF) (2023). Annual Impact Report 2023. Available at: https://belizefund.bz/download/annual-impact-report-2023/?wpdmdl=54276&refresh=67bbb2b8ef9ff1740354232.

Belize Funds for a Sustainable Future (BFSF) (2025). About the Belize Fund for a Sustainable Future. Available at: https://belizefund.bz/.

Bertram, et al. (2021). The blue carbon wealth of nations. Nature Climate Change, 11, 704–709. Available at: https://www.nature.com/articles/s41558-021-01089-4.

Brookings (2023). Cape Town: Lessons from Managing Water Scarcity. Available at: https://www.brookings.edu/articles/cape-town-lessons-from-managing-water-scarcity/.

Browder et al. (2019). Integrating Green and Grey: Creating Next Generation Infrastructure. Available at: https://www.wri.org/research/integrating-green-and-gray-creating-next-generation-infrastructure.

C40 (2021). Urban Cooling Toolbox. Available at: https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/1Q000000gSgz/JB7m_GoT_hdVZC64KxK_COtx6ljGry6aNjtCPavce14.

CRC for Water Sensitive Cities (n.d.). Adelaide Airport Irrigation Trial. Available at: https://watersensitivecities.org.au/wp-content/uploads/2018/10/13-Adelaide-Airport_FINAL.pdf.

Cetrulo, at al. (2019). An analytical review of the efficiency of water and sanitation utilities in developing countries. Water Research, 161, 372–380. Available at: https://doi.org/10.1016/j.watres.2019.05.044.

City of Cape Town (2025). Clearing alien invasive plants restores 48 million litres of water daily. Available at: https://www.capetown.gov.za/Media-and-news/Clearing%20alien%20invasive%20plants%20restores%2048%20million%20litres%20of%20water%20daily.

Climate ADAPT (2016). Regional flood management by combining soft and hard engineering solutions, the Norfolk Broadlands. Available at: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/regional-flood-management-by-combining-soft-and-hard-engineering-solutions-the-norfolk-broadlands.

Climate Bonds Initiative (2023). Sustainable Debt Global State of the Market 2023. Available at: https://www.climatebonds.net/files/reports/cbi_sotm23_02h.pdf.

Climate Policy Initiative (2024). Global Landscape of Climate Finance 2024. Available at: https://www.climatepolicyinitiative.org/wp-content/uploads/2024/10/Global-Landscape-of-Climate-Finance-2024.pdf.

Conservation International (2022). Vida Manglar Impact Report. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/cispata-bay-mangroves-2022-impact-report.pdf?sfvrsn=2b5b6f4d_3.

Conservation International (n.d.). Share the Facts About Mangroves. Available at: https://www.conservation.org/act/share-the-facts-about-mangroves.

Conservation International (n.d.). Vida Manglar Carbon Project. Available at: https://www.conservation.org/projects/vida-manglar-carbon-project.

Consolidated Contractors Company (2023). As-Samra Wastewater Treatment Plant. Available at: https://www.ccc.net/project/as-samra-wastewater-treatment-plant/.

Convention on Biological Diversity (n.d.). Kunming-Montreal Global Biodiversity Framework: 2030 Targets (with Guidance Notes). Available at: https://www.cbd.int/gbf/targets.

DC Water. EIB Fact Sheet. https://www.dcwater.com/sites/default/files/finance/eib-factsheet.pdf.

Delmon (2010). Understanding Options for Public-Private Partnerships in Infrastructure. Available at: https://ppp.worldbank.org/public-private-partnership/sites/default/files/2022-05/WPS5173_0.pdf.

District of Columbia Water and Sewer Authority (n.d.) FACT SHEET: DC Water Environmental Impact Bond Results. Available at: https://www.dcwater.com/sites/default/files/finance/eib-factsheet.pdf.

District of Columbia Water and Sewer Authority (n.d.). Clean Rivers Project. Available at: https://www.dcwater.com/cleanrivers.

District of Columbia Water and Sewer Authority (n.d.). Impervious Area Charge. Available at: https://www.dcwater.com/customer-center/rates-and-billing/impervious-area-charge.

