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UNDRR
UN Office for Disaster Risk Reduction

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

NATURE-BASED SOLUTIONS FOR DISASTER RISK REDUCTION

WORDS INTO ACTION



WORDS INTO ACTION

Engaging for resilience in support of the Sendai Framework for Disaster Risk Reduction 2015-2030

The Words into Action (WiA) guidelines series aims to ensure worldwide access to expertise, communities of practice and networks of DRR practitioners. The guidelines offer specific advice on the steps suggested to implement a feasible and people-centered approach in accordance with the Sendai Framework for Disaster Risk Reduction 2015-2030. These guidelines are not meant to be exhaustive handbooks that cover every detail, and those who need more in-depth information will find references to other sources that can provide them with it.

Using a knowledge co-production methodology, WiA work groups take a participatory approach that ensures wide and representative diversity in sources of know-how. WiA is primarily a knowledge translation product, converting a complex set of concepts and information sources into a simpler and synthesized tool for understanding risk and learning. It is also meant to be a catalyst for engaging partners and other actors.

In summary, the WiA guidelines are pragmatic roadmaps to programming an effective implementation strategy. This is facilitated by promoting a good understanding of the main issues, obstacles, solution-finding strategies, resources and aspects for efficient planning. The guidelines can be a valuable resource for national and local capacity building through workshops and training in academic and professional settings. They can also serve as a reference for policy and technical discussions.

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SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

UNDRR
UN Office for Disaster Risk Reduction

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CONTENTS

Acknowledgements 2
Foreword 7

01

Overview of this guide 8

1.1 About this guide 11

02

Nature-based solutions for disaster risk reduction and climate change adaptation 22

2.1 Rationale 24
2.2 The current status of nature-based solutions 60

03

Implementing the Sendai Framework with nature-based solutions 72

3.1 Sendai Framework priorities for action and ecosystems 74
3.2 Sendai Framework Monitor and ecosystems 138

04

Mainstreaming and upscaling 158

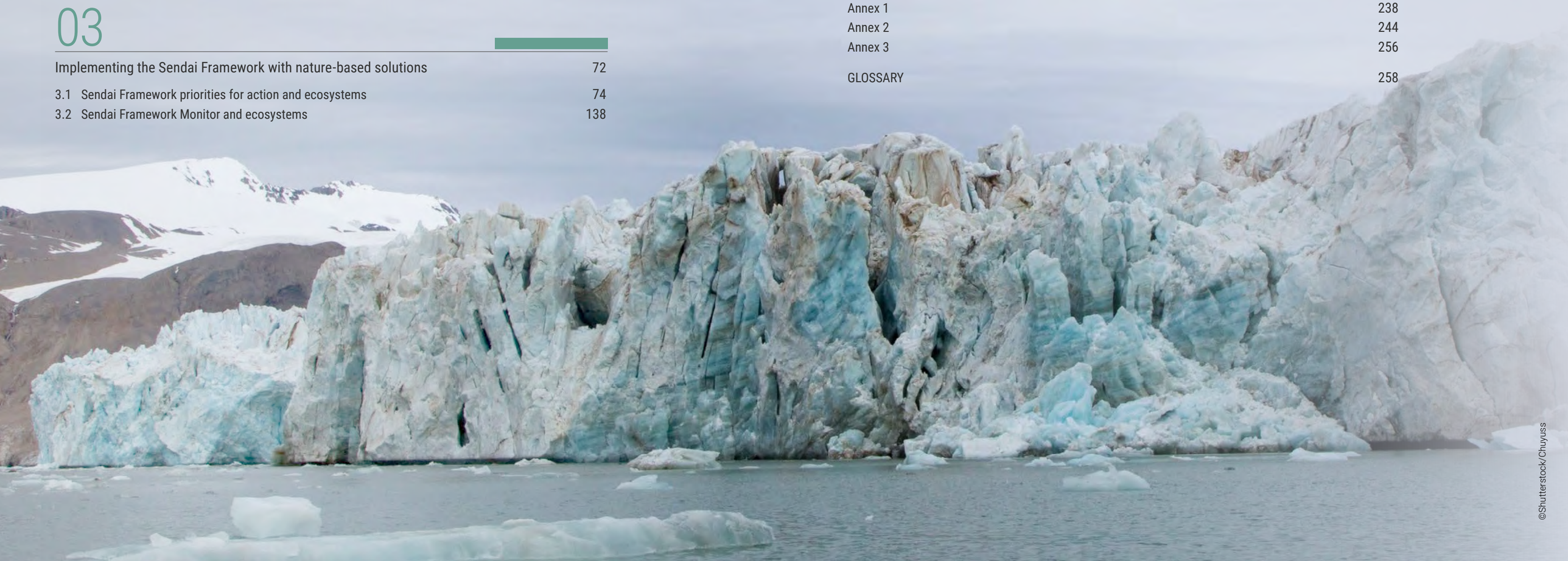
4.1 Policy coherence 162
4.2 Uptake and engagement 178
4.3 Financing nature-based solutions 208
References 216

05

Annexes 236

Annex 1 238
Annex 2 244
Annex 3 256

GLOSSARY 258



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FOREWORD



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Our planet is facing crises on multiple fronts. Climate change is altering our seasons and living environments. Disasters from natural hazards are now occurring three times more often than in the last 50 years. In 2020 alone, more than 50 million people were affected by water- and climate-related events while fighting COVID-19. We also face widespread, unprecedented biodiversity loss which impacts on how ecosystems function and deprives people from clean water and air, and productive land. More than 85% of wetlands, vital for water retention, food resources and flood control, have been lost over the last 50 years.

At the heart of all of these emergencies are our unsustainable development pathways. Nature is essential to regulating global climate, reducing disaster risk, providing food, water and other vital resources, and avoiding the spread and emergence of diseases.

Nature is also a source of solutions. The power of nature for enhancing our planet's resilience, is recognized by the 2030 Agenda for Sustainable Development, the Paris Agreement on Climate Change, Sendai Framework on Disaster Risk Reduction as well as through the United Nations Convention to Combat Desertification, Convention on Biological Diversity, and Ramsar Convention on Wetlands. We now need to translate these commitments into action.

The United Nations Environment Programme's new medium-term strategy tackles three inter-linked global crises which are drivers of disaster risk: climate change, biodiversity loss and pollution. UNEP works to harness the power of science and collective knowledge to shift our relationship with nature and reduce these drivers of risk. By working through partnerships, UNEP has led efforts to advance best practices in implementing ecosystem-based disaster risk reduction and climate change adaptation in over 41 vulnerable countries. We have shown through many of our projects and work with partners how effective these Nature-based Solutions can be.

The United Nations Office for Disaster Risk Reduction is the focal point and convener of the United Nations system for disaster risk reduction, supporting countries and societies to implement the Sendai Framework. In line with this mandate, UNDRR partners with stakeholders to develop Words into Action guides which are practical publications supporting on-ground implementation of disaster risk reduction policies for resilience.

The Sendai Framework is all about seeing risk holistically and dealing with it sustainably. Target (e) of the Sendai Framework calls for governments at both the national and local level to develop disaster risk reduction strategies. Nature-based solutions should be a vital element in these strategies.

It is our great pleasure to jointly share this new publication on Words into Action: Nature-based Solutions for Disaster Risk Reduction, which provides policy and practical guidance to Member States drawing extensively from experts' and practitioners' knowledge and experience. We hope that this guidance will assist countries in developing and advancing their national disaster risk reduction and climate strategies through scaled up implementation of Nature-based Solutions.

水鳥 真美.

01

OVERVIEW OF THIS GUIDE



1. INTRODUCTION

Some of the most important systemic risks faced by humankind today are environment related: extreme weather, biodiversity loss, natural hazards and human-made environmental disasters (WEF, 2020). In large part, the rising risks are the result of environmental degradation occurring worldwide due to increased human activity. The Global Assessment Report on Disaster Risk Reduction 2019 (UNDRR, 2019) further highlights the importance and urgency of dealing with these and other systemic risks by taking an interconnected and pluralistic approach to understanding risk. The environment, interacts and intersects with all we do and thus many of these systemic risks can only be reduced by working with rather than against nature; a concept known as nature-based solutions. While the term nature-based solution is new, managing natural resources and improving the flow of ecosystem services for disaster risk reduction is not (see for example UNDRR, 2009). The science of nature-based solutions thus has a long history upon which to draw.

1.1 About this guide

This guide aims to give practical, how-to-do information on setting up and implementing nature-based solutions (NbS), especially for disaster risk reduction (DRR), but also for climate change adaptation (CCA). It is designed to help implement the Sendai Framework for Disaster Risk Reduction 2015-2030 (hereafter referred to as the Sendai Framework). The Sendai Framework recognizes that environmental degradation can cause hazards and that disasters also have an impact on the environment. It recognizes that environmental management is a key component that can reduce disaster risk and increase resilience:

- Poor land management, unsustainable use of natural resources and degrading ecosystems are highlighted as underlying drivers of disaster risk
- Environmental impacts of disasters are recognized
- Countries are explicitly encouraged to strengthen the sustainable use and management of ecosystems for building resilience to disasters

(United Nations, 2015; PEDRR, 2016).



Sand dunes Yala National Park, Sri Lanka. © B. McAdoo



Re-greening, Sudan © UNEP



Nederrijn River Rhenen, Netherlands. © M. Staverijn



NATURE-BASED SOLUTIONS

Nature-based solutions (NbS) are defined by IUCN as: “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”.

There are features within the landscape, such as forests, mangroves, sand dunes, sea grasses, rivers, etc., that mitigate hazards by their presence and function. Protecting ecosystems is one way to ensure that they can function and provide services (such as acting as natural buffers) and reduce the risk of ecosystem-loss and degradation. Other such ecosystem-based approaches for disaster risk reduction include the restoration and sustainable management of ecosystems/environment. The term Eco-DRR is used for such disaster reduction measures and ecosystem-based adaptation, or EbA, for those aimed at climate change. Eco-DRR tackles both climatic and non-climatic hazards, while EbA addresses climatic hazards and adaptation to long-term climatic change and its impacts. In some circumstances, to enhance effectiveness of DRR, it is also possible to combine these 'green' approaches with engineered structures, resulting in so-called 'hybrid' infrastructure. Including NbS within a national DRR strategy is a "no-regrets" option because investing in these practices not only provides disaster risk reduction, it also responds to climate change while providing other benefits, such as the preservation of natural resources. Furthermore, NbS are key to addressing systemic risk because they involve working with the socio-ecological system as a whole.

Addressing the environment within a DRR strategy provides congruency with international development and environmental protection targets, such as the United Nations' Sustainable Development Goals (SDGs). As well as addressing SDGs 11 and 13 on sustainable cities and climate action, tackling environmental degradation and enhancing ecosystem services for disaster risk reduction directly input into SDGs 14 and 15, relating to life on land and sea. Eco-DRR also addresses commitments under the Convention on Biological Diversity, the Ramsar Convention on Wetlands and the UN Convention to Combat Desertification, while also contributing to climate change adaptation plans. Cross-fertilization is possible between work undertaken for country commitments under the aforementioned agreements and DRR strategies. This also means that data and indicators can be shared, reducing the burden of reporting.

There is a growing scientific and operational evidence base that shows that NbS work and are cost-effective, although decisions on what to implement where are always context and site specific. National policies, communities (particularly women, youth and children) and the private sector are key players to ensure success of NbS. National policies can provide the legal framework and incentives for undertaking NbS. Communities have local knowledge and are often stewards of the environment, thus working with them is crucial. Furthermore, local communities are on the frontline of disasters and civil society organizations are often involved in DRR. Finally, the private sector can help scale up NbS for DRR and CCA in terms of financing and implementation.

This guide will help stakeholders of all kinds (policymakers, civil society organizations, the private sector, etc.) deliver on the environmental components of the Sendai Framework and upscale implementation of NbS to increase resilience of populations. Ensuring a gender- and rights-based approach is also an important component in this equation.

The guide is organized into three main chapters:

Chapter 2

is an introduction to what nature-based solutions are, why they are important, and what the current state of play is in the world.

Chapter 3

goes into more detail on how to implement NbS in the context of the Sendai Framework. Many tools and resources are given non-exhaustively.

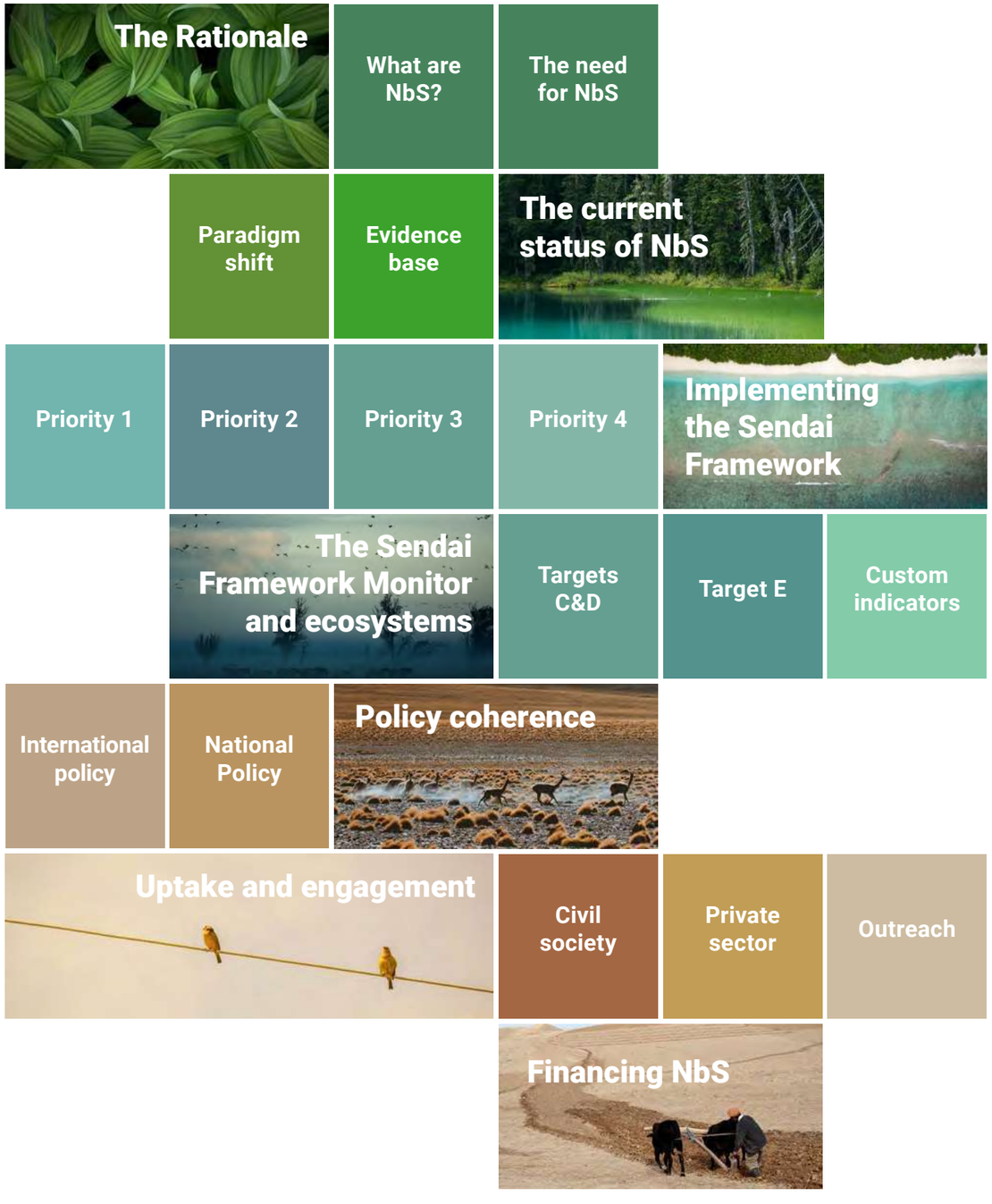
Chapter 4

is about mainstreaming and upscaling NbS to deal with disasters and climate risks. It covers policy coherence and how to engage communities, including women and youth, and the private sector.

Figure 1 gives an overview of the organization of the guide.

FIGURE 1

Organization of the guide



Chapter summaries

Chapter 2









Nature-based solutions (NbS) are actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges, such as climate change and disaster risk, effectively and adaptively, simultaneously providing human well-being and biodiversity benefit. They are an umbrella concept that encompasses ecosystem-based approaches for climate change adaptation (EbA) and disaster risk reduction (Eco-DRR), and many other environmental management, restoration and conservation approaches and activities.

see section 2.1.1





The World Economic Forum's Global Risk Report 2020 showed that the five most likely risks are environmental: extreme weather, biodiversity loss, climate action failure, natural hazards and human-made environmental disaster. NbS can address many of these concerns simultaneously. Indeed, they offer a win-win situation by countering environmental degradation, biodiversity loss and climate change (through mitigation and adaptation) and help to reduce the risk of disasters. NbS may not always be the silver bullet, but they are an important part of a strategy for long-term sustainable development, and a critical element in leading towards a decarbonized world.

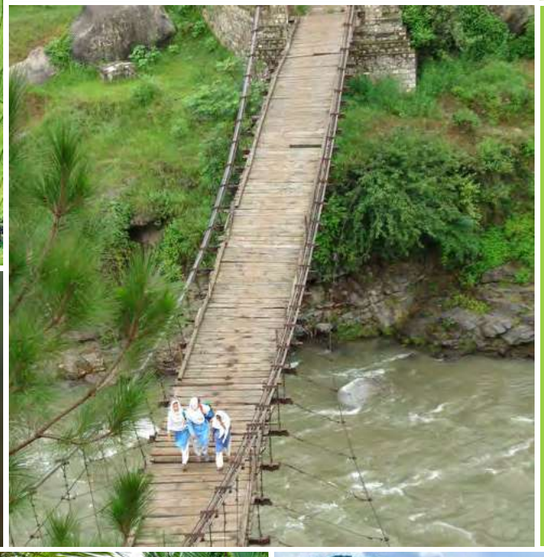
see section 2.1.2





The main advantages of NbS over engineered (hard) infrastructure are the multiple benefits they provide and their cost-effectiveness. Furthermore, hard infrastructure often has unintended negative environmental consequences, one of the reasons many countries are now choosing, for example, to 'renature' their rivers after previously canalizing them to reduce flood risk.

see section 2.1.2 - 2.2.1





There is a growing evidence base on NbS and their effectiveness in different situations. The evidence is ample from many different ecosystems, although some of the most detailed studies have been conducted in mountain and mangrove areas. In many situations, a mix of ecosystem-based and hard infrastructure, or 'hybrid' measures, will be the best option in terms of reducing risk; indeed, many urban NbS are hybrid measures. The effectiveness of NbS is context dependant and there exist knowledge gaps, which research is currently trying to fill.

see section 2.2.2







Chapter 3



It is important to recognize the potential of NbS for DRR and strengthen environmental governance and natural resource management accordingly (Sendai Priority for action 2). A range of means and instruments are available to integrate ecosystem-based approaches into DRR, including planning approaches, management approaches and formal processes.

see section 3.1.2



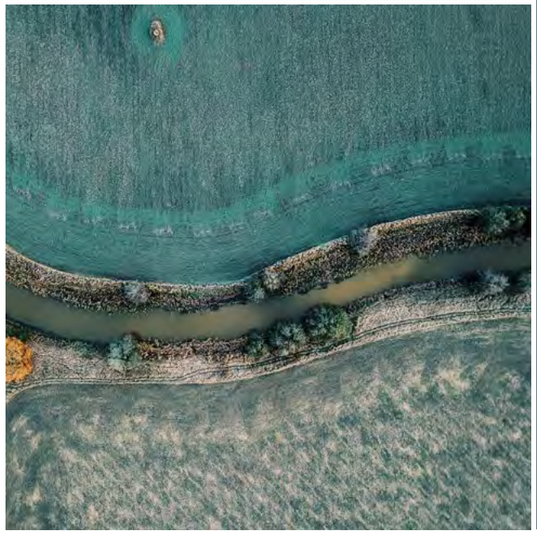
Sendai Priority for action 3 focuses on investing in DRR to achieve resilience. Resilience as defined by the Sendai Framework is "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions". Ecological engineering, conservation, restoration and sustainable management of ecosystems all can help increase resilience, not only of the environment itself but also of people.

see section 3.1.3

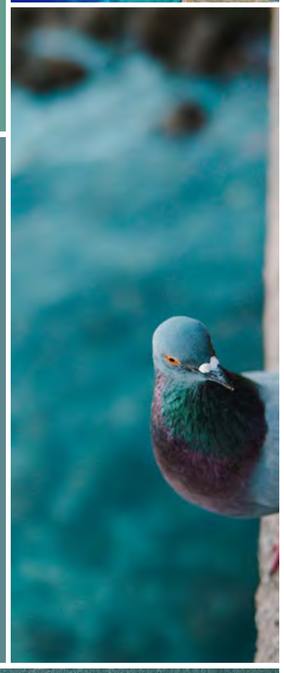
The Sendai Framework is the global policy guiding DRR and resilience-building efforts over the period 2015-2030. It recognizes and promotes the role of ecosystems and environment as a cross-cutting issue through its four priority areas for action to prevent new and reduce existing disaster risks (section 3.1). There exist many tools and indicators that can be used to integrate ecosystems into understanding disaster risk (Sendai Priority for action 1), which is important because evidence shows that ecosystems can regulate and mitigate hazards, control exposure and reduce vulnerability.

see section 3.1.1









Ecosystem-based considerations can be taken into account in all phases of the disaster risk management cycle/spiral. While the Sendai Framework does not currently include text on ecosystems management in Priority 4 (Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction), doing so could serve to make the result more effective in the long run. For instance, it could contribute to the "incorporation of disaster risk management into post-disaster recovery and rehabilitation", one of the goals of Priority for action 4.

see section 3.1.4

The Sendai Framework Monitor functions as a progress tracker for the Sendai Framework.

see section 3.2

Two of the seven Sendai Framework targets – C and D on critical infrastructure losses – explicitly mention green (and blue) infrastructure (GI). Within the Sendai Framework Monitor, categories related to GI that can be included are: coastal defenses; mangroves; parks and green space; urban tree canopy; regional stormwater reservoirs; rain gardens; rainwater harvesting; ground reinforcement for landslide prevention; and underground water infiltration trenches and storage systems.
Assessing disaster impact(s) on GI as well as monitoring the progress in reducing it (them) involves three steps: 1. Inventories of GI; 2. Regular monitoring of GI; and 3. Assessments of disaster impacts on GI.

see section 3.2.1



Target E of the Sendai Framework aims to: "Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020". It is imperative to integrate NbS into national and local DRR strategies to ensure coherence with climate change adaptation planning. Given the importance of the environment in the potential to reduce disaster risk, the inclusion of targets/goals, objectives and activities directly related to the environment can be an asset to national and local DRR strategies.

see section 3.2.2

The Sendai Framework Monitor allows countries to create their own targets customized to their strategy. To report on their customized targets, countries can either input their own indicators, or choose from a predefined list. Some of these predefined customized indicators originate from the UNDRR's Resilient Cities Campaign and are ecosystem-related.

see section 3.2.3

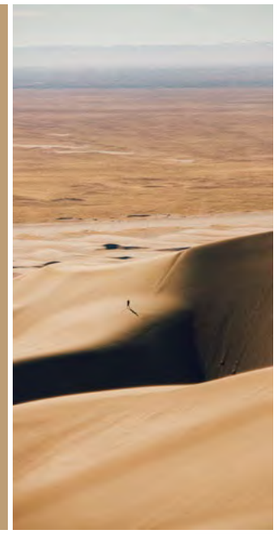
Chapter 4





Many policy mechanisms covering the environment have become silo operations. As stated in the 2019 Global Assessment Report, "Global challenges are more and more integrated and responses are more and more fragmented" (UNDRR, 2019). In this context, coherence in implementing global agendas and other international policies becomes increasingly important, especially as policy incoherence can seriously undermine sustainable development. A lack of policy coherence for NbS can lead to inaction or even conflicting agendas and trade-offs.

see section 4.1



However, NbS extend beyond the sphere of governments and policymakers; taking action to protect the environment and harness nature's benefits are also the prerogative of communities, civil society organizations (including NGOs), individuals and the private sector.
Communities, women and youth are on the frontline of disasters and as such they need to be included in DRR activities. With regards to NbS, many of these groups are in charge of natural resource management and their engagement makes them powerful actors for change. Children are also strong actors of change and have engaged in NbS in various ways.

see section 4.2.1

The private sector plays a critical role in advancing DRR and CCA by investing in the support of ecosystems and biodiversity. From a business perspective, there are two main reasons for which engagement in adaptation and risk reduction, in general, is attractive: 1) managing risks; 2) capitalizing on business opportunities. Businesses need to first understand the impact they have on nature and the ways in which they depend on it to enable decision-making. In many cases, adopting NbS makes business sense, whether from a financial, legal, reputational or operational stance.

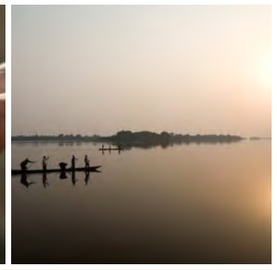
see section 4.2.1











Finally, the question of how to finance NbS is not only about finding resources but also about re-allocating budgets initially reserved for grey (hard) infrastructure and about redirecting 'perverse subsidies' (leading to degradation of ecosystems) towards NbS. It also involves finding sustainable financial mechanisms that lend themselves to investments that can be difficult to evaluate, on the one hand, or result in assets that are largely illiquid on the other.

see section 4.3

There exist many international policy agreements which already integrate NbS relating to DRR and CCA, including the Sustainable Development Goals (SDGs), the Rio conventions, the Ramsar Convention on Wetlands and, of course, the Sendai Framework to various degrees. Integrating NbS into DRR strategies can help to achieve the targets and goals of other agreements.

see section 4.1.1

National policy and laws are important mechanisms for ensuring not only DRR but also the inclusion of NbS in DRR policies. They can also create an enabling environment for the mainstreaming and upscaling of NbS. The process of formulating and implementing national adaptation plans (NAP) can support the implementation of enhanced adaptation action and the development of integrated approaches to adaptation, sustainable development and DRR, including through NbS.

see section 4.1.2



Outreach is a very important part of increasing uptake of NbS. Awareness raising is the first stage of outreach, followed by education and training and the availability of other services to aid uptake and implementation. These services are often provided by NGOs, civil society organizations, academia and government.

see section 4.2.2





We hope that this guide is useful and will help countries mainstream and integrate nature-base solution in their DRR strategies.

02

NATURE-BASED SOLUTIONS FOR DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION



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2.1 Rationale

2.1.1 What are nature-based solutions?

Nature-based solutions (NbS) emerged mid-2000s as a bridge concept promoted primarily by the International Union for Conservation of Nature (IUCN) and the European Commission (EC) as an effective combination of measures to addressing climate and disaster risks (**Figure 2.1**). It is an umbrella term covering a range of ecosystem-based approaches for different societal challenges within the paradigm of sustainable development. There are several terms in use that are related to NbS and this chapter aims to clarify most commonly used terms and their interlinkages. IUCN defines NbS as: "Actions to protect, sustainably manage and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016; IUCN Resolution WCC2016-Res-069). The EC, in turn, defines NbS as: "Solutions that aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions inspired by, supported by or borrowed from nature, using and enhancing existing solutions to challenges as well as exploring more novel solutions. Nature-based solutions use the features and complex system processes of nature, such as its ability to store carbon and regulate water flows, in order to achieve desired outcomes, such as reduced disaster risk and an environment that improves human well-being and socially inclusive green growth" (EC, 2015). The two definitions are similar; while IUCN emphasizes natural or modified ecosystems, the EC admits the possibility of including artificially created systems (e.g. re-created wetlands) as a type of NbS (Ruangpan et al., 2020). **Figure 2.1** depicts some of these concepts. The figure shows three societal aims (the large icons on the outer ring):

Dealing with climate change through climate change adaptation and mitigation.

Taking care of our planet for the long-term through climate change mitigation and environmental management.

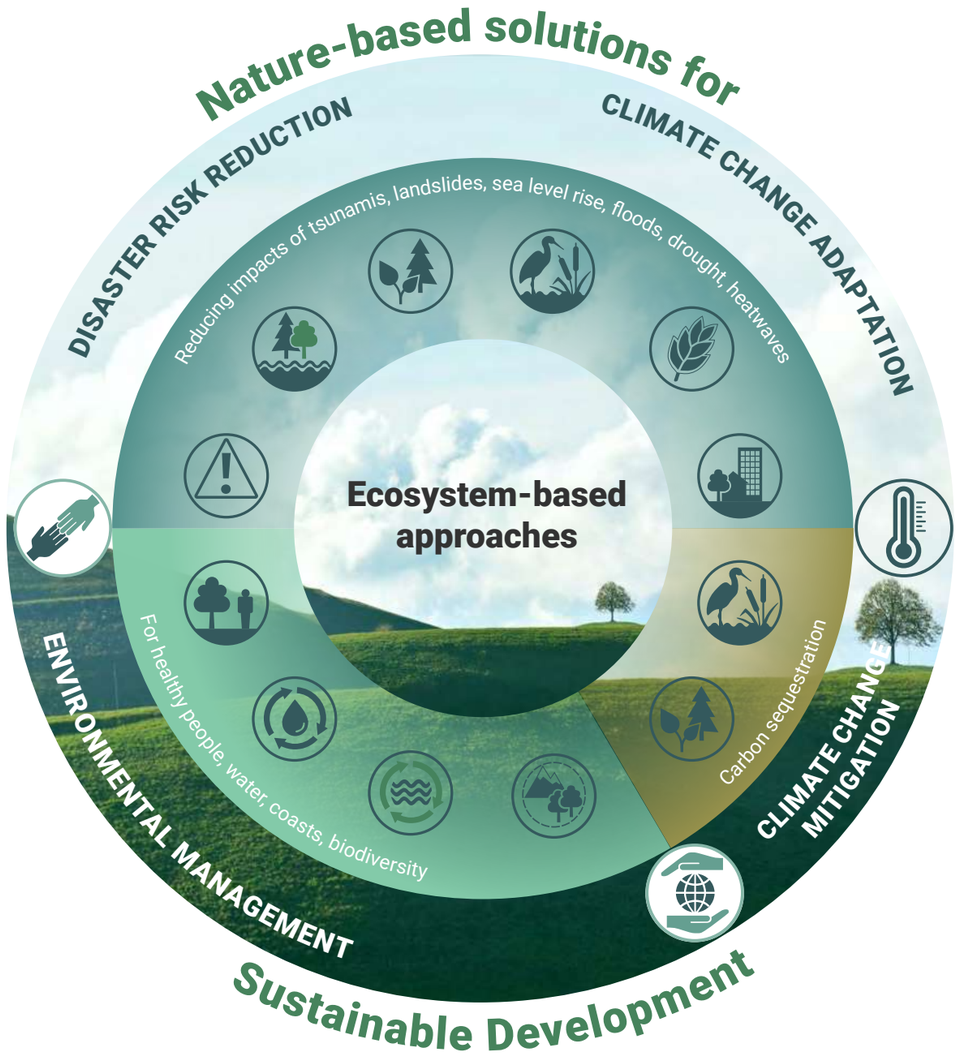
Protecting people and livelihoods through environmental management and disaster risk reduction and climate change adaptation.

Ecosystem-based approaches are encompassed within the NbS umbrella concept. These approaches aim to manage land, water, sea and living resources in a way that promotes conservation and sustainable use in a holistic and equitable way. The NbS concept is based on a scientific understanding of the interconnectedness of nature and people, and prizes biodiversity and functioning ecosystems and their services (supporting, regulating, provisioning and cultural) within the landscape/seascape. Thus, management that goes contrary to biodiversity and natural processes, such as planting monocultures or intensive farming, is not considered an ecosystem-based approach, and thus does not qualify as sound/effective NbS.



FIGURE 2.1

Nature-based solutions for sustainable development. Adapted from UNEP/PEDRR 2020



We will now explain the different ecosystem-based approaches encompassed in NbS by dividing them into four inter-related concepts. We will start with environmental management, followed by disaster risk reduction and climate change adaption, and finally climate change mitigation (see **Figure 2.1**).

Environmental management

Many targets in the Sustainable Development Goals (SDGs) require environmental management and land use planning for their achievement. Environmental management approaches are overarching tools that ensure an integrated approach and can be combined with one another along with other actions, such as restoration, for example. These approaches are:



SUSTAINABLE LAND MANAGEMENT (SLM)

SLM was defined by the UN 1992 Rio Earth Summit as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions."[1] It includes management practices in agriculture and forestry aiming at sustaining ecosystem services and livelihoods. SLM practices have already been adapted, tried and tested to reduce the expansion of dryland areas and erosion on slopes. For example, the World Overview of Conservation Approaches and Technologies (WOCAT), a global network on SLM, has developed a global database on sustainable land management practices that are currently practiced around the world.[2]

- **Integrated fire management** can be an important component of land management in some contexts. It aims to balance the beneficial and negative effects of fire on the natural environment and socio-economic circumstances in a given landscape or region and reduce risk of wildfire disasters that threaten human life and ecosystem functions. The Global Fire Monitoring Center (GFMC) has developed numerous resources to support fire management, with case studies and examples from different ecosystems and contexts around the world[3].

Target 15.3 of the SDGs bears on sustainable land management with its aim to achieve "land degradation neutrality" (LDN)[4] worldwide by 2030.

INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

IWRM is a governance and development process to manage water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment. Ensuring stakeholder participation in this process is crucial and is often undertaken in water committees. IWRM is also one of the most common approaches to dealing with climate change adaptation and disaster risk reduction because it is often used to control flood peaks and ensure a water reserve for drought periods (Sudmeier-Rieux et al., 2019). There exist many guidance documents on IWRM (see section 3.1.2 and **case studies 3.4 and 3.5**).

see section 3.1.2

see case studies 3.4

see case studies 3.5

INTEGRATED COASTAL ZONE MANAGEMENT (ICZM)

ICZM is a multi-disciplinary approach to manage coastal zones. It includes land use planning, marine spatial planning, resource management and, often, community involvement. It is a natural resource-management approach which is increasingly including risk considerations by planning and managing people and resources to reduce coastal risks (Sudmeier-Rieux et al. 2019). Combining ICZM and IWRM is a powerful integrated approach that has also been labelled 'ridge-to-reef' (mountain to sea) (see **case study 2.1** and **case study 3.3**)

see case studies 2.1

see case studies 3.3

PROTECTED AREAS MANAGEMENT (PAM)

Protected areas are a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Conservation activities are management activities, such as coppicing or removing invasive species, that aim to keep an area in a specific natural or semi-natural state. Integrating DRR with protected area management can be a powerful way to utilize natural buffers effectively in reducing impacts from a number of hazard events. Furthermore, it can help social and economic development of local communities though integrated natural resources management governance.

The International Union for Conservation of Nature (IUCN) denominates seven categories of protected areas:

- Category Ia — Strict nature reserve
- Category Ib — Wilderness area
- Category II — National park
- Category III — Natural monument or feature
- Category IV — Habitat/species management area
- Category V — Protected landscape/seascape
- Category VI – Protected area with sustainable use of natural resources

1 https://knowledge.unccd.int/topics/sustainable-land-management-slm
2 https://www.wocat.net/en/global-slm-database
3 https://gfmc.online/
4 The United Nations Convention to Combat Desertification (UNCCD) adopted LDN as the principle target of the Convention at COP12, in October 2015

CASE STUDY 2.1

Ridge-to-reef for ecosystem-based disaster risk reduction (Eco-DRR) in Haiti

The United Nations Environment Programme (UNEP) undertook an Eco-DRR pilot project (2012-2016) in Haiti, with funding from the European Union, applying a ridge-to-reef approach. Actions took a holistic appraisal of the landscape and applied activities at three levels:

1) to reduce erosion and sedimentation in the upland watershed through reforestation and sustainable vetiver cultivation. This ensures fewer problems downhill, such as siltation and pollution at the coast.
2) to protect the coastline from storm surges and flooding through revegetation at both river mouths and along the shoreline.
3) to ensure sustainable fisheries and the safety of fishermen through participatory action planning, shelter creation, boat improvement and safety training.

Source: https://postconflict.unep.ch/publications/Haiti/Haiti_Eco_DRR_case_study_2016.pdf



Disaster risk reduction and climate change adaptation

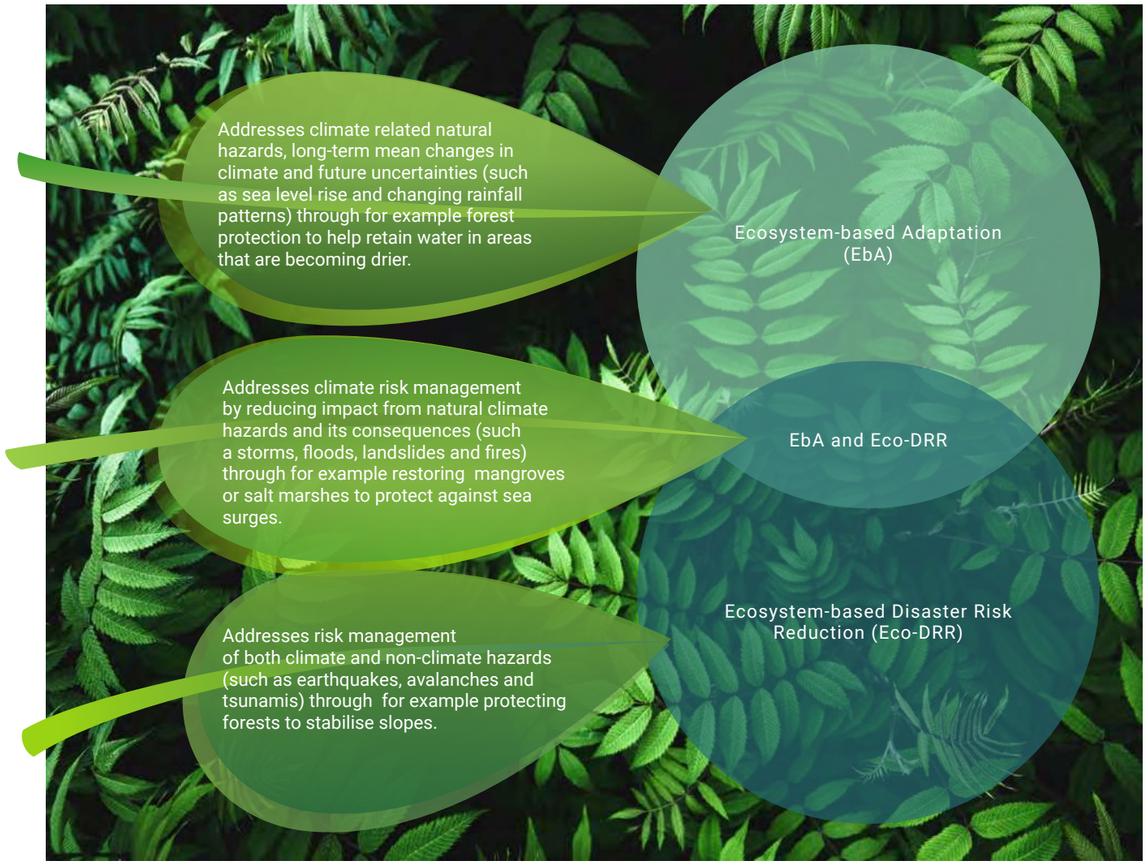
Ecosystem-based disaster risk reduction (Eco-DRR) and ecosystem-based adaptation (EbA) are related approaches (see Doswald and Estrella, 2015) and can also be thought of as a continuum, from mitigating large-scale disasters, such as tsunamis and landslides, to adapting to different climatic conