Increasing infrastructure resilience with Nature-based Solutions (NbS)

A 12-STEP TECHNICAL GUIDANCE DOCUMENT FOR PROJECT DEVELOPERS

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Mariana Silva, IDB
Greg Watson, IDB
Amal Lee Amin, IDB
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Barney Dickson, United Nation's Environment Program
John Firth, Acclimatise
Amanda Rycerz, Acclimatise
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Omar Cardona, Ingeniar Risk
Rafael Fernandez, ITEC: Ingenieria Technica y Cientifica
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Valeria Chavez, UNAM
William Castleton, Boskalis

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Rain gardens retain stormwater runoff helping to reduce peak flooding.

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Source: DASonnenfeld / CC BY-SA

Acronyms

CAPEX	Capital Expenditure
CbA	Cost benefit Analysis
CEA	Cost Effectiveness Analysis
ICA	Incremental Cost Analysis
KPI	Key Performance Indicators
LAC	Latin American and the Caribbean
NbS	Nature-based Solutions
O&M	Operations and Maintenance
PES	Payment for Ecosystems
PPP	Public Private Partnership

Introduction

As greenhouse gas emissions continue to rise, climate change impacts are becoming more acute and frequent, driving the need to ensure climate resilience in infrastructure investments across Latin America and the Caribbean (LAC). Natural hazards are exacerbated by climate change, ENSO[1] events, and global change that is increasingly volatile, uncertain, complex, and ambiguous. Solutions that can build climate resilience, deliver enhanced infrastructure services, and maintain the valuable ecosystems that humans depend on, are urgently required in LAC to address a range of issues in tandem (IDB and UNEP, 2019).

There is general recognition and growing awareness that Nature-based Solutions (NbS) can play an important role in increasing climate change resilience and ensuring the delivery of sustainable infrastructure services. However, NbS have not been widely deployed to enhance climate resilience in infrastructure projects in LAC and in addition, the private sector has not fully engaged or invested in the use of NbS (IDB and UNEP, 2019). Indeed, there is a wealth of academic research and literature on the potential and capacity of ecosystems to increase resilience of economic assets and communities, yet there is a large gap to fill between academic research and practical application.

Ensuring that NbS are systematically incorporated into decision-making will require concerted efforts on several fronts and enhanced partnerships including strong involvement of the private sector. First, there is a large unfinished agenda to strengthen the upstream policy and institutional framework in most countries that needs to be consolidated in order to unlock investments, attract the private sector, and ensure a sharp focus on natural capital and green infrastructure from the outset. Second, each individual project needs to be designed, built, and operated with an NbS approach. A forthcoming Market Assessment by IDB and UNEP (2020) examines barriers and enablers to private sector uptake of NbS in LAC. The assessment finds that throughout LAC;

UPSTREAM

- NbS are typically not mainstreamed into policy, legislation, and regulations and thus not reflected at the design and procurement stages of public infrastructure services.
- There is a need to improve access to capital markets, conditions and scalability of green financial instruments suitable for NbS investment in LAC.

DOWNSTREAM

- Defining and understanding the business case and revenue stream are important first steps to building support and securing finance for NbS projects.
- Project developers require additional data, methodologies, tools and know-how to incorporate NbS into the infrastructure cycle.

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1 El Niño-Southern Oscillation (ENSO) is an irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean, affecting the climate of much of the tropics and subtropics.

Urban green infrastructure can reduce the heat island effect and help regulate storm-water runoff.
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Source: Pixabay

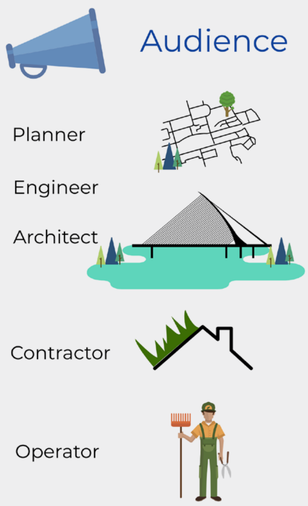
While the upstream barriers will need to be addressed to create a more enabling environment for NbS uptake in LAC, the present document addresses the downstream barriers by outlining a **12-step process** to integrate NbS into the project development cycle. Ideally, NbS will be integrated into the earliest stages of project development to optimize output and cost efficiency, yet NbS can be integrated at various stages of project development. For example, NbS can play an important role in project maintenance in areas where NbS may have not featured in project design (e.g. roads, coastal infrastructure). This guidance emphasizes the importance of integrating NbS from project inception, recognizing that there are various entry points. **The goal of this document is to provide guidance to project developers to prepare bankable sustainable infrastructure[2] projects that build climate resilience, and consider NbS as a substitute, compliment, or safeguard to conventional infrastructure projects.**

2 The four dimensions of sustainable infrastructure include; economic and financial sustainability, institutional sustainability, environmental sustainability and climate resilience and social sustainability. NbS in this context focuses on securing environmental sustainability and climate resilience of infrastructure projects. For more information see: https://publications.iadb.org/publications/english/document/Attributes_and_Framework_for_Sustainable_Infrastructure_en_en.pdf

How this guidance was developed

This Technical Guidance document was developed based on a review of guidance documents focused on integrating NbS project development[3], engineering and green infrastructure implementation guides, sustainable infrastructure literature, and NbS literature and case studies (see references). After completing a preliminary draft, the guidance was iterated at an IDB hosted technical workshop with project developers predominantly from Latin America and the Caribbean (LAC) (see acknowledgements). This document is the result of the collaborative effort. In parallel, a separate NbS guide for policy makers will be released in Spring 2020.

Figure 1: Target audience for the technical guidance document



Objective: this technical document provides guidance to project developers on how to prepare bankable climate resilient projects that consider NbS as a substitute, compliment, or safeguard to conventional infrastructure projects.

REFERENCE DOCUMENT

Due to the short nature of this document, this guidance document references external sources that can provide more detailed information or guidance. Recommended sources to consult are provided in Annex A.

INTENDED AUDIENCE

The guidance document is intended for **LAC-based public or private project developers** (see figure 1) with an interest in implementing NbS as a substitute, compliment or safeguard to traditional gray (engineered) infrastructure in response to a resilience challenge (e.g. flooding of coastal roadways during storm events, water shortages, flooding and landslides post-extreme rainfall). It also provides useful background information for all those involved in the planning development, procurement, financing, and operation of NbS. This document supports ***private*** developers to define and understand the business case and how NbS can deliver increased value to infrastructure projects, while ***public*** developers can utilize it to integrate NbS into tender and upstream planning and procurement documents. Likewise, this guidance document will be useful if NbS is included in a tender or procurement document and the project developer needs guidance on how to incorporate NbS into project pipelines. This guidance document is designed to apply - and where necessary modify - the steps of conventional project development, to integrate the use of NbS. It does not assume that readers have an extensive knowledge of NbS.

3 'Integrating NbS into project development' refers to projects that include NbS as a substitute, compliment, or safeguard in the planning and development of infrastructure assets. A substitute could refer to restoring a coral reef, versus constructing a breakwater for coastal protection; a compliment could refer to restoring a watershed surrounding a dam to regulate water supply and reduce sedimentation; a safeguard could refer to planting / restoring mangroves around a coastal roadway to protect against saltwater intrusion and sea level rise. When Natural and gray elements work together, they are commonly referred to as 'integrated solutions'.

What are Nature-based Solutions (NbS)?

Natural features are created and evolve over time through nature's physical, geological, biological, and chemical processes, forming coral reefs, barrier island, wetlands, dunes and forests. Nature-based features are designed, engineered and constructed to mimic nature's characteristics in order to provide specific services (e.g. in-land flood mitigation, coastal risk reduction) (Bridges et al, 2015). NbS can encompass natural features, nature-based features, and approaches that combine natural and gray elements, the latter referred to as integrated solutions. **NbS refers to activities associated with the protection, management, enhancement, and restoration of nature to deliver climate resilient infrastructure.**

NbS can be used to compliment, substitute, or safeguard to traditional gray infrastructure while delivering enhanced resilience and a series of co-benefits (e.g. supporting biodiversity, local livelihoods, and tourism and recreational opportunities) (Browder et al, 2019). While examples abound, a substitute could refer to restoring a coral reef, versus constructing a breakwater for coastal protection; a compliment could refer to restoring a watershed surrounding a dam to regulate water supply and reduce sedimentation; a safeguard could refer to planting / restoring mangroves around a coastal roadway to protect against saltwater intrusion and sea level rise. As such, NbS can be used to close the infrastructure access and quality gap in a climate resilient manner.

Watershed restoration can help regulate water supply and remove sediment for dams.

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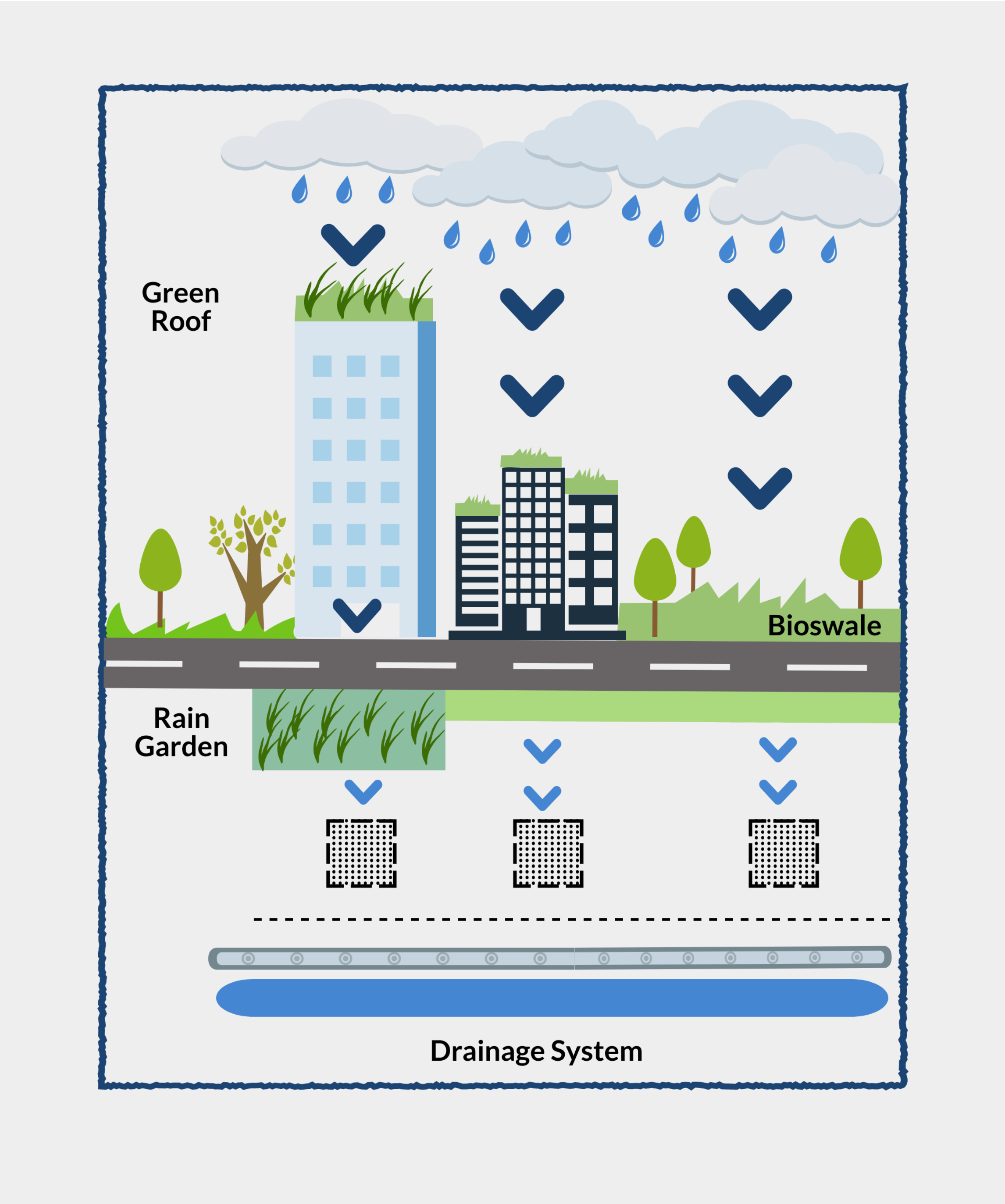
Source: Pixabay

Table 1: Examples of how infrastructure solutions can be delivered by gray solutions, NbS, or integrated solutions that combine natural and gray elements.

Challenge	Engineered (Gray) Solution	Nature-based Solution	Integrated Examples
Urban stormwater & flood management	• Retrofitted / enhanced urban storm-water drainage systems • Engineered flood protection	• Green roofs • Urban gardens & green spaces • Riparian and wetland vegetation restoration, creation & management	• Uptake of green roofs, bioswales & raingardens to regulate storm-water runoff & reduce flows to drainage system
Extreme (urban) heat	• Cooling centers and air conditioning • Spray decks • Pools • Misting systems • Shading devices	• Green roofs • Urban gardens and green spaces • Street trees	• Green roofs, bio swales and rain gardens cool by evapotranspiration and reduce urban heat island effect
Coastal flooding, storm surge, sea level rise & erosion	• Seawalls, dykes, permanent artificial walls & temporary storm barriers • Improved drainage systems	Conservation, management, restoration, or creation of: • Coral reefs (including the use of artificial substrate) • Oyster reef • Seagrass • Coastal wetlands; mangrove & salt marsh • Sand dunes & beaches	• Restoring / conserving mangroves belts that support sea dykes as a first line of defense to reduce flood risk and erosion
Inland flooding	• Alluvial dykes & dams (creation, retrofitting & maintenance) • Improved pumping, piping and storage systems	• Upstream vegetation management • Forest restoration • Riparian and wetland restoration / creation and management, living weirs & check-dams • Floodplain management	• Forest restoration surrounding alluvial dykes and dams
Landslides	• Retaining walls • Gabions	• Upslope vegetation management • Reforestation & afforestation	• Upslope vegetation strengthening the resilience of retaining walls
Water scarcity	• Reservoirs / dams • Concrete catchments • Aqueducts • Desalination plants (coastal)	• Watershed restoration, including reforestation or afforestation • Permeable 'green' areas for groundwater replenishment	• Watershed restoration surrounding dams to regulate water supply & decrease erosion & sedimentation
Soil erosion & sedimentation	• Retaining walls • Terracing Dredging programs	• Upslope vegetation restoration & management • Reforestation and, where appropriate, afforestation • Management of littoral vegetations and wetlands	

Source (above): IDB & UNEP (2019, forthcoming).

Figure 2 (left): green infrastructure (e.g. green roofs, rain gardens and bioswales) regulate storm water runoff to drainage systems, serving as an integrated green-gray solution.



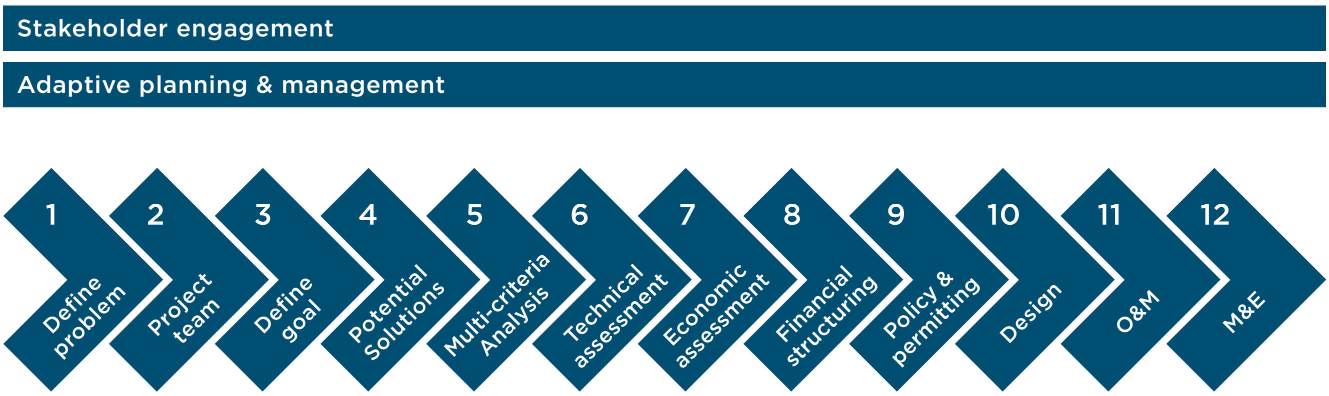
Source: IDB & UNEP (2019, forthcoming).

Twelve steps to integrate NbS into project development

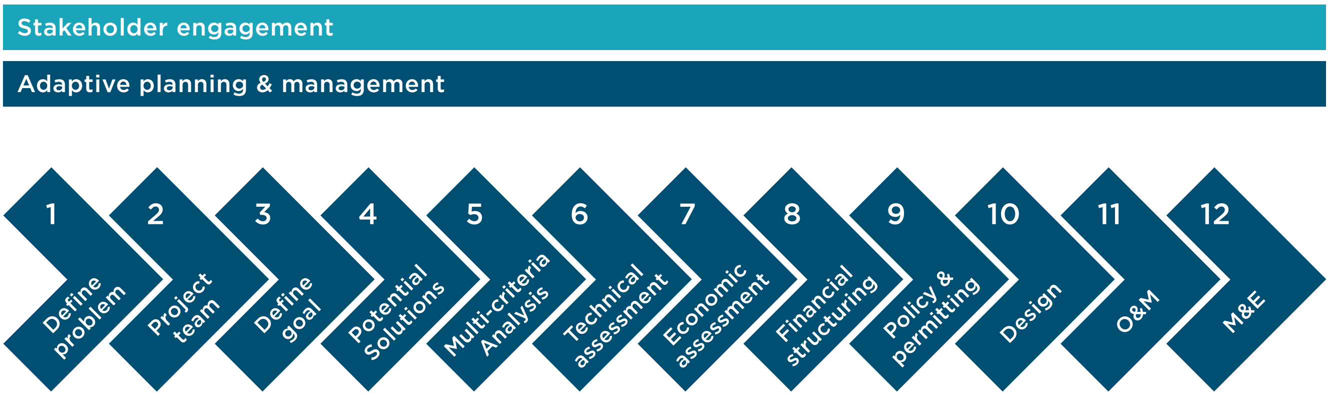
Figure 3 provides a conceptual diagram of the 12 steps involved in integrating NbS into the project development cycle. Each step is further elaborated throughout the document. This document presents a generalized process, although some project developers may define these steps differently. Further, this process is not strictly linear as there are many opportunities for iteration and revision.

Two cross-cutting themes, stakeholder engagement and adaptive planning and management, apply to all project stages. Figure 3 presents the project steps in a linear form, however this is designed to be an iterative process and there is scope to revisit and revise prior steps in the project lifecycle.

Figure 3: Conceptual Diagram: Integrating NbS into Project Development



Cross-Cutting Themes



i. Stakeholder Engagement

Successful integration of NbS into project development requires collaboration among a range of experts and stakeholders. Stakeholders will help define siting, performance requirements, potential ancillary benefits, and chronic failure. As NbS are inherently multi-purpose, and may spread over broad geographic areas, stakeholders are likely to bring different interests and goals to the consultations, which can present a challenge to manage. Yet it is important that all relevant stakeholders are included in the corporate governance process and invited to consultations to create project buy-in, justification, and build a sense of project ownership. Identifying long-term and stable partners is particularly important in the context of shared responsibility, and where capacity is required. Project developers will need to gain awareness of local socio-cultural components and / or legal arrangements that can support the consultation processes, which will differ from location to location. It is important to engage with project beneficiaries and all stakeholders that will be involved in the NbS lifecycle.

Recommendations for stakeholder engagement are denoted in a box with a star throughout the guidance document. ★

PROJECT DEVELOPERS SHOULD:

Define the governance process for stakeholder engagement:

- Determine how often and at what stages to hold stakeholder consultations.
    - *Will all stakeholders be involved in all stages or will it be a subset?*
- Determine decision-making mechanisms (e.g. group consensus or voting)?
- Stakeholder mapping: Identify the stakeholders to include early on and through all phases of the project lifecycle (e.g. planning, implementation, operation and maintenance) and the project beneficiaries.

The project's spatial and temporal characteristics will define stakeholder engagement. Project developers should engage with:

- **Policy stakeholders from national and local government and public agencies:**
  - Relevant (national, regional, and local) authorities and decision-makers in regard to NbS policy and planning. Failure to adhere to policy and planning requirements may result in bureaucratic hurdles and project delays down the line.

    Regulatory and permitting authorities may have limited experience evaluating NbS projects as existing codes and regulatory standards may not properly account for NbS, resulting in a situation where a project is outside the framework or scope of current procedures. Project developers should therefore engage with permitting authorities from the inception phases to build confidence, support, and if necessary, establish special permissions or permitting arrangements.
  - Decision-makers may also help project developers align with other government projects and initiatives to maximize results (e.g urban regeneration, climate change and biodiversity initiatives) and project developers should strive to maximize engagement with authorities from various agencies. Yet if an administration changes (local, regional, national), support for NbS projects could fall through. Therefore, project developers should identify when elections are taking place and define project goals during periods of stand-alone, no regret measures.

- **Community: landowners, representative groups, community members, Non-Government Organizations (NGOs), civil society groups and local businesses.**
  - Communities will have local knowledge that could help inform NBS design, performance, management, and monitoring. Allocating responsibilities to communities through various project stages (e.g. monitoring) can contribute to a sense of project ownership.
  - Community engagement should be inclusive, equitable, meaningful, and consider positive and negative impacts particularly towards vulnerable and marginalized groups. If the project will present negative consequences towards stakeholders, proper compensatory mechanisms should be identified early on.
  - NGO's may have a vested interest in supporting NbS projects, in particular organizations with environmental, biodiversity or community enrichment mandates.

- **Experts: scientists, academics, technical experts**
  - Universities and technical institutes can offer access to relevant information, data, methodologies and personnel (including graduate students to support research). As NbS is still in its infancy in the LAC region, knowledge institutes can play an important role in developing and disseminating NbS-knowledge.

- **Broader project team**
  - Identify and engage with the wider project team including financers, operators and owners of the project (see step 1). It is important that the eventual project team is involved from the inception stage to maximize buy-in and efficiencies.

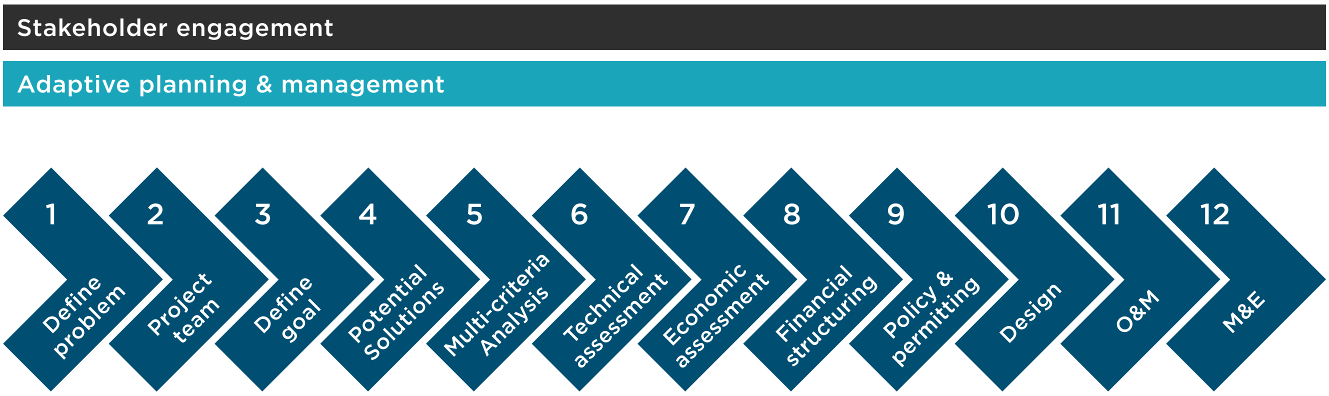
- **Project beneficiaries:**
  - Identify and engage with the project beneficiaries (e.g. landowners, utility providers, municipality, investors) that will receive the resilience benefits and co-benefits. NbS benefits can be diffuse and therefore the project beneficiaries may be different from the investors and the infrastructure users. Also, some benefits may materialize in the future and therefore beneficiaries should be mapped out over time and engaged throughout the project lifecycle.

- **Identify stakeholder capacity**
  - Do stakeholders fulfill capacity requirements or are training programs required? For example, communities may lack a thorough understanding of environmental impacts, and NbS benefits, and educational and capacity building opportunities may help build greater support and capacity at the community level.

Step i: Expected Outcomes

- Define the governance process for stakeholder engagement.
- Map and identify the stakeholders and beneficiaries to engage (across all stages of project lifecycle).
- Develop a repository / mechanism to document stakeholder engagement: clearly document all decisions, agreements, and minutes from stakeholder engagements.

ii. Adaptive Planning & Management



Adaptive planning & management differs from traditional planning and management approaches as it is not strictly linear and incorporates iterative and flexible elements to counterbalance the uncertainty associated with meeting project goals (Somarakis et al, 2019). Management of risk and uncertainty likewise plays an important role in conventional infrastructure projects, however NbS requires a better understanding of biophysical environments. **The performance of natural systems is variable, and can be expected to change over time, contributing an element of uncertainty and complexity to NbS projects.** Adaptive planning and management deals with decision-making over time and under deep uncertainty. The elements of uncertainty benefit from a more adaptive process whereby the results in one phase of planning and development inform decision-making in a subsequent phase, and the results of assessments in a project step may require adjustments in prior phases. For example, if results from the technical assessments (e.g. biophysical analysis) show that the preferred NbS option does not meet the resilience requirements, the project developer can revisit prior steps and make adjustments as needed.

Once the project has been implemented, an adaptive plan identifies design adaptation and / or additional measures in situations in which NbS is not delivering on the project goals (e.g. due to changes in climate and socio-economic conditions, and / or uncertainties in NbS performance over time).

Figure 4: Adaptive Planning & Management

Figure 4: Adaptive planning and management approach corresponding with steps in this technical guidance document. The diagram shows the general flow of project steps and also areas where steps can be revisited to make required adjustments. See annex A for further resources for adaptive management.

Step ii: Expected Outcomes

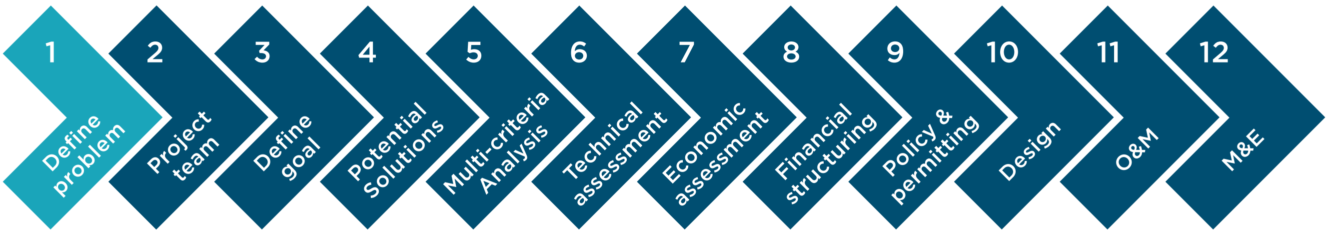
- Develop an adaptive planning and management approach

Planning Steps

1. Define the problem

Stakeholder engagement

Adaptive planning & management



The problem, the project goals (3) and potential solutions (4) should be viewed through the lens of a **systems analysis**. A systems analysis seeks to evaluate how systems function by analyzing interactions between and within the natural environment and socio-economic sub-systems. For example, prior to solving societal issues by means of infrastructure development, it is crucial to understand the drivers of the problem and how this relates to the biophysical and socio-economic environment. As NbS do not operate in isolation, a systems approach seeks to understand the feasibility and effectiveness of applying NbS in the broader context. See Annex A for more information on Systems Analysis.

a. **Identify the vulnerabilities and hazards** (e.g. drought, waste management, flooding, urban heat island effect etc.). The IDB has developed a Disaster and Climate Risk Assessment Methodology (see Box 1) that can help project developers identify and assess climate change risks and identify resilience opportunities.
   - *What are the drivers of the problem?*
   - *What are the systemic effects of the problem? (e.g. broader environmental, and socio-economic challenges)*
   - *What are the direct impacts, and indirect impacts?*
     e.g. direct impacts: flooded roads,
     e.g. indirect impacts: inability to drive to work when roads are flooded.
   - *How do the problems rank in order of priority?*

b. **Define the problem scale** (e.g. urban, landscape, river catchment, coastal area). A landscape approach is essential here as the entire system needs to be taken into account.

c. **Define how the problem is likely to be exacerbated by future impacts over time** (e.g. climate change, population increase, resource demand).

d. **Identify and assess the main uncertainties that are relevant for project planning.**

The project developer will already have a general understanding of the problem. This step presents the opportunity to assess the problem(s) on a more granular scale with stakeholders.

Box 1: IDB's Disaster and Climate Risk Assessment Methodology[i]

The IDB has developed a methodology to facilitate the identification and assessment of climate change effects, as well as resilience opportunities in all relevant projects during their upstream preparation and implementation phases. It builds upon the current disaster risk screening process and provides guidance for project teams, executing agencies, technical experts, and external consulting and design firms, on conducting disaster and climate change risk assessments in relevant operations, ensuring added value to projects. While this methodology was not designed explicitly for NbS, it is applicable through its focus on infrastructure disaster risk management and resilience building (Esquivel et al, 2018).

Mangrove root systems provide valuable coastal protection services.

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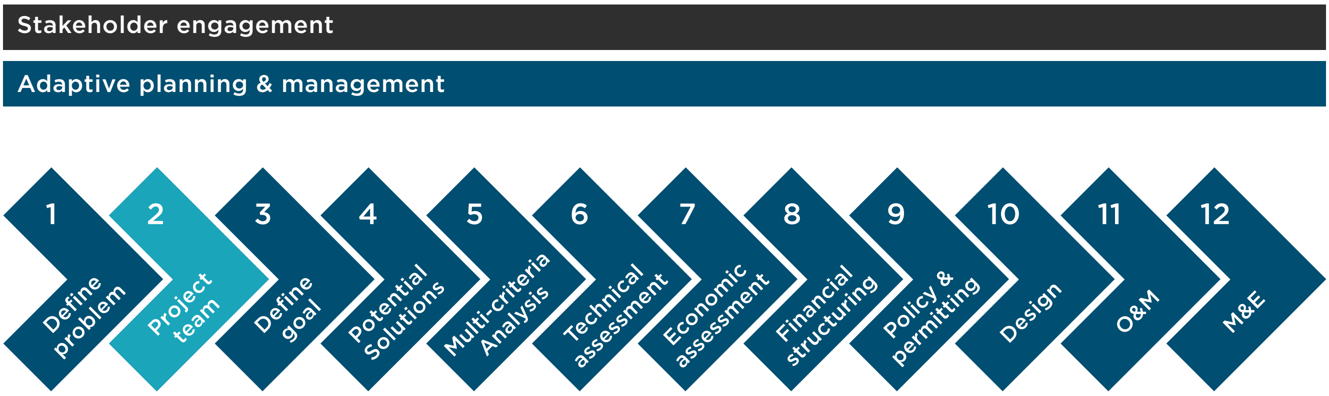
Source: Pixabay

2. Establish the project team and governance



The project team and governance protocol should be defined in the preliminary stages of project development, although it will likely evolve as the project becomes more defined. For example, based on the outcomes of forthcoming project steps, a need for specific expertise may emerge that is not apparent in the early inception phase. The principles of organizing a project team are discussed below:

a. **Secure project team capacity** with the necessary skill set and qualifications related to the integration of NbS (and other areas of infrastructure development) and identify, and address, capacity gaps early on. This applies to all project stages inclusive of technical assessments, economic and financial analysis, design and operations and maintenance (O&M).

b. **Ensure that there is clarification of roles and responsibilities** within the project team and of all stakeholders and team members are clearly assigned. If the project is a PPP, the role of the public vs. private sector should be clearly defined. Roles and responsibilities should be documented in a written agreement such as a Memorandum of Understanding (MoU).

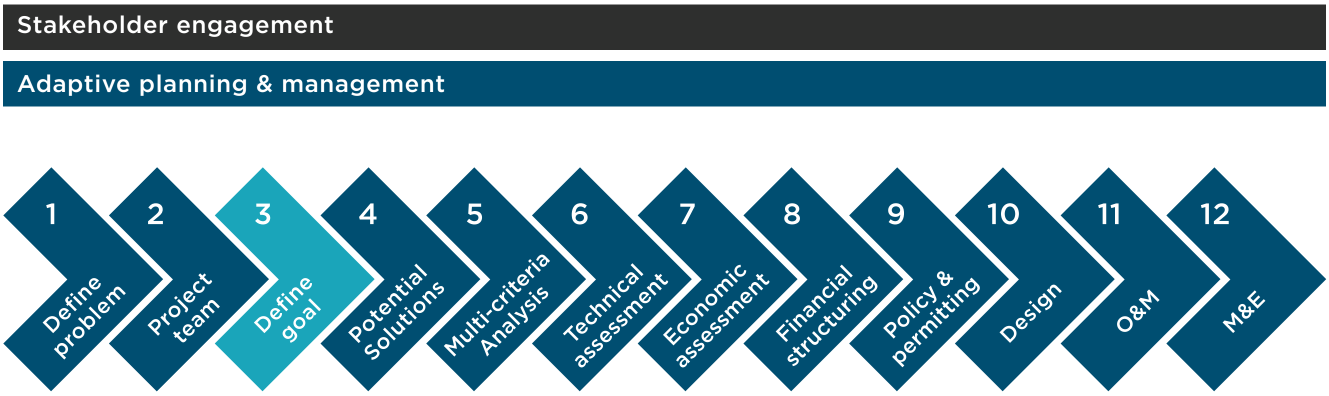
c. **Establish a decision-making framework** that aligns with rules and regulations, is equitable, and is implemented in accordance with the project timeline.

d. **Ensure transparency and disclosure (including financial disclosure).** Project information and decision-making should be transparent and accessible. This may also help mitigate the potential risk for corruption.

Step 1: Expected Outcomes

- Appoint project team members with relevant skill set and expertise.
- Clarify roles and responsibilities (e.g. in an MoU)
- Establish a transparent decision-making process and disclose among stakeholders.

3. Define the project goal and objective



a. **Define the objectives or goals in the context of the problem.** (e.g. reduce flood risk)

b. Define the principles and performance standards that the solution should adhere to (e.g. cost-effective, resilient, operating and performance standards, multifunctional).

3.1 Determine the project success criteria

- Define the Key Performance Indicators (KPI). These could be a combination of qualitative / quantitative indicators and should include co-benefits.
  e.g. reduce the number of flood days to no more than 5 per year.
- Define the reference or baseline scenario (e.g. 20 flood days per year).

Define KPI with stakeholders and liaise with government/ academia for data needs.

In certain contexts, flood risk can be reduced with the conservation and management of coastal ecosystems (e.g. mangroves, marshes, wetlands).

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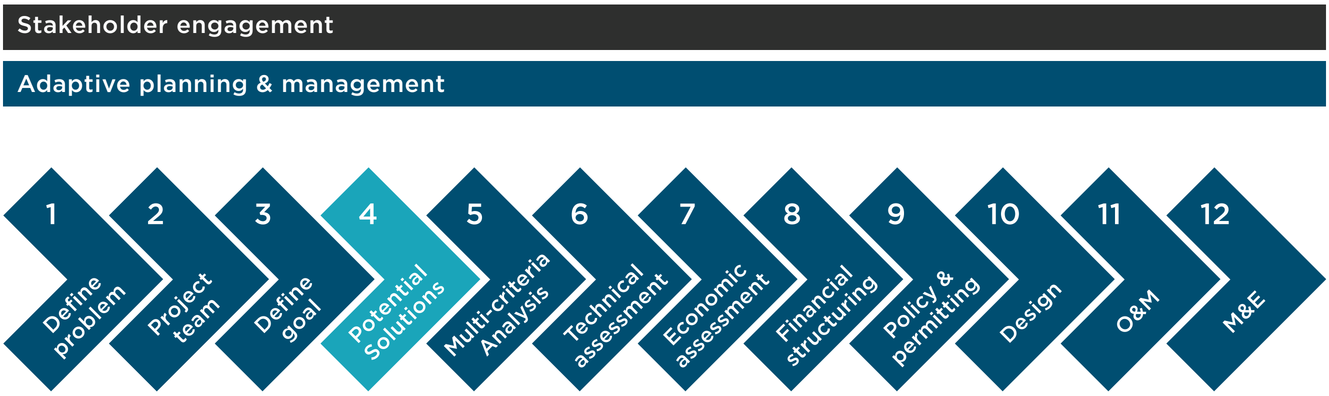
Source: Pixabay

4. Identify the suite of potential solutions that could address the problem, meet the project goals, and evaluate options in the local context.



The potential suite of solutions will vary depending on the resilience challenge and will include NbS as a substitute, safeguard or compliment to gray infrastructure. The project developer should consider how long it will take for the NbS to provide the full range of resilience benefits, and whether a gray solution is appropriate in the interim. The categories of potential solutions may include:

a. NbS as a substitute for gray infrastructure (natural, green)
e.g.
- Restored coral reef or artificial coral reef providing coastal defense services
- Green roof providing urban stormwater management
- Constructed wetland providing water treatment and stormwater management
- Forested area providing slope stabilization

b. NbS as a safeguard to traditional gray infrastructure
e.g. mangrove increasing the resilience of a coastal roadway

c. NbS as a compliment to gray infrastructure - Integrated green-gray approach
e.g. watershed restoration to support water flow for a hydroelectric dam

4.1. Evaluate how the proposed solutions fit within the local context (constraints and opportunities).

- **Institutional:** How do the proposed interventions (a-c) fit in within the broader institutional and social context? Are they perceived to be legitimate by stakeholders? Are there any notable constraints (e.g. security, social instability)?
- **Policy:** How do the proposed interventions fit within the policy context? Are special permissions or permitting arrangements (see step i)?
- **Capacity:** What is the local technical capacity to implement options a-c? Are there opportunities for capacity building / training (see step 1)?

★ **Evaluate solutions in local context with stakeholders.**

- **Financial:** What are the opportunities to secure funding and financing? In what time frame (see step 8)?
- **Environment:** How do the proposed solutions fit within the environmental context? Do they strengthen existing flora and fauna, and do they maintain and/or promote biodiversity? Or do they damage and/or exacerbate the current biophysical state of the environment?

Steps 2 - 4: Expected Outcomes:

- Define the project goals and determine the Key Performance Indicators (KPIs)
- Identify the potential solution(s) 4(a-c) that could address the resilience problem (1) and meet the project goals (2).
- Assess the local context and identify external constraints and challenges to address.
- Take forward the viable solutions to the Multi-criteria Analysis (MCA).

Conserving ecosystems is important to safeguard gray infrastructure against flood and landslide risks.

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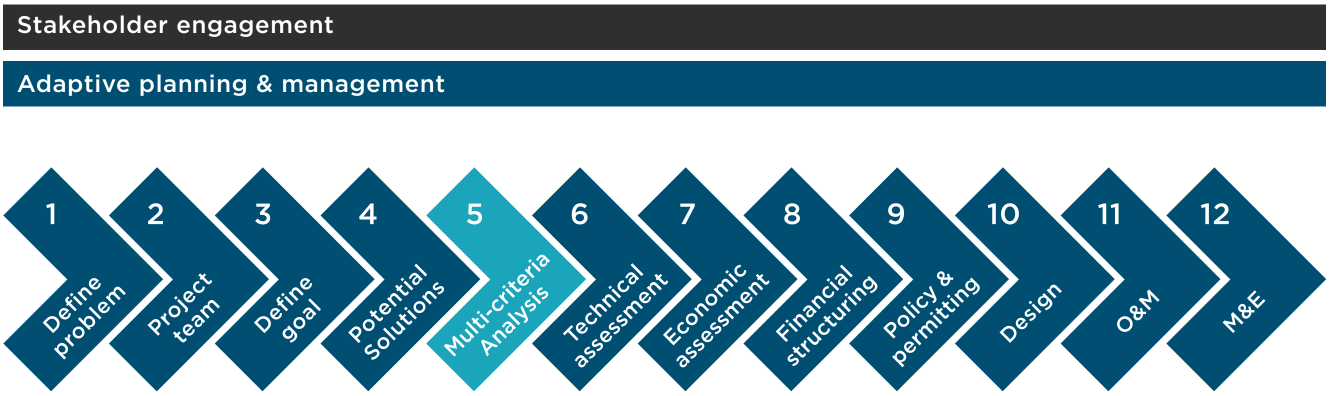
Source: Pixabay

5. Multi-Criteria Analysis (MCA)



At this stage project developers can conduct a comparative, high-level Multi-Criteria Analysis (MCA) of each potential solution identified in step 4(a-c), and potentially with gray alternatives. At this stage the MCA will likely be qualitative or based on quantitative estimates, as technical assessments have not yet been completed, and project developers do not have the full range of information to effectively scrutinize alternatives. This MCA presents an initial opportunity to compare a range of solutions and eliminate those solutions that do not appear feasible.

A. Define the criteria that should be used to compare solutions. This could be informed by the KPI defined in step 2.1. Criteria could include;

- **a. Costs:** capital investment costs (CAPEX) and O&M costs (OPEX).
- **b. Resilience benefits and avoided costs**
- **c. Ecosystem services or co-benefits** (e.g. environmental, social, economic)
- **d. Risks and tradeoffs.**
- **e. Maturity timeline** (e.g. how long will it take for the NbS to reach maturity and provide resilience benefits, this is a particular important KPI since NbS tend to capitalize their benefits on longer term horizons)
- **f. Lifespan of the NbS and the broader project**

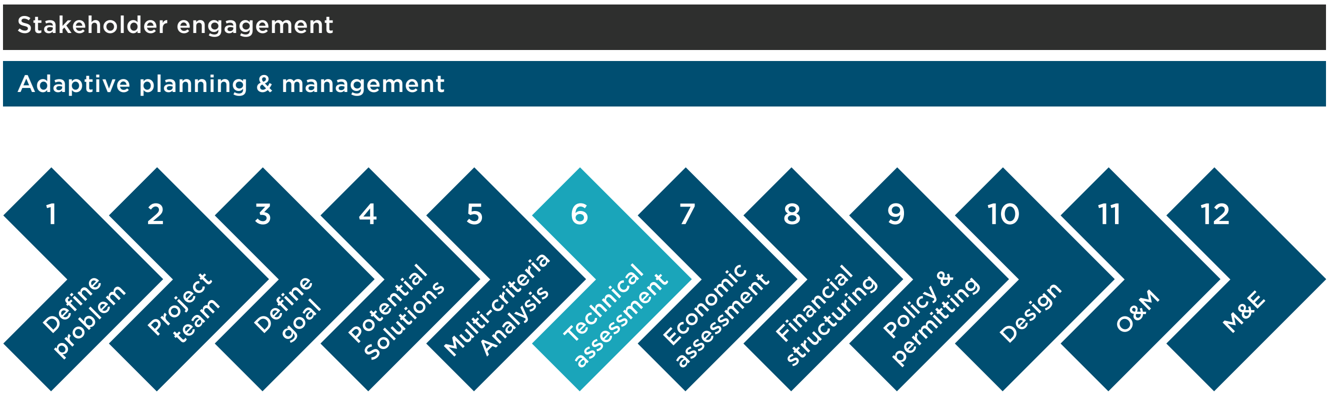
Stakeholder engagement: evaluate potential options with community members and project beneficiaries.

Collect the required information and compare the solutions against one another and identify the most viable solutions to take forward for technical analysis.

Step 1-5: Expected Outcomes, MCA Analysis

- Based on the outcomes of the pre-planning stages, identify the solution(s) to take forward to the planning stage. If there is too much uncertainty to make a decision the project developer should revisit prior steps to collect more information, or choose more than one option to take forward for technical and economic analysis.
- In the following stages the assessment becomes increasingly quantitative which may provide valuable information to conduct an additional MCA

6. Technical Assessments

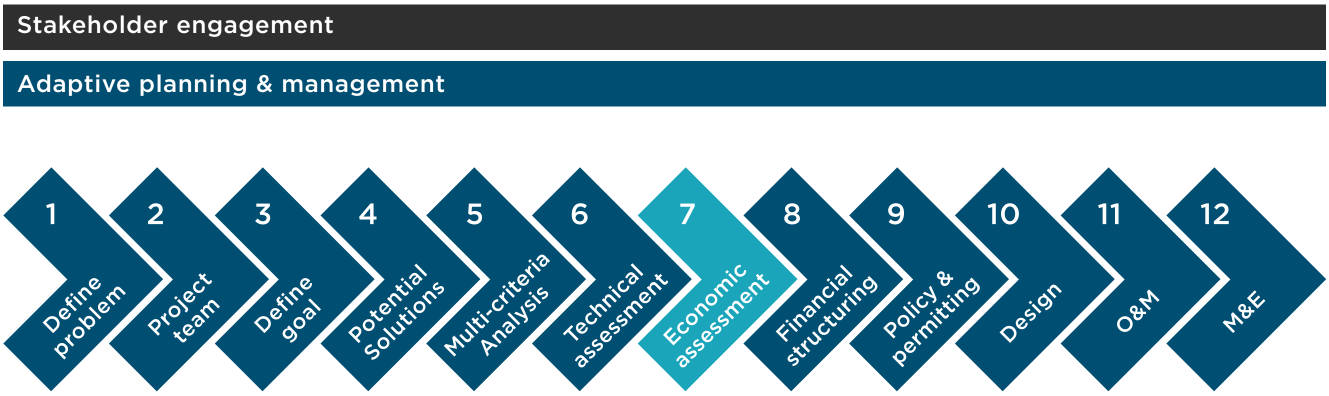


A. **Conduct baseline risk assessment** for future monitoring (e.g. business as usual)
B. **Conduct a risk assessment** (hazard, exposure, vulnerability) of current and future risks: natural hazards, climate change, environmental, social, governance, policy, technology, and economic risks.
C. **Develop a disaster contingency plan:** if the NbS succumbs to an extreme event and is destroyed. In most cases the benefits of NbS require a long period to reach maximum potential. If they are destroyed, how to deal with the lack of risk reduction measures that the NbS provided?
D. **Define the life span of NbS:** ecosystems may take longer to mature and realize their full potential (e.g. trees need to grow to provide the full extent of flood protection services). The project timeline should be of sufficient length to allow ecosystem services to reach maturity and consider the length of time in which the NbS will degrade.
E. **Define the project boundaries (spatial scale) and siting location.** This will also inform the planning process and stakeholder engagement (i).
F. **Conduct scenario modelling:** evaluate NbS performance under different / future scenarios.
G. **Conduct a benefit assessment:** evaluate the range of socio-economic and environmental benefits that the NbS will offers in the short-term and long term (see section 7 for information on how to quantitatively value NbS benefits).
H. **Conduct an environmental impact assessment:** evaluate the range of impacts (positive and negative) of the NbS on ecological and socio-economic systems now and into the future.

Step 6: Expected Outcomes

- Baseline risk assessment (for future modeling) and NbS risk assessment
- Define project lifespan, boundaries and siting location
- Scenario modeling
- Benefits assessment
- Environment Impact Assessment (EIA). Ensure that the EIA meets local, regional, and national requirements

7. Economic Assessment



Calculating NbS costs and benefits

Articulating the multiple benefits of NbS in monetary terms is necessary to define and understand the business case and compare it to alternatives. As such all ecosystem benefits must be converted into monetary terms. When considering the cost and benefits over the NbS lifecycle, there are important methodological considerations that differ from traditional project development – costs and benefits may not be realized at the same time. It is therefore important to accurately estimate the timing of incurring costs and delivering benefits, to allow for proper **discounting effects.** For example, there is usually a time lag before NbS fully mature (e.g. while ecosystems develop) and the NbS functionality may continue to improve or change over time (Somarakis et al, 2019). As for all projects, methodologies to conduct economic assessment may include a cost-benefit analysis (CbA) or a cost-effectiveness analysis (CEA). NbS projects should be measured against a reference scenario (e.g. business as usual) to illustrate how the NbS option adds value.

Costs

a. **Design and construction costs (CAPEX):** upfront investment costs inclusive of initial capital and material expenses covering all aspects of design, permitting and construction. Note that NbS schemes may involve additional land requirements, which may incur additional purchase, transaction, or governance costs, as compared to gray infrastructure solutions.
b. **O&M (OPEX)** over the project life cycle (e.g. pest control, landowner payments), inclusive of any expenses associated with decommissioning.
c. **Opportunity costs:** the foregone value of implementing NbS as opposed to an alternative option (e.g. using land for an alternative purpose)
d. **Transaction costs:** costs associated with the time, effort and resources to implement, monitor and maintain NbS projects. This may include feasibility studies, securing permits, training staff on new construction techniques, and stakeholder engagement costs. As project developers tend to have less experience with NbS, the transaction costs are likely to be high (Gray et al, 2019).

Cost-benefit example, Now Jade, Mayan Rivera

Table 3: Economic Assessment of Now Jade Resorts: artificial coral reefs in Puerto Morelos, Mexico

Project lifespan:	**20 years**
Discount Rate:	**12%**
Inflation Rate:	**3%**

Category	Cost / Year	0 (2009)	1 (2010)	2 (2011)	3 (2012)
Transaction costs	Feasibility studies	$44,867.45			
	Studies & permits	$2,450.00			
Design & Construction	Manufacture & Installation	$206,084.84			
	Construction Supervision	$12,000.00			
O&M	Monitoring (materials & labor)		$1500.00	$1,500.00	$1,500.00
	Maintenance (materials & labor)		$2,500.00	$2,500.00	$2,500.00
	TOTAL	$265,402.29	$4,000.00	$4,000.00	$4,000.00

Now Jade is a luxury resort located in Mexico's Mayan Rivera in the town of Puerto Morelos. In 2009 and again in 2014 Now Jade financed the construction and installation of two artificial coral reefs to protect the hotel's beachfront from sand erosion. Table 3 above shows the costs associated with the development of the initial reef in years 0-3 (2009). The costs do not include opportunity costs as there were no proposed alternative uses of the offshore location. A full Now Jade CbA and methodology inclusive of assumptions can be found in Annex A along with other resources to conduct CbA.

Benefits

NbS projects will generate **direct benefits** (e.g. to the project beneficiary) as well as **co-benefits** that are likely more diffuse and difficult to value in monetary terms (e.g. habitat for biodiversity, carbon sequestration, community livelihood benefits, recreation and amenity value). For resilience based NbS projects, direct benefits are usually realized through avoided costs or losses. **Table 4** shows the avoided costs of sand replenishment of Now Jade's artificial coral reef.

In certain cases **revenue generation** is possible, through monetizing direct benefits or co-benefits (e.g. tourism, water, carbon off-sets). **Table 5** provides examples of three NbS projects alongside business-as-usual alternatives, identifies potential resilience and co-benefits and valuation methods for direct benefits and co-benefits.

Stakeholder Engagement: Data for CBA can be difficult to obtain. Liaise with government / academia for data needs.

Sensitivity Analysis: when there is uncertainty regarding the performance of a particular variable(s) (e.g. cost or benefit) project developers should undertake a **sensitivity analysis** to understand how the CbA outcomes vary by altering the costs and benefits.

Table 4: Avoided costs and monetized benefits associated with Now Jade artificial coral reef

Avoided costs and monetized benefits	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Avoided costs for sand replenishment	$0	$315,000	$315,000	$315,000	$315,000	$420,000
Monetized benefits	N/A	N/A	N/A	N/A	N/A	N/A
Total avoided costs (year 0 to year 20, accounting for inflation)	$8,739,274.19					

Table 4: In the case of Now Jade, the cost of sand replenishment was used as a proxy for avoided costs. In the absence of the artificial reef there would be a net annual loss of beach sand, resulting in incremental beach erosion and requiring annual sand replenishment. The costs of sand replenishment at Now Jade was estimated at roughly $420,000 annually if no artificial reef had been installed. One artificial reef (years 1 to year 4), it is estimated to protect 75% of the beach, and therefore 75% of sand replenishment costs would be avoided ($315,000 annually). From the completion of the second reef structure (in year 5), the beach sedimentation pattern is fully restored. Therefore 100% of the avoided losses are accounted from year 5 only, after the installation of the second reef. In the case of Now Jade there were no additional monetized benefits as Now Jade does not promote reef-related tourism, fishing or other human interventions (e.g. education, bioprospecting). If the resort did permit these activities, they would be included in the benefits analysis.

Source: IDB and UNEP, 2020 forthcoming.

Table 5: Benefits and valuation methods of NbS

NbS example	Business as Usual	Direct Benefits	Valuation Method (direct benefits)	Co-benefits (sample)	Valuation Method (co-benefits)
Artificial coral reef for coastal erosion management Source: IDB (2019)	Sand replenishment	1. Reduced coastal erosion 2. Coastal protection, reduced flood risk	1. Avoided costs associated with annual sand replenishment (business as usual alternative) 2. Expected damage cost avoided	Habitat for biodiversity Recreation (swimming and snorkeling)	Willingness to Pay

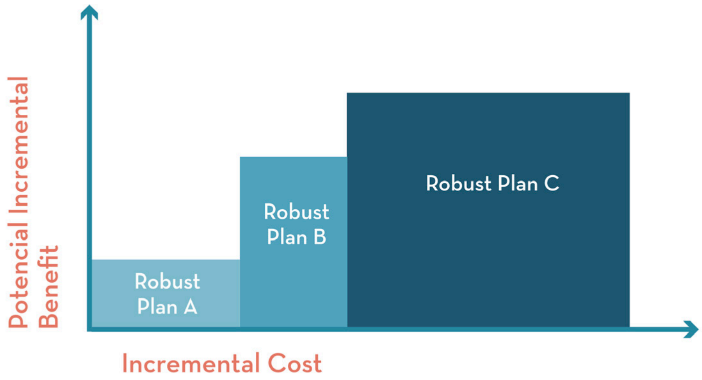
NbS example	Business as Usual	Direct Benefits	Valuation Method (direct benefits)	Co-benefits (sample)	Valuation Method (co-benefits)
Coral reef restoration for flood risk reduction Regurero et al, 2019. (direct benefits)	Seawall or breakwater	Coastal protection, reduced flood risk	Cost-based methods: avoided damages and replacement costs	Tourism and recreation Habitat for biodiversity Fishing	Contingent valuation, Travel cost method Market price of landings associated with on-reef fishing
Watershed ecosystem restoration to regulate water supply and reduce sedimen-tation for hydropower Source: Ozment et al, 2019	Water treatment (sediment removal) and dredging	Water flow regulation	Avoided costs (energy, labor, equipment) for water treatment (e.g. sediment removal), avoided dredging costs and asset depreciation	Tourism and recreation, Carbon sequestration and storage Conserving biodiversity Improving rural economies and livelihoods Climate mitigation	Travel costs and hedonic pricing

Table 5 depicts NbS projects alongside business-as-usual alternatives, and showcases the direct resilience benefit and a sample of co-benefits associated with NbS uptake. It also includes potential valuation methods for resilience benefits and co-benefits.

Incremental Cost Analysis (ICA)

Following the completion of the economic analysis (CBA or CEA) an additional analysis can be performed to calculate the incremental costs of increasing the baseline investment to add additional benefits (e.g. resilience, co-benefit) to a project. In simplest terms, ICA allows decision makers to understand how much a more robust solution might cost to deliver similar performance under an incrementally more stressful scenario, but that would also provide other ancillary benefits. Incremental benefits usually entail avoided performance loss (e.g. reduction in drought risk and flood damage) and reductions in system failure under incrementally more stressful future scenarios, although can also include co-benefits (e.g. recreational spaces, habitat for biodiversity). The incremental investment can therefore, in some cases, serve as an insurance or hedge against the baseline scenario. The level of investment needed to increase robustness is determined by comparing the benefits and costs of successively more robust plans that systematically reduce risks association with uncertain futures. Beginning with the least robust plan (figure 5), decision-makers can weight each plan's additional costs against the incremental benefits, and the level of risk that decision-makers are prepared to accept (Mendoza et al, 2018). Annex A provides references to a methodology to conduct ICA.

Figure 5: Incremental costs and benefit comparison for three plans



Source: Mendoza et al, 2018.

Step 7: Expected Outcomes

- **An economic analysis** (E.g. CbA, CEA) that captures all costs and benefits in monetary terms. The economic analysis should be compared against a reference scenario (e.g. BAU). An ICA can also prove useful to justify to understand the costs and benefits of increasing resilience.
- **MCA Analysis:** at this stage an MCA may be conducted again, reflecting the quantitative data that was obtained in steps 6 and 7.

Coral reefs provide coastal protection through wave attenuation along with additional co-benefits (e.g. habitat for fish species, tourism and recreation).

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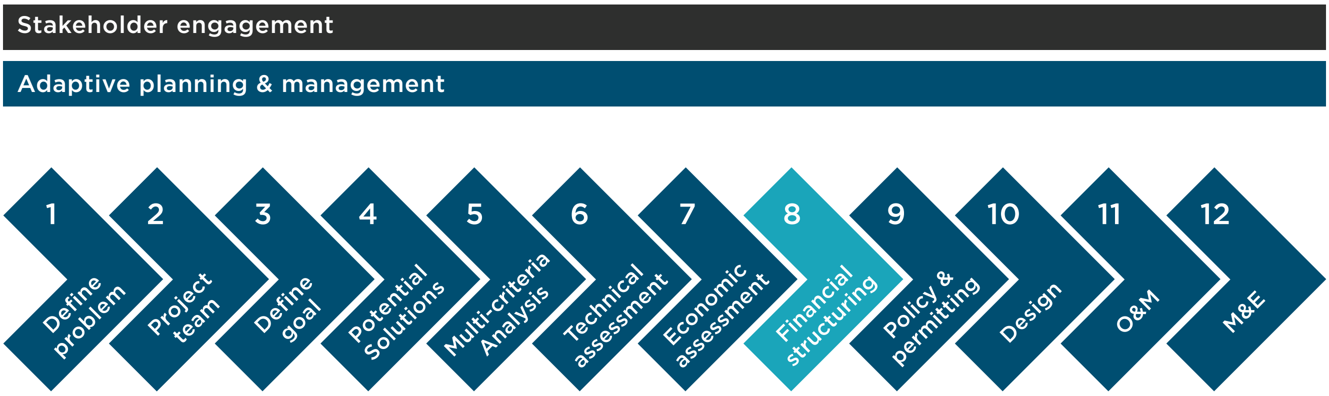
Source: Pixabay

8. Financial Structuring



As innovative solutions, NbS do not benefit from the decades of precedent that underpin traditional infrastructure investment, and investors and lenders are often inexperienced with financing NbS projects. A forthcoming report by IDB and UNEP (2020) indicates that a major barrier to NbS implementation in LAC is the difficultly associated with accessing finance[4]. While there are limited tailor-made financial instruments for NbS in LAC, there are still opportunities to access financing, for example through blended finance, PPP, and green finance (Green Bonds, Green credit lines, dedicated climate finance, among others). Figure 6 shows the players that are typically involved in project finance and possible funding sources and instruments. More detailed guidance documents on potential funding sources for NbS projects can be found in Annex A.

As a first step to secure financing, project developers will need to show the financial sustainability of the NbS over the lifecycle. Some of this information will have been defined in step 7 (e.g. costs, benefits).

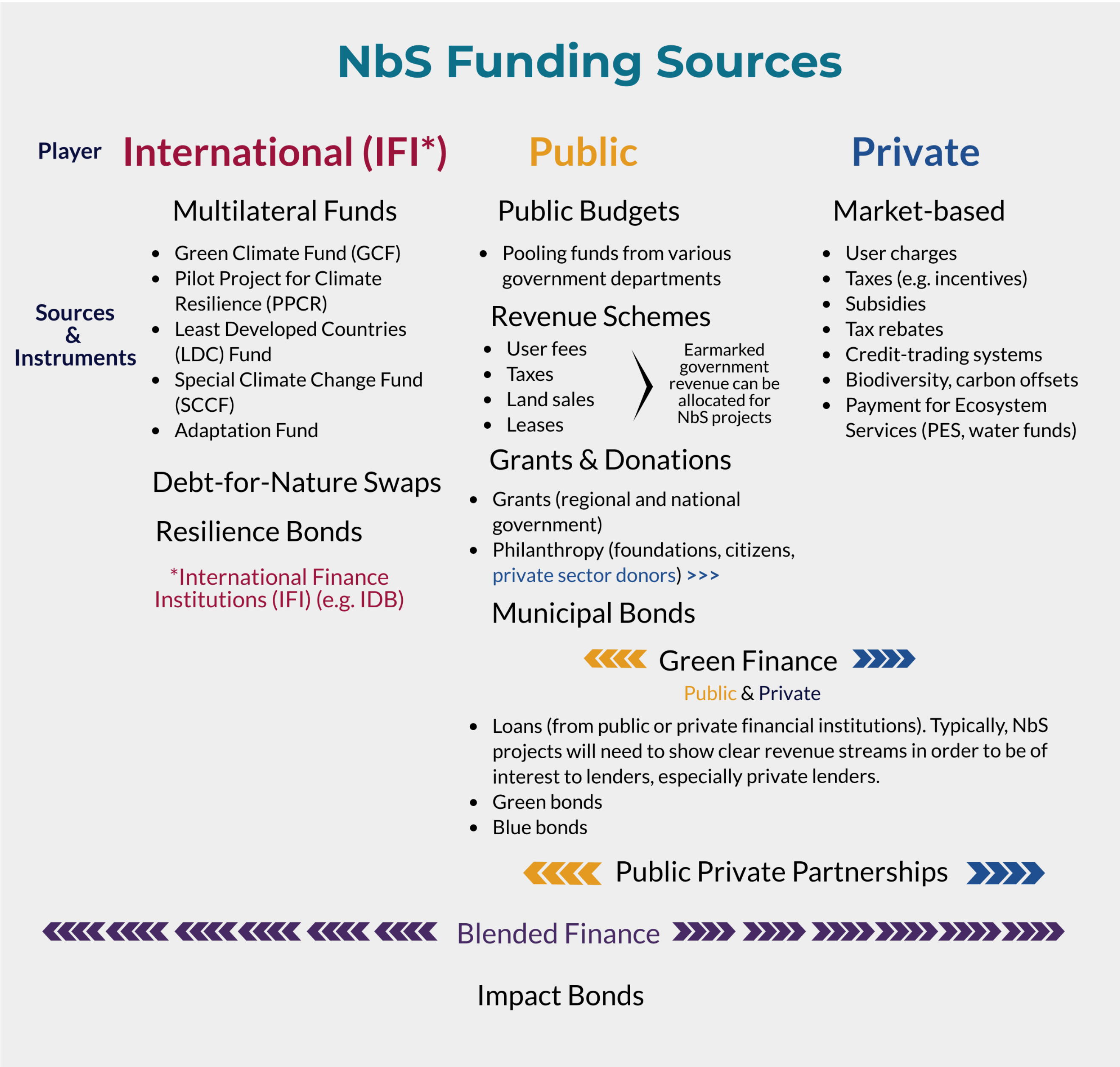
Discount cash flows to present value

- **Identify sources of revenue over the project lifecycle:**
  - Stemming from direct benefits or co-benefits; eco-tourism, regulated water supply, carbon offsets, payments for ecosystem services.
- **Analyze capital requirements**
  - Analyze capital investment, transactions, and O&M costs, and at what intervals they are required.
- **Analyze the ability of the project cash flows to cover future financial requirements under various funding mechanisms**

Stakeholder engagement: Identify and engage with public and private investors, lenders or partners that may be willing to finance NbS projects. For example, third-party beneficiaries could be approached to contribute financially (or in-kind) to the project.

4 Financing refers to meeting the upfront capital costs of the asset (e.g. public, private), while funding refers to how the asset is paid for over the duration of its lifecycle (e.g. user, taxpayer, customer).

Figure 6: NbS Funding Sources



NbS can be funded by international funds, public funds, market-based funds or from combined funding sources (e.g. blended finance). Green finance and PPPs are examples of public-private blended finance.

Source: Authors, modified from Trinomics and IUCN, 2019

Incremental Cost Analysis (ICA)

As discussed in Section 7, some project benefits can be financed through an ICA. For example, the incremental cost of expanding the size of a wetland to increase water retention capacity may align with a government's mandate to increase habitat space for migratory bird species. Incremental benefits for NbS projects can serve multiple goals, and attract stakeholders willing to provide project finance.

NbS value proposition to investors

A major barrier preventing the creation of bankable, sustainable infrastructure projects that build climate resilience, and consider NbS as a substitute, compliment or safeguard to conventional projects, is the inability to clearly identify the revenue streams generated by the NBS component and incorporate it into the overall project financial structure. Not all NbS will be able to generate revenue streams, however they may offer the potential to reduce disaster risks and address societal issues in a multifunctional manner, in ways that gray infrastructure cannot. Thus, NbS can help gain access to funding by reducing project risks, possibly making investors more likely to invest due to risk reduction. It is important for project developers to find innovative structures to captures those benefits in monetary terms (e.g. carbon credits, reduced risk premiums). To demonstrate that there are ways to monetize the NbS benefits, table six shows five successful and replicable financing structure examples in LAC.

Table 6: Examples of NbS project financing in LAC

Case Study	Financing Players	Project Financing
1. Coastal Zone Management Trust, Quintana Roo, Mexico (See figure 7, below)	Private (hotel & tourism operators)	• Hotel and tourism operator with beach front properties pay a concession to the government • Twenty-five percent of the totals concessions are put in a Trust Fund which is allocated for on-going coral reef maintenance and the purchase of an annual parametric insurance policy. • Parametric insurance premium is roughly 10% of the coverage amount. E.g. $3 million insurance coverage would cost $300,000.00. • If a qualifying event occurs (e.g. hurricane in Quintana Roo) the insurance premium will pay out, and that money (i.e. $3 million) will be used to repair any damage caused to the reef.
2. TNC water fund financing model (LAC wide)	Public & private	• Finance pooling mechanisms based on Payment for Ecosystem Services (PES). Downstream public and private users invest in upstream land and water management activities (e.g. reforestation), aggregating investment capital through the water fund. • Seed capital can be provided by a private party, the government or both • Currently there are 24 water funds supported by TNC in LAC and 19 more under development.
3. Managing water supply for hydroelectric power through restoration of Landscape Reserve, Peru	Public & private	• Corporate stewardship financing model • A private company (CELEPSA - Compañía Eléctrica El Platanal S.A.) manages a Patronage in collaboration with SERNANP (the government national protected area authority) to contribute to the management of the Nor Yauyos Cochas Landscape Reserve, which has conservation of ecosystem services, in particular water regulation, as a major objective. • On top of the funding from the Patronage, some activities were funded by the Ecosystem based Adaptation Mountain Ecosystems Project (2011-2015). This came about as a result of the community's ownership of and commitment to the measures' implementation, demonstrating their empowerment, interest and contribution as a co-partner in the participatory planning process.

Case Study	Financing Players	Project Financing
4. Watershed forest restoration to support functioning of the Itaipu Dam, Paraguay / Brazil	Public (municipalities) & private (dam authority)	• Itaipu Preserva was initiated in 2014 with approximately USD $11.5 million in binational financing to expand efforts to restore and encourage natural regeneration of degraded areas in the protection strip of the Itaipu Binacional reservoir. • Blended finance program where 1/3 of seed funding (approximately USD $8 million in 2007) was provided by the dam operator (Itaipu Binacional) through its annual budget for Coordination and Administration, 1/3 by cities, and 1/3 by farmers and other community actors .
5. Climate resilient livestock farming, Southern Cone, Argentina	Multilateral (GEF) & public foundation money (including US Forest Service and Bobolink Foundation)	• Seed capital provided by GEF for the first 10 years; the total financing was approximately USD $800,000 and annual project costs are around USD $100,000. • The Grasslands Alliance is taking steps to move towards a self-sustaining and market-based approach exploring how some of the profit from certified beef sales go towards covering project costs. However, international funding will still be required to keep the project running during the transition period as the economic conditions in Argentina are currently not conducive for private investment.

Table 6 provides examples of (5) NbS financing approaches in LAC. Broader case study descriptions are provided in Annex B.

Source: IDB and UNEP (2020, forthcoming).

Figure 7: Financing Structure of the Coastal Zone Management Trust

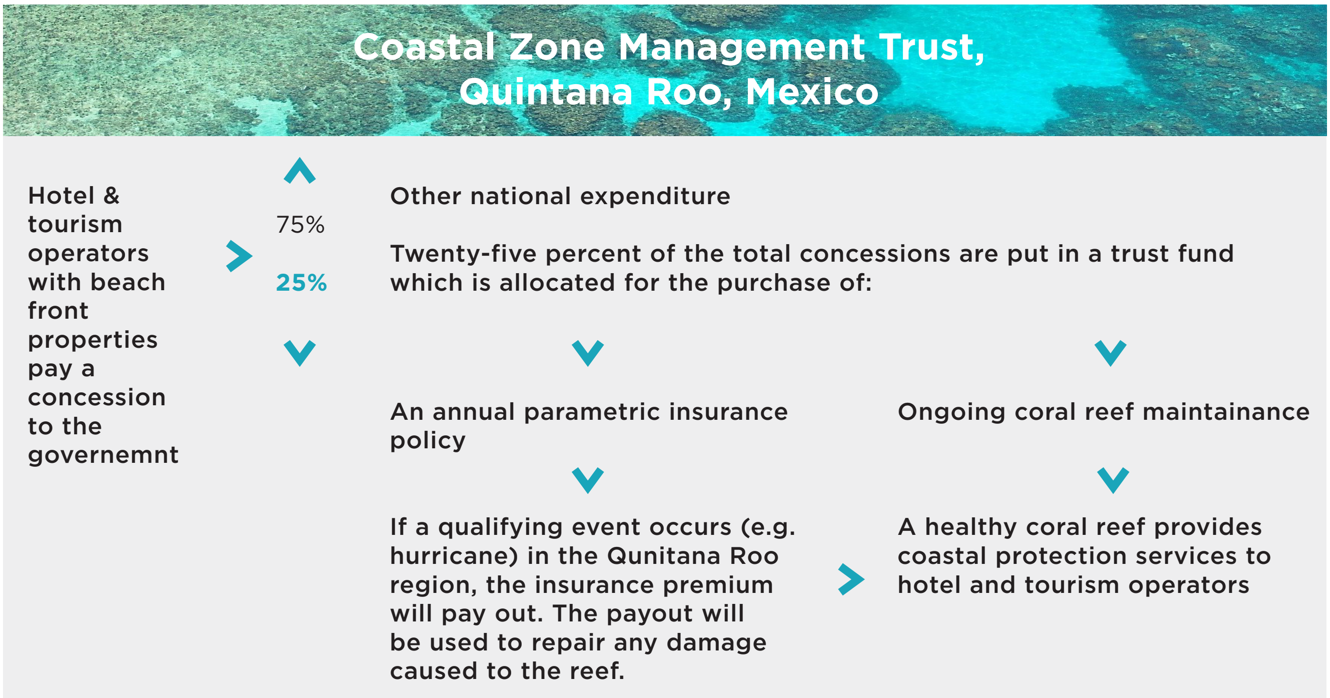


Figure 7 illustrates the financial structure of the Coastal Zone Management Trust, see table 6 case study 1.

Step 8: Expected Outcomes

- Financial Model (Discounted Cashflow Analysis)
- Identified sources of finance and engagement with lenders and investors

Sand dunes and beaches protect against coastal erosion and offer tourism and recreation opportunities.

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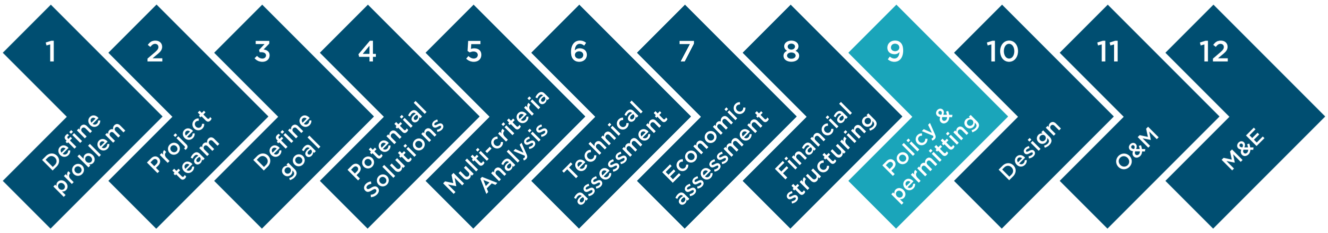
Source: Pixabay

9. Policy & permitting

Stakeholder engagement

Adaptive planning & management



NbS projects will need to demonstrate policy compliance, as a condition to receive the required permits. For example, constructed wetlands will need to show that they can treat water to existing and anticipated future regulatory standards. Project developers may also face challenges if metrics for compliance do not translate accordingly for NbS (e.g. height requirements for a seawall may not apply to mangrove ecosystems that support coastal protection).

Securing permits can be time-intensive and require extensive coordination with multiple departments, and this process should begin during inception stages (see: i). The time and resources spent engaging with policy stakeholders and securing the necessary permits should be reflected in the investment costs or transaction costs (see: step 6).

Stakeholder engagement Engage with regulating and permitting authorities to encourage project buy-in and avoid bureaucratic hurdles. NbS may also contribute to wider policy objectives (e.g. climate change mitigation) thereby creating broader support.

PROJECT DEVELOPERS SHOULD:

a. Demonstrate the legal compliance of the NbS

- E.g. Does the design of the constructed wetland treat water to code?

b. Secure appropriate permits land, easement, zoning, environmental (EIA), and natural resource.

Importantly, the potential risks associated with corruption and business malpractice cannot be ignored in any construction project involving grey and/or NbS solutions. As with any major traditional infrastructure project, project developers will need to remain vigilant and should be especially aware of the potential for increased risks when securing permits and consents for NbS projects. As noted earlier, NbS schemes are likely to require the co-operation of officials to secure permits because they may be seen as beyond code which could create opportunities for rent seeking, kickbacks, or corruption. To reduce the likelihood of corruption, interactions between all stakeholders throughout the project lifecycle should be open, transparent and documented, and all stakeholders should be aware of this.

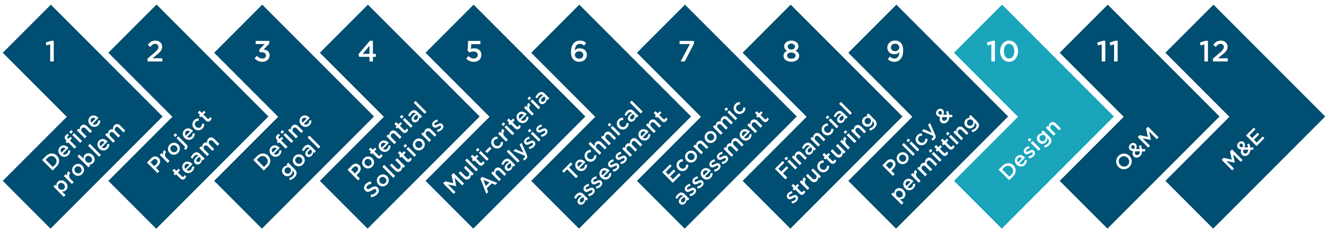
Step 9: Expected Outcomes

- Demonstrate the legal compliance of the NbS project
- Secure necessary permits

10. Design & implementation plan

Stakeholder engagement

Adaptive planning & management



The specific approach to design and implementation will vary greatly depending on the NbS. For example, designing and implementing a living roof will require different steps and expertise than transplanting coral, or restoring mangroves along a coastal road. However, in general, NbS design will be progressively iterated, from conceptual, preliminary and detailed stages, to take into account the results from stakeholder engagement, meet regulatory requirements, deliver against financial targets and ensure the project meets its KPIs. The design will be informed by the various steps and information collected up to this point.

Stakeholder engagement: include stakeholders involved in O&M to design for reduced O&M costs and engage eventual project beneficiaries.

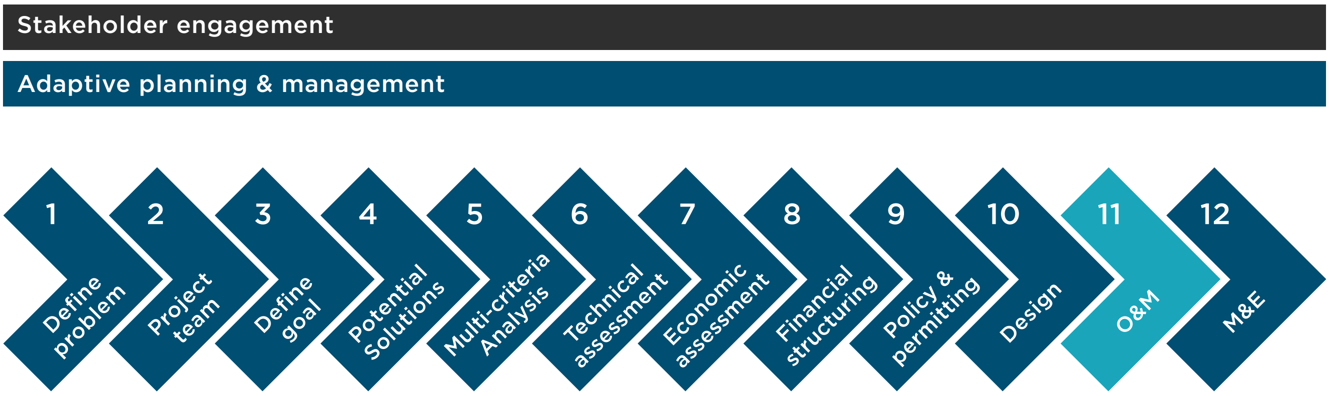
Table 7: Design stage and tasks

Design Stage	Tasks
Conceptual Design: explore design possibilities	Ensure that the conceptual design reflects the project goals and is: • Economically and financially sustainable (step 7 & 8) and optimizes long-term O&M costs through design (see step 7 &11). Incremental cost analysis can be used to determine the true cost differences between alternative designs (see Annex A) • Policy compliant (see step 9). • Socially preferable (see step i) • Environmentally sound (step 6)
Preliminary design: define and assess main design components	• Develop a detailed cost estimate based on the preliminary design
Detailed design & specifications: performance indicators and detailed work plan for implementation	• Detailed project budget • Clearly detailed work tasks and construction timeline in phases (inclusive of ecosystem and engineered aspects) • Material, labor, equipment and techniques to be used in each phase.

Step 10: Expected Outcomes

- Conceptual Design > Preliminary design > **Detailed design and specifications plan**

11. Operations & maintenance plan



An O&M plan is essential to optimize long-term NbS service delivery and achievement of the project's KPIs (step 3.1). O&M should begin in the project planning stage, structured in the financial stage (step 9) and should be optimized in the design stage (step 10), to ensure that there is appropriate funding, personnel, and expertise to conduct O&M activities.

Key considerations

- **Frequency:** O&M activities should be planned at appropriate time-intervals, which may differ from conventional infrastructure maintenance. For example, seasonality may increase maintenance requirements in summer months versus winter months, or wet seasons versus dry season. Further, maintenance requirements may be greater in regions where there is high climate variability or proximity to pollution sources (consider additional requirements for aesthetic maintenance as well).
- **Funding:** ensure that there are dedicated funding streams for maintenance costs (including labor and equipment).
- **Compliance:** ensure that O&M activities are policy compliant. For example, water treated by constructed wetlands will likely have to comply with certain water treatments standards applicable to conventional wastewater treatment facilities.
- **Personnel:** ensure that personnel have the proper skill set and capacity for O&M activities. Some O&M activities may require a highly specialized skillset and may require additional training.
- **Contingency:** build in contingency into maintenance and inspection schedules to account for extreme events. This would likewise be recommended for conventional infrastructure.

NbS maintenance activities may include

- Fertilization
- Slope re-stabilization
- Debris and sediment removal
- Invasive species removal / weeding
- Pest and disease monitoring and control
- Plant nursery and species transplantation

Basic Elements of an O&M plan will include:

- A description of maintenance activities and what they entail
- Parties responsible for maintenance activities
- Maintenance schedules
  - *Informed by site- and project- specific requirements*
  - *What NbS components need to be maintained and at what intervals?*
- Inspection requirements (align with monitoring activities).
- Frequency of inspections
  - *Informed by site- and project- specific requirements (EPA, 2013).*

Stakeholder engagement: include stakeholders involved in O&M to design for reduced O&M costs and engage eventual project beneficiaries.

Step 12: Expected Outcomes

- O&M plan over the project lifecycle

Plants provide important insulation services as a component of living roofs.

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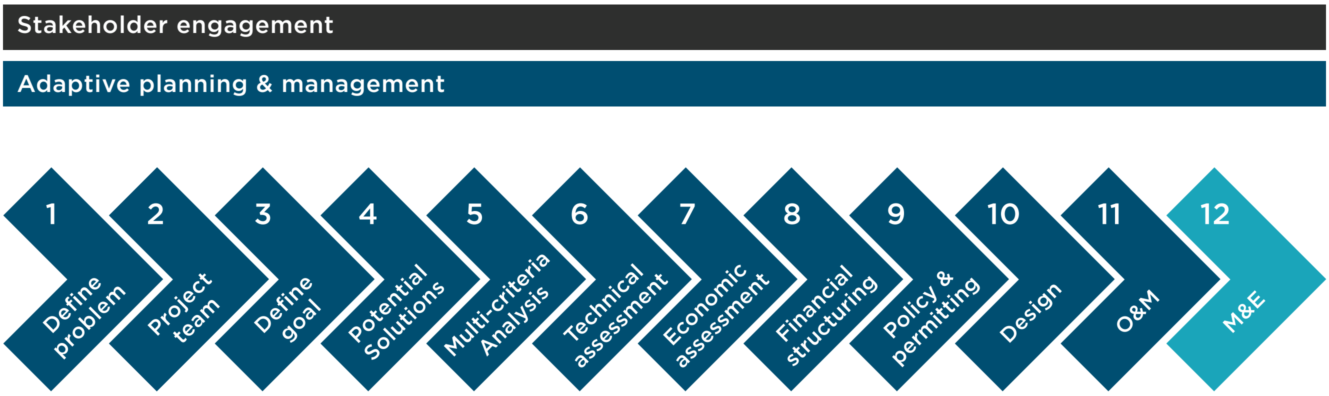
Source: Pixabay

12. Monitoring & evaluations (M&E) plan



Monitoring and evaluation (M&E) is important to provide evidence of progress and performance and to build internal knowledge (and capacity) on the merits and performance of NbS. M&E is an essential component of adaptive project management; based on the results of monitoring, the project can be modified, if needed, to improve performance.

In addition to performance monitoring, monitoring of changing conditions (e.g. climate change, socio-economic conditions) is also important to timely identify when adaptation measures need to be implemented (e.g. removal of invasive species, substitution of plants for more heat-tolerant varieties)

Regular project monitoring and evaluation (M&E) should take place to ensure that:
- **Implementation:** the project is implemented according to the design.
- **Effectiveness:** the project is operating effectively (once implemented),
- **Performance:** the project is delivering the intended results, and if not, can it be adjusted to achieve intended results (Huthoff et al, 2018). This is critical to building the evidence base and ensuring effectiveness and improvements over time.

It is important to ensure sustained monitoring over time, which could potentially be achieved with community-based monitoring, or support from academic institutions conducting research projects. The project contractor will likely not be involved in any M&E activities, other than during an initial hand over period, but will be responsible for training the operator and its staff. Therefore, capacity for M&E activities should be identified in the stakeholder and project team phases (step 1).

A monitoring plan should address the following questions:
- *How will monitoring be funded?*
- *How will the required information be collated?*
- *Is preliminary data collection required to support the monitoring process?*
- *Does capacity to conduct M&E assessments need to be enhanced?*
- *What methods will be used (or adapted)?*
- *Who will carry out the monitoring?*
- *Who will receive the monitoring reports? (Geberemariam, 2017).*

Stakeholder engagement: identify community members and academic researchers that may be willing to support M&E activities.

A set of indicators should be developed corresponding to monitoring implementation, effectiveness, and performance. It is important to select a relevant set of indicators and incorporate them into monitoring and evaluation plan. This should align with the KPIs defined in step 3.1. Potential performance indicators, and examples of the indicators, are provided in Table 8.

Table 8: M&E sample performance indicators

Performance Indicator	Examples
Avoided cost	• The restored coral reef reduces the need for sand replenishment by X percent equalling X amount saved in annual sand replenishment costs; • The green roof reduces energy costs by $X amount per month
Revenue generation	• The reforestation initiative stabilizes water supply by x volume per year, generating x amount of revenue, relative to prior years.
Risk reduction	• The oyster reef dissipates storm surge and reduces in-land flood risk by x% • During periods of torrential rainfall, the forest reduces the number of homes affected by landslides
Regulatory Compliance	• The intervention operates according to code
Co-benefit production	• Supporting local livelihoods: the NbS generates x employment opportunities associated with tourism; • Supports biodiversity: the mangrove provides nesting sites to x number of migratory bird species; • Climate change mitigation: the forest sequesters approximately x amount of C02 per year

M&E sample performance indicators and examples. ‘X’ denotes a potential percentage or dollar amount.

Step 12: Expected Outcomes

- A long-term M&E plan that defines personnel and responsibilities.

The Way Forward

Integrating Nature-based Solutions into infrastructure projects presents a unique opportunity to increase the resilience of the asset and services, while delivering important co-benefits that will support communities, the environment, and mitigate carbon change impacts through carbon sequestration. To fully seize the opportunity presented by NbS, it is important to mainstream NbS uptake into project development.

Integrating NbS into project development requires, to varying degrees, a different process than the one used in conventional project development. For example, stakeholder engagement (i) and project governance (step 2) may be more extensive or require engagement with different stakeholders, technical assessments may require additional biophysical analysis (step 6), and financial structuring (step 8) may include novel arrangements, new sources of capital and bring new players to the table. While NbS planning requires strengthened capacity, new knowledge, data, methodologies, and tools, there is a wide range of resources available to support this process.

Project developers do not need to obtain all the expertise to design and implement NbS, they simply need to understand the process, and be able to structure the appropriate teams. The 12-step process presented in this technical guidance is iterative and there are ample opportunities to learn throughout, revisit, and revise prior steps as needed. Beyond this guidance document there are wide variety of resources to support project developers, as noted in Annex A.

Project developers in LAC can also benefit from experiences and lessons learned in other countries, for example throughout Europe, Asia, and the U.S., where NbS features prominently in urban development and coastal risk management. Rather than being perceived as an 'add-on' or luxury, integrating NbS into project development can create cost-effective and climate resilient infrastructure that can give project developers a competitive advantage. As shown in step 7, the direct and co-benefits presented by NbS can be monetized through revenue streams or avoided losses, thereby creating a value-add benefit that gray infrastructure cannot offer.

By learning the process of integrating NbS into project development, project developers can access new market niches, competitively respond to tenders, and potentially access new sources of finance for NbS projects. For example, decades ago energy efficiency finance was rarely included in project development, while today they are fully mainstreamed into investment decision processes. The NbS market has the potential to develop in the same way, and project developers with knowledge to structure bankable and climate resilient projects that incorporate NbS will be ideally positioned to seize the opportunities it brings.

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Annex A: Supplementary Resources

A B C	Corresponding step in TG	Topic(s)	Source	Description
A	Overview	Technical, social, economic and financial dimensions, and enabling policies	Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T., and Lange., G.M. (2019). Integrating Green and Gray. Creating Next Generation Infrastructure. World Bank Group and World Resources Institute. Available at, https://www.wri.org/publication/integrating-green-gray.	World Bank and WRI overview and guidance on how to integrate natural approaches into infrastructure development. Global focused with 3 LAC case studies.
B	Overview	Technical, Institutional, Policy and Financial in LAC context	IDB, UNEP, Acclimatise and UNEP'S World Conservation Monitoring Center. (2020, forthcoming). Nature-based Solutions. Scaling private sector uptake for climate-resilient infrastructure in Latin America and the Caribbean.	This forthcoming report examines barriers and opportunities to scale private-sector NbS in LAC. It offers recommendations directed at project developers, financial institutions, and policy makers. It does not offer technical guidance however provides a good overview of the current environment of NbS uptake in LAC.
C	Overview	Project Development, Technical Innovation, Business case and Policy	Somarakis, G., Stagakis, S., & Chrysoulakis, N. (Eds.). (2019). ThinkNature Nature-Based Solutions Handbook. ThinkNature project funded by the EU Horizon 2020 research and innovation program.	European Union, Think Nature Handbook covers a range of topics inclusive of integrating NbS into project development. EU focused.
D	Overview	Stakeholder engagement, governance, performance metrics, formulate alternatives	U.S. Army Corps of Engineers. Chapter 3: Build a team, identify problems in, Managing Water for Drought. Available at, https://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/94nds8.pdf	USACE Water management and drought guide. Provides useful guidance on stakeholder engagement.

A B C	Corresponding step in TG	Topic(s)	Source	Description
E	Stakeholder engagement	Stakeholder engagement, conflict resolution with computer applications	Cardwell, H., and Langsdale, S. 2008. The Shared Vision Planning Primer: How to incorporate computer aided dispute resolution in water resources planning. U.S. Army Corps of Engineers.	USARCE guidebook on conflict resolution related to water resources planning.
F	Stakeholder engagement	Stakeholder engagement, conflict resolution	Griffiths, J., & Lambert, R (eds). 2013. Free Flow: Reaching Water Security Through Cooperation. UNESCO Publishing. Available at, https://unesdoc.unesco.org/ark:/48223/pf0000222893	Guidebook focused on cooperation in water management
G	Stakeholder engagement	Stakeholder engagement, participatory planning	Mendoza, G., & Cardwell, H. 2009. Integrated water resource Management in Peru through shared vision planning. International Center for Integrated Water Resources Management, Institute for Water Resources of the US Army Corps of Engineers; and Pedro Guerrero, Project for Modernization of Water Resources Management, National Water Authority of Peru, Ministry of Agriculture of Peru.	Shared Vision Planning (SVP) approach for water resource management in Peru
H	Adaptive planning and management	Adaptive planning and decision making under uncertainty	Haasnoot, M., Kwakkel, J., H., Walker, E, W., ter Maat, J. 2013. Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world. Global Environmental Change, 23(2), pp. 485-498. Available at, https://www.sciencedirect.com/science/article/pii/S095937801200146X?via%3Dihub	A method for decision-making under uncertain global and regional changes called dynamic adaptive policy pathways. Two complementary approaches for designing adaptive plans include: adaptive policymaking and adaptive pathways. The former is a theoretical approach describing a planning process and signposting if adaption is needs, the latter provides an analytical approach for exploring and sequencing possible actions based on alternative external developments over time.

A B C	Corresponding step in TG	Topic(s)	Source	Description
I	Define the Problem, Define the project goal and objective, Identify potential solutions	Systems analysis	Deltares. (2019. Systems Analysis, Builidng with Nature. Available at, https://publicwiki.deltares.nl/display/BTG/System+Analysis	Guidance to understanding systems by analyzing the interactions between/within its natural and socio-economic subsystems
J	All Steps 1-12	Define and understand the business case, stakeholder engagement, financing, Case studies (U.S. focused), design and implementation	Gartner, E.T., Mulligan, J., Schmidt, R. and Gunn, J., 2013. Natural Infrastructure Investing in Forested Landscapes for Source Water Protection in the United States. World Resources Institute. Available at, https://www.wri.org/publication/natural-infrastructure	Overarching guidance document focused on forest landscapes for water protection. U.S. focused.
K	All Steps 1-12	Planning, Assessment, Design, Implementation, Monitoring, Management, Evaluation	World Bank. 2017. Implementing nature-based flood protection. Principles and Implementation guidance. Washington, DC: World Bank. Available at, http://documents.worldbank.org/curated/en/739421509427698706/Implementing-nature-based-flood-protection-principles-and-implementation-guidance	Five principles and implementation guidance for NbS for flood risk management Builds and expand upon guidance developed by: NOAA, US Army Corp of Engineers and Deltares / Ecoshape
L	All Steps 1-12	Initiation, planning & design, construction and O&M	Deltares. (2019). Building With Nature Guideline (BwN). Available at, https://publicwiki.deltares.nl/display/BTG/Steps+and+phases	Step by step guidelines produced by Deltares and EcoShape for building with nature.
M	All Steps 1-12	Initiation, planning & design, construction and O&M	US Army Corps of Engineers (2019). Engineering with Nature. Available at, https://ewn.el.erdc.dren.mil/	U.S Army Corp guidelines, case studies and resources for engineering with nature

A B C	Corresponding step in TG	Topic(s)	Source	Description
N	6. Technical Assessment	Climate change risk assessment	Esquivel, M., Barandiarán, M. and Zuloaga, D., 2018. Executive Summary of the Disaster and Climate Risk Assessment Methodology for IDB Projects: A Technical Reference for IDB Project Teams. Inter-American Development Bank. Available at, https://publications.iadb.org/en/executive-summary-disaster-and-climate-risk-assessment-methodology-idb-projects-technical-reference	IDB Methodology to identify and assess climate change, disaster risk and resilience opportunities in project planning and implementation phases.
O	6. Technical Assessment	Mapping and valuing ecosystem services and their benefits	Stanford University (2019). InVEST integrated valuation of ecosystem services and tradeoffs. Natural Capital Project. Available at, https://naturalcapitalproject.stanford.edu/invest/	InVEST is an online free tool for exploring how changes in ecosystems are likely to lead to changes in benefits that flow to people. InVEST often employs a production function approach to quantifying and valuing ecosystem services.
P	6: Technical assessment	Risk assessment (financial)	International Institute for Sustainable Development. 2019. Sustainable Asset Valuation tool (SAVi). Delivering insight for investing in sustainable infrastructure. Available at, https://www.iisd.org/sites/default/files/publications/sustainable-asset-valuation-savi-tool-brochure.pdf	A tool / methodology to put a financial value on risks and externalities that are not well understood and therefore ignored in traditional investment assessments. These can include legal and environmental risks, resource and revenue risks, and climate-change-related risks. SAVi assesses the impact of these risks on the financial performance of an infrastructure project or portfolio.

A B C	Corresponding step in TG	Topic(s)	Source	Description
Q	7: Economic Assessment	Assessing cost and benefits of green infrastructure	Gray, E., S, Ozment, J. Carlos Altamirano, R. Feltran-Barbieri, and G. Morales. 2019. "Green-Gray Assessment: How to assess the Costs and Benefits of Green Infrastructure for Water Supply Systems" Working Paper. World Resources Institute. Available at, www.wri.org/publication/green-gray-assessment.	Implementation guidance for evaluating costs and benefits of green-gray infrastructure for water supply systems. Globally applicable and includes 4 LAC-based case studies
R	7: Economic Assessment	Cost Effectiveness Analysis and Incremental Cost Analysis	U.S. Army Corps of Engineers. 1994. Cost Effectiveness Analysis for environmental planning: 9 easy steps. Available at, https://apps.dtic.mil/dtic/tr/fulltext/u2/a319365.pdf	USACE guidance document on how to do a cost effectiveness analysis and incremental cost analysis.
S	7: Economic Assessment	Cost-benefit Analysis (CbA) Case Study	IDB. 2020. NbS Cost Benefit Analysis 'Now Jade'.	CbA analysis for an artificial coral reef in Puerto Morelos, Mexico to determine whether the NbS was economically viable as compared to the conventional alternative (annual sand replenishment).
T	7 & 8: Economic Assessment and Finance	Economic analysis, financing options, sensitivity analysis	Ozment, S., Feltran-Barbieri, F., Hamel, P., Gray, E., Baladelli Ribeiro, J., Barreto, S.R., Padovezi, A., Piazzetta Valenete, T. (2019). Natural Infrastructure in Sao Paulo's Water System. World Resources Institute. Available at, https://wriorg.s3.amazonaws.com/s3fs-public/18_REP_SaoPauloGGA_finalweb.pdf	Case study of Cantareira Water Supply System, Brazil. Economic case for investment and financing opportunities with methodologies and valuation methods
U	8. Finance	Define and understand the business case and finance	European Investment Bank (EIB). 2018. Investing in Nature: Financing Conservation and Nature-Based Solutions, A Practical Guide for Europe. Available at, https://www.eib.org/attachments/pj/ncff-invest-nature-report-en.pdf	Guidance document focused on securing Finance for NbS and Conservation Projects. EU context.

A B C	Corresponding step in TG	Topic(s)	Source	Description
V	10. Design	Integrating natural and nature based into project development for coastal resilience.	Bridges, T.S., Burks-Copes, K.A., Bates, M.E., Collier, Z.A., Fischenich, J.C., Piercy, C.D., Russo, E.J., Shafer, D.J., Suedel, B.C., Gailani, J.Z. and Rosati, J.D., 2015. Use of natural and nature-based features (NNBF) for coastal resilience. US Army Engineer Research and Development Center, Environmental Laboratory, Coastal and Hydraulics Laboratory. Available at, https://www.researchgate.net/profile/Burton_Suedel/publication/271763884_Use_of_Natural_and_Nature-Based_Features_NNBF_for_Coastal_Resilience/links/54d0de560cf29ca81103f45e/Use-of-Natural-and-Nature-Based-Features-NNBF-for-Coastal-Resilience.pdf	Technical guidance document that covers a range of topics related to integrating natural and nature-based features into project development for coastal resilience. US focused. Steps include: 1. Classifying, mapping, and characterizing NNBF 2. Developing vulnerability metrics 3. Developing performance metrics 4. Assessing and ranking proposed alternatives 5. Considering sediment as a resource for NNBF 6. Monitoring and assessing NNBF to support adaptive management 7. Considering policy challenges and implications.
W	10. Design 1	Incremental cost analysis	Ridgley, R., Hansen, W.J., Orth, K., and Franco, S. (1995). Evaluation of environmental investments procedures manual: Interim, cost effectiveness and incremental cost analysis. US Army Corps of Engineers. Available at, https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/1353/	Guide document to compare project plans and justifications when using non-monetary criteria, such as habitat area.
X	1. O&M	O&M for green infrastructure	Environmental Protection Agency (EPA). (2013). The Importance of Operation and Maintenance for Long-Term Success of Green Infrastructure. A Review of Green Infrastructure O&M Practices in ARRA Clean Water State Revolving Fund Projects. Available at, https://www.epa.gov/sites/production/files/2015-04/documents/green_infrastructure-om_report.pdf	An EPA, U.S. focused Guidance to O&M planning. Covers topics such as O&M requirements accountability, compliance, education and capacity building, and documentation

Annex B: Case study descriptions

1. Coastal Zone Management Trust, Quintana Roo, Mexico
The Coastal Zone Management Trust 'the Trust' was established in Quintana Roo in 2019 in recognition of the important revenue generating opportunities and protective services offered by the MesoAmerican Coral Reef. The trust collects hotel and tourism concessions to fund ongoing coral reef maintenance activities, and to purchase a novel parametric insurance policy for hurricane-induced coral reef damage.

Hotel owners and tourism operators with beach front properties in Quintana Roo fund the Trust through the Zofemat tax. Twenty-five percent of the tax collected from the Zofemat is allocated to the Trust. The trust funds are used to purchase an annual parametric insurance policy and to fund on-going coral reef maintenance. The insurance premium amounts to about ten percent of the policy coverage (e.g. $3 million coverage would cost $300,000 annually). If a qualifying event occurs (e.g hurricane exceeding a specific wind speed threshold in the pre-defined areas), the insurance premium will pay out, and the insurance coverage will be used to repair the reef.

2. Funding watershed restoration to secure water supply in Lima, Peru
Note: this is one example of a TNC water fund in LAC.
The Latin American Water Funds Partnership, coordinated by The Nature Conservancy (TNC), has projects helping to address water insecurity throughout South America. Aquafondo, a water fund in Lima, was set up in 2010 to apply concepts used successfully in other locations to improve water security in Lima. Several organizations in Peru, including Backus, Rotoplas, Nestlé and the Peruvian Society of Environmental Law, are providing money for a water fund which finances watershed restoration projects aiming to reduce Lima's water insecurity in the face of ongoing ecosystem degradation and climate change.

3. Managing water supply for hydroelectric power through restoration in the Nor Yauyos-Cochas Landscape Reserve, Peru
The Nor Yauyos-Cochas Landscape Reserve (NYCLR) covers an area greater than 220,000 ha in the Andean highlands. Its main goal is to conserve the Cañete and Cochas-Pachacayo River watersheds.

A few months before the protected area was designated (in 2001), hydroelectric concessions were granted to a private energy company, Compañía Eléctrica El Platanal S.A. (CELEPSA), to operate on the Cañete River downstream of the reserve.

The reserve is classified as a direct use protected area in which the sustainable use of natural resource is allowed. Nineteen native communities live in the reserve, divided into 12 districts with approximately 15,000 inhabitants. Grasslands in the reserve are widely used for pastoral activities and growing native crops, which form the main livelihood for local people.

Since 2015, the Board has focused on two specific objectives, which try to articulate and harmonize the interests of the local population, the NYCLR authority and CELEPSA:
- Improving water availability and distribution; and
- Improving grassland and livestock management.
- Three strategies were identified to achieve these objectives:

- Restoration of “green infrastructure” (natural wetland and grassland habitats) in the upper Cañete catchment to promote the capture and storage of water;
- Restoration of pre-Colombian local hydraulic infrastructure controlling the water flows, which allows to increase vegetation cover;
- Management of camelids (including alpacas and llamas) and promotion of vicuña conservation.

4. Watershed Restoration in Itaipu, Binacional, Brazil

Itaipu Binacional, a hydro-power company, operates the Itaipu Dam, located on the Paraná River on the border between Brazil and Paraguay. The hydroelectric dam is the world’s second largest by installed capacity (14,000 MW), and the largest in terms of effective generated output (103.1 TWh in 2016).

Sediment flowing into rivers and blocking dams is a problem in the watersheds throughout Latin America, exacerbated by soil exposure and erosion caused in part by deforestation and poor management of agricultural land. Over the half-century prior to the Dam’s construction, large areas of land in the river watershed had been degraded through forest clearing for soy and corn plantations, smallholdings, small cities and meat-packing plants, reducing the provision of ecosystem services. Blockage from sediment and periods of dry weather posed significant challenges for the Dam’s efficient functioning and economic return.

Itaipu Binacional needed a secure, high quality (low sediment), continuous water flow to maintain energy generation. Plans were made to protect, and where absent create, a natural forest buffer around the edge of the reservoir, to reduce erosion and encourage natural water filtration through the soil, reducing sediment loads and regulating water flows. In the company-owned area surrounding the Dam, Itaipu Binacional has planted over 44 million trees and created a network of protected natural areas.

The initial restoration and protection efforts of Itaipu Binacional have provided a range of benefits for the functioning of the dam, as well as for local communities and wildlife. The program has seen rapid expansion, and now operates in more than 50 municipalities. It has also become an internationally recognized model for watershed management and sustainable water and energy solutions around the world.

5. Buenos Aires Urban Ecosystem Regeneration Program, Argentina

The neighborhood of Villa Soldati, located in southwestern Buenos Aires, is an area of high vulnerability. It is bordered by the Riachuelo, Argentina’s most contaminated river and one of the most polluted waterways in the world, and crossed by the Cildáñez Stream, an outlet for industrial waste and effluents from a nearby livestock market. Runoff from around 1500 local businesses, including tanneries, chemical plants and factories, flows directly into the Riachuelo, contaminating it with arsenic, cadmium and lead.

The lack of cleaning and maintenance of Cildáñez Stream, as well as three overflow lakes has also been linked to regular floods. Due to these combined effects, the Riachuelo often gets blocked when it rains, and overflow affects surrounding neighborhoods. During the historic levels of flooding which took place in Buenos Aires in 2013, Villa Soldati was one of the most affected neighborhoods in the city. Considering this risk of flooding as well as factors related to social vulnerability, Villa Soldati is considered one of the most vulnerable areas of Buenos Aires.

The government of Buenos Aires undertook urban ecosystem restoration to reduce pollution and its impacts. The restoration includes making use of native flora through artificial wetlands creation and phytoremediation to reduce flood risk and pollution, the creation of a natural park to helped restore vegetation that can help regulate water resources, increase water filtration, and control erosion and runoff.

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