Dutch State Treasury Agency (2023). State of the Netherlands Green Bond Framework. Available at: https://english.dsta.nl/binaries/dsta-english/documenten/publication/2023/09/08/green-bond-framework---updated-8-september-2023/State+of+the+Netherlands+-+Green+Bond+Framework+-+updated+8+September+2023.pdf.

Dutch State Treasury Agency (2023). Water investments at the heart of the new Dutch Sovereign Green Bond. Available at: https://english.dsta.nl/news/news/2023/09/08/water-investments-at-the-

heart-of-the-new-dutch-sovereign-green-bond-the-dutch-state-treasury-agency-announces-the-new-green-dsl-to-be-issued-on-17-october-2023.

Dutch State Treasury Agency (2024). State of the Netherlands Green Bond Report 2023. Available at: https://english.dsta.nl/documents/publication/2024/05/29/2023-green-bond-report.

Dutch Water Sector (2018). Royal HaskoningDHV to design Colombia's first two navigation locks. Available at: https://www.dutchwatersector.com/news/royal-haskoningdhv-to-design-colombias-first-two-navigation-locks.

ENGIE (2021). The City of Paris selects ENGIE and its partner the RATP group to manage its cooling network. Available at: https://www.engie.com/en/journalists/press-releases/the-city-of-paris-selects-engie-and-its-partner-the-ratp-group-to-manage-its-cooling-network?utm_source=chatgpt.com.

ENGIE (2022). What carbon-free solution can we offer for the Paris district cooling system?. Available at: https://www.engie.com/en/business-case/engie-x-fraicheur-de-paris.

Ecosistemas del Dique (2025). Proyecto. Available at: https://ecosistemasdeldique.com/proyecto.

Engie (2022). What carbon-free solution can we offer for the Paris district cooling system?. Available at: https://www.engie.com/en/business-case/engie-x-fraicheur-de-paris.

Environment Agency (2021). Broadland flood alleviation project reaches 20 year landmark. Available at: https://www.gov.uk/government/news/broadland-flood-alleviation-project-reaches-20-year-landmark.

Expansion (2022). Sacyr wins contract for Canal del Dique in Colombia for 640 million. Available at: https://www.expansion.com/empresas/inmobiliario/2022/12/08/63922042e5fdead4408b461e.html.

FAST-Infra (2024). What are the objectives of the FAST-Infra Label?. Available at: https://www.fastinfralabel.org/faqs/what-are-the-objectives-of-fast-infra-label.

Fondo para la Protección del Agua (FONAG). (n.d.). Fondo para la Protección del Agua - FONAG: Quito, Ecuador. Available at: https://www.fondosdeagua.org/content/dam/tnc/nature/en/documents/latin-america/wfquito.pdf.

Fraîcheur de Paris (2022). The City of Paris selects the ENGIE group and its partner, the RATP group, to manage its cold network. Available at: https://www.fraicheurdeparis.fr/actualite/la-ville-de-paris-retient-le-groupe-engie-et-son-partenaire-le-groupe-ratp-pour-gerer-son-reseau-de-froid.

Fraîcheur de Paris. (n.d.). Refreshing Parisians, strengthening the city's resilience, adapting Paris to global warming. Available at: https://www.thegpsc.org/sites/gpsc/files/paris_district_cooling.pdf.

FullAvanteNews (2020). COLOMBIA: Recover the Canal del Dique may be a reality. Available at: https://fullavantenews.com/colombia-recover-canal-del-dique-reality/.

G20 Indonesia (2022). G20/GI Hub Framework on How to Best Leverage Private Sector Participation to Scale Up Sustainable Infrastructure Investment. Available at: https://cdn.gihub.org/umbraco/media/4832/g20-gi-hub-framework-to-scale-up-investment-in-sustainable-infrastructure.pdf.

GCA (2023). Financing NBS for Adaptation. Available at: https://www.eci.ox.ac.uk/sites/default/files/2023-12/Financing_NbS_for_Adaptation-GCAOxford2023-finalv2.pdf.

GFDRR (n.d.). ThinkHazard!. Available at: https://thinkhazard.org/en/.

GFDRR, et al. (2018). Nature-based Solutions for Disaster Risk Management. Available at: https://wriorg.s3.amazonaws.com/s3fs-public/NBS_for_DRM_brochure.pdf. Note: Includes examples from Alabama, the Netherlands, and Vietnam

Global Facility for Disaster Reduction and Recovery (GFDRR). (2014). Making a Riskier Future: How Our Decisions Are Shaping Future Disaster Risk. Available at: https://www.gfdrr.org/riskier-future/.

Global Infrastructure Hub (2020). Unpacking complexity to provide solutions for funding and financing of infrastructure.

Global Infrastructure Hub (2022). Tibar Bay Port. https://www.gihub.org/innovative-funding-and-financing/case-studies/tibar-bay-port/.

Government of the Democratic Republic of Timor-Leste (2014). [Draft] Concession Agreement relating to the Tibar Bay Port Project. Available at: https://www.laohamutuk.org/econ/PPP/Tibar/2016/DraftConcessionAgreement19Dec2014.pdf.

Government of the Netherlands (n.d.). Delta Programme: flood safety, freshwater, and spatial adaptation. Available at: https://www.government.nl/topics/delta-programme/delta-programme-flood-safety-freshwater-and-spatial-adaptation.

Greater Cape Town Water Fund (2025). Decision Support System. Available at: https://public.tableau.com/app/profile/waterfunds/viz/GCTWFDSSv1/PublicDSS.

Green Finance Institute (2018). Quintana Roo Reef Protection (Parametric Insurance). Available at: https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/quintana-roo-reef-protection-parametric-insurance/.

Green Finance Institute (citing the Climate Policy Initiative). DC Water Environmental Impact Bond. https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/dc-water-environmental-impact-bond/.

Green Finance Institute, 2024. Quintana Roo Reef Protection (Parametric Insurance). Available at: https://hive.greenfinanceinstitute.com/gfihive/revenues-for-nature/case-studies/quintana-roo-reef-protection-parametric-insurance/.

Grey and Sadoff (2007). Sink or Swim? Water Security for Growth and Development. Water Policy, 9 (6). Available at: 10.2166/wp.2007.021.

Hallegatte, S. and Rozenberg, J. (2017). Climate change through a poverty lens. Nature Climate Change 7, 250–256 (2017). https://doi.org/10.1038/nclimate3253.

Headwaters Economics (2020). Overcoming Financial Obstacles: Fargo, North Dakota. Available at: https://headwaterseconomics.org/wp-content/uploads/Fargo-Report-R5.pdf.

Headwaters Economics (2024), Fargo-Moorhead Economic Resilience Report, available at: https://headwaterseconomics.org/wp-content/uploads/Fargo-Report-R5.pdf.

IDB Invest (2024). IDB Invest and BBVA Colombia Announce Successful Placement of First Biodiversity Bond by a Financial Institution in LAC. Available at: https://www.idbinvest.org/en/news-media/idb-invest-and-bbva-colombia-announce-successful-placement-first-biodiversity-bond.

IFC (2022). A Climate Opportunity for the Private Sector: Designing Investor-Friendly Carbon Markets. Available at: https://documentsinternal.worldbank.org/search/33943992.

IFC (2022). Biodiversity Finance Reference Guide. Available at: https://www.ifc.org/en/insights-reports/2022/biodiversity-finance-reference-guide.

IFC (2024). BBVA Colombia and IFC issue the world's first biodiversity bond in the financial sector. Available at: https://www.ifc.org/en/pressroom/2024/28298.

IMF (2022). Belize: Swapping Debt for Nature. Available at: https://www.imf.org/en/News/Articles/2022/05/03/CF-Belize-swapping-debt-for-nature.

IPBES (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services. Available at: https://zenodo.org/records/3553579. Note: This definition is cited in footnote 4.

IPCC (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability: Summary for Policymakers. Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf.

Infrahub Africa. (n.d.) Greater Cape Town Water Fund. Available at: https://www.infrahub.africa/case-studies/greater-cape-town-water-fund.

Ingleton et al. (2019). Adelaide Airport Heat Reduction Trial. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0019/419203/Airport-Case-Study.pdf.

International Finance Corporation (2022) Catalogue of Nature-Based Solutions for Infrastructure Projects. Available at: https://www.ifc.org/content/dam/ifc/doc/2023/catalogue-of-nature-based-solutions-for-infrastructure-projects.pdf.

Jacobs. (n.d.) Broadland Flood Alleviation Project. Available at: https://www.jacobs.com/projects/broadland-flood-alleviation-project#:~:text=The percent20Broadland percent20Flood percent20Alleviation percent20Project.

Jourbert and Ziervogel (n.d.). Day Zero: Once City's Response to a Record-Breaking Drought. https://dayzero.org.za/. Note: Day zero was estimated to be on 21 April 2018 and this was cancelled in March 2018

Kapital Afrik (2022) Timor Port protects mangroves in Tibar Bay. Available at: https://www.kapitalafrik.com/2022/05/10/timor-port-protects-mangroves-in-tibar-bay- percentEF percentBF percentBC/.

Kennisportal Klimaat adaptatie (n.d.). National Climate Adaptation Strategy (NAS). Available at: https://klimaatadaptatienederland.nl/en/policy-programmes/national-strategy/nas/.

Kerth and Baxandall (2011). Tax-Increment Financing: The Need for Increased Transparency and Accountability in Local Economic Development Subsidies. Available at: https://publicinterestnetwork.org/wp-content/uploads/2011/12/Tax-Increment-Financing-vMD.pdf.

Latin American Water Funds Partnership (n.d.). Fondo para la protección del agua – FONAG. Available at: https://www.fondosdeagua.org/content/dam/tnc/nature/en/documents/latin-america/wfquito.pdf.

Latin American Water Funds Partnership. (n.d.). The Water Funds. Available at: https://www.fondosdeagua.org/en/the-water-funds/.

La'o Hamutuk (2013). Tibar Bay Port: Summary of Environment and Social Scoping Study. Available at: https://www.laohamutuk.org/econ/PPP/Tibar/scoping-summary-w-site-selection-annex-december-2013-english.pdf.

La'o Hamutuk (2017). Tibar Bay Port – Environmental Management Plan. Available at: https://www.laohamutuk.org/Env/TibarPort/EMP_301320-13728-MA-REP-1300_Rev2DOct2017.pdf.

Local residents approved multiple sales tax initiatives - two ½-cent local sales taxes and one ½-cent countywide sales tax – until 2084.

Mairie de Paris (2018). Paris Climate Action Plan. Available at: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5ae2f905a2f4220ae645f026/5af7316614ad660b652531de/files/Paris_-_Paris_Climate_Action_Plan.pdf?1526890697.

Marzouk and Ali (2018). Mitigating risks in wastewater treatment plant PPPs using minimum revenue guarantee and real options. Utilities Policy, 53, 121–133. Available at: https://doi.org/10.1016/j.jup.2018.06.012.

Metro Flood Diversion Authority (2024). Fargo-Moorhead Metropolitan Area Flood Risk Management Project: Draft Adaptive Management and Mitigation Plan, May 2024. Available at: https://fmdiversion.gov/wp-content/uploads/2024/05/FMM_AMMP_Main-Document-May-2024.pdf.

Millennium Challenge Corporation (2018). As-Samra Wastewater Treatment Plant Expansion Project. Available at: https://www.mcc.gov/resources/story/section-jor-ccr-as-samra-project/.

Ministry of Infrastructure and Water Management (2021). Delta Programme 2021: Staying on track in climate-proofing the Netherlands. Available at: https://english.deltaprogramma.nl/documents/publications/2020/09/15/dp2021-eng-printversie.

Ministry of Water and Irrigation (2023). Jordan's National Water Strategy 2023-2040. Available at: https://www.mwi.gov.jo/EBV4.0/Root_Storage/AR/EB_Ticker/National_Water_Strategy_2023-2040_Summary-English_-ver2.pdf.

NASA (n.d.). Arctic Sea Ice Minimum Extent. NASA Climate Change: Vital Signs of the Planet. Available at: https://climate.nasa.gov/vital-signs/arctic-sea-ice/.

Natural Climate Solutions Alliance (2024). Vida Manglar. Available at: https://www.wbcsd.org/wp-content/uploads/2024/08/Vida-Manglar.pdf.

OCTO (2024). Vida Manglar Project: Certifying conservation actions to reduce carbon emissions and benefit local communities. Available at: https://octogroup.org/vida-manglar-project-certifying-conservation-actions-to-reduce-carbon-emissions-and-benefit-local-communities/.

OECD (2021), Water Governance in Cape Town, South Africa, OECD Studies on Water, Available at:

https://doi.org/10.1787/a804bd7b-en.

Peninsula Beverage. (n.d.) Coca-Cola's investment in Cape Town Water Fund. Available at: https://www.peninsulabeverage.co.za/news-events/coca-cola-s-investment-in-cape-town-water-fund-1/.

Qian et al. (2020). Investigation on Airport Landscape Cooling Associated with Irrigation: A Case Study of Adelaide Airport, Australia. Sustainability, 2020, 12(19), Available at: https://doi.org/10.3390/su12198123.

Realfin (2024). Private infrastructure transactions between 2013-2023. Note: This was derived through World Bank PPIAF analysis of Realfin data.

Rentschler, et al. (2022). Flood exposure and poverty in 188 countries. Available at: https://doi.org/10.1038/s41467-022-30727-4. Note: This study was supported by the Global Facility for Disaster Reduction and Recovery (GFDRR).

Respira (2022). Climate Impact X and Respira's landmark auction for blue carbon credits oversubscribed with global demand. Available at: https://www.respira-international.com/press-release-climate-impact-x-and-respiras-landmark-auction-for-blue-carbon-credits-oversubscribed-with-global-demand/.

Royal HaskoningDHV (n.d.). System improvement Canal del Dique. Available at: https://coastalsolutions.ireport.royalhaskoningdhv.com/12001001A1.

Sacyr (2023). We signed the Certificate of Commencement over the Canal del Dique Ecosystems P3. Available at: https://sacyr.com/en/-/acta-inicio-ecosistemas-canal-del-dique.

Sandoval and Posada (2022). Canal del Dique – Public Bidding for the Second Fluvial Project of the 5G Concessions in Colombia. Available at: https://cms.law/en/col/publication/canal-del-dique-public-bidding-for-the-second-fluvial-project-of-the-fifth-generation-5g-of-concessions-in-colombia.

Schiermeier (2010). Few fishy facts found in climate report. Nature. 466 (170). Available at: https://doi.org/10.1038/466170a.

South African Breweries (SAB). (n.d.) SAB affirms commitment to water sustainability with over R5 million investment. Available at: https://www.sab.co.za/article/sab-affirms-commitment-water-sustainability-over-r5-million-investment.

South Pole Carbon Asset Management (2020). Blue Carbon Project Gulf of Morrosquillo "Vida Manglar". Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

Stantec (2017). Adelaide Airport irrigation project: Financial and Economic Analysis. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0008/424727/Adelaide-Airport-irrigation-project.pdf.

Sustainable Banking and Finance Network (SBFN) (2024). SBFN Toolkit: Sustainable Finance Taxonomies. Available at: https://www.sbfnetwork.org/wp-content/uploads/2024/05/SBFN-Toolkit_Sustainable-Finance-Taxonomies.pdf.

Swiss Re (2021). How insurance is protecting the world's second biggest coral reef. Available at: https://www.swissre.com/risk-knowledge/mitigating-climate-risk/insurance-protecting-coral-reef.html.

Tanzania Rural and Urban Roads Agency (n.d.). Msimbazi Basin Development Project. Available at: https://www.msimbazibasin.tz/.

The Nature Conservancy (2020). Greater Cape Town Water Fund: Fact Sheet. Available at: https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf.

The Nature Conservancy (2022). Case Study: Belize Blue Bonds for Ocean Conservation. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Belize-Debt-Conversion-Case-Study.pdf.

The Nature Conservancy (2024). Science Behind the Scenes in Cape Town: A new interactive tool tracks the progress of water-saving activities that can help avoid the next "Day Zero". Available at: https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/new-tool-validates-cape-town-water-fund/.

The Nature Conservancy (n.d.). Ecuador Water Funds. Available at: https://www.nature.org/en-us/about-us/where-we-work/latin-america/ecuador/our-work-in-ecuador-water/.

The Nature Conservancy. (2019) Greater Cape Town Water Fund: Business Case, April 2019. Available at: https://www.nature.org/content/dam/tnc/nature/en/documents/GCTWF-Business-Case-April-2019.pdf.

The Nature Conservancy. (2024) 'Insuring Nature to Ensure a Resilient Future'. Available at: https://www.nature.org/en-us/what-we-do/our-insights/perspectives/insuring-nature-to-ensure-a-resilient-future/.

The Nature Conservancy. (n.d.). Urban Water Blueprint: About. Available at: https://water.nature.org/waterblueprint/about/.

The United Republic of Tanzania (2022). Stakeholders Engagement Plan for the Msimbazi Basin Development Project. Available at: https://www.tamisemi.go.tz/storage/app/media/uploaded-files/Stakeholders percent20Engagement percent20Plan percent20Msimbazi percent20Project.pdf.

UNEP (2024). Kungming-Montreal Global Biodiversity Framework. Available at: https://www.cbd.int/gbf.

UNEP (2024). The climate data challenge: the critical role of open-source and neutral data platforms. Available at: https://www.unepfi.org/themes/climate-change/the-climate-data-challenge-the-critical-role-of-open-source-and-neutral-data-platforms/.

UNESCO (2012). Canal del Dique - Dike Canal. Available at: https://whc.unesco.org/en/tentativelists/5756/.

UNICEF (n.d.). Jordan: Water, sanitation and hygiene. Available at: https://www.unicef.org/jordan/water-sanitation-and-hygiene#:~:text=Jordan%20is%20the%20second%20most,which%20defines%20severe%20water%20scarcity.

US Army Corps of Engineers (n.d.). Mission and Vision. Available at: https://www.usace.army.mil/About/Mission-and-Vision/.

US EPA (2024). Learn About Heat Island Effects. Available at: https://www.epa.gov/heatislands/learn-about-heat-island-effects.

US Global Change Research Program: 1880 – 2023 data: https://www.globalchange.gov/indicators/sea-level-rise.

USA EPA (2017). DC Water's Environmental Impact Bond: A First of its Kind. Available at: https://www.epa.gov/sites/default/files/2017-04/documents/dc_waters_environmental_impact_bond_a_first_of_its_kind_final2.pdf.

United Nations Climate Change, 2017. Itaipu Dam Works to Combine Energy, Environment and Biodiversity. Available at: https://unfccc.int/news/itaipu-dam-works-to-combine-energy-environment-and-biodiversity.

United Nations Environment Programme (2021). Step up climate change adaptation or face serious human and economic damage. Available at: https://www.unep.org/news-and-stories/press-release/step-climate-change-adaptation-or-face-serious-human-and-economic.

Verra (n.d.). Blue Carbon Project Gulf of Morrosquillo "Vida Manglar". Available at: https://registry.verra.org/app/projectDetail/VCS/2290.

Vida Manglar (n.d.). Vida Manglar. Available at: https://www.vidamanglar.co/#proyecto.

Wen, at al. (2024). Analyzing the effect of public private partnership mode on sewage treatment in China. Scientific Reports, 14 (1), 9531. Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC11045736/#CR1.

William and Leung (2022). Do Airports Have Their Own Climate?. Meteorology, 2022, 1(2), 171-182. Available at: https://doi.org/10.3390/meteorology1020012.

World Bank (2012). Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided. Available at: https://unfccc.int/sites/default/files/resource/World%20Bank_Turn%20Down%20the%20Heat.pdf.

World Bank (2016). Blended Financing for the Expansion of the As-Samra Wastewater Treatment Plant in Jordan. Available at: https://documents1.worldbank.org/curated/ar/959621472041167619/pdf/107976-Jordan.pdf.

World Bank (2016). Jordan: As-Samra Wastewater Plant Expansion. Available at: https://documents1.worldbank.org/curated/pt/254401468187770179/pdf/106247-BRI-ADD-SERIES-PUBLIC.pdf.

World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. Available at: https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

World Bank (2017). Protecting the Atlantic Forest: Creating a Biodiversity Corridor in Eastern Paraguay. https://www.worldbank.org/en/results/2017/10/30/protecting-the-atlantic-forest-creating-a-biodiversity-corridor-in-eastern-paraguay.

World Bank (2017). Public-Private Partnerships: Reference Guide Version 3. Available at: https://ppp.worldbank.org/public-private-partnership/sites/default/files/2024-08/PPP%20Reference%20Guide%20Version%203.pdf.

World Bank (2018). Nature-based Solutions for Disaster Risk Management. GFDRR, WBG, WRI. https://wriorg.s3.amazonaws.com/s3fs-public/NBS_for_DRM_brochure.pdf.

World Bank (2019). The Msimbazi Opportunity: Transforming the Msimbazi Basin into a Beacon of Urban Resilience. Available at: https://documents1.worldbank.org/curated/ru/842751555397752385/pdf/Executive-Summary.pdf.

World Bank (2021). Resilience Rating System. Available at: https://documents1.worldbank.org/curated/en/701011613082635276/pdf/Summary.pdf.

World Bank (2021). Unlocking Private Investment in Climate Adaptation and Resilience. Available at: https://www.worldbank.org/en/news/feature/2021/03/04/unlocking-private-investment-in-climate-adaptation-and-resilience.

World Bank (2022). Project Appraisal Document: Msimbazi Basin Development Project. Available at: https://documents1.worldbank.org/curated/en/099815009132223369/pdf/BOSIB0e7180b840870b0d1076ddb9095955.pdf.

World Bank (2024). Note on Nature Finance Tracking Methodology. Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099020524182036310/bosib1722f330c0fd18f8818b41d9bbe465.

World Bank (2025). What is Climate and Disaster Risk Screening and why is it important?. Available at: https://climatescreeningtools.worldbank.org/what-climate-and-disaster-risk-screening-and-why-it-important.

World Bank (n.d.). Msimbazi Basin Development Project. Available at: https://www.worldbank.org/en/country/tanzania/brief/msimbazi-basin-development-project/.

World Bank (n.d.). PPPRC: PPP Contract Types and Terminology. Available at: https://ppp.worldbank.org/public-private-partnership/applicable-all-sectors/ppp-contract-types-and-terminology/.

World Bank Group. 2019. Wading out the Storm: The role of poverty in exposure, vulnerability, and resilience to floods in Dar es Salaam. Available at: https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/626361565186647096/wading-out-the-storm-the-role-of-poverty-in-exposure-vulnerability-and-resilience-to-floods-in-dar-es-salaam.

World Bank and UNCDF (2024). Local Governments Climate Finance Instruments: Global Experiences and Prospects in Developing Countries. Available at:

https://openknowledge.worldbank.org/entities/publication/56bd01a9-4aea-482d-a89a-c5b30b13becb.

World Bank, et al. (2022) Climate Toolkits for Infrastructure PPPs. Available at: https://www.worldbank.org/en/topic/sustainableinfrastructurefinance/brief/climate-toolkits-for-infrastructure-ppps.

World Bank. 2024. Rising to the challenge. https://www.worldbank.org/en/publication/rising-to-the-challenge-climate-adaptation-resilience.

World Economic Forum (2024) Pioneering Climate-Positive Approach to Mangrove Ecosystems. Available at: https://www.weforum.org/stories/2024/11/how-colombia-mangrove-stewards-are-pioneering-a-climate-and-nature-positive-approach/.

World Economic Forum. Case study: DC Water's Environmental Impact Bond. https://www3.weforum.org/docs/WEF_Urban_Transformation_Case_Study_DC_Water_2022.pdf.

World Wildlife Fund (2022). 69% average decline in wildlife populations since 1970, says new WWF report. Available at: https://www.worldwildlife.org/press-releases/69-average-decline-in-wildlife-populations-since-1970-says-new-wwf-report.

Yescombe and Farquharson (2018). Public-Private Partnerships for Infrastructure: Principles of Policy and Finance. 2nd ed. Elsevier, Oxford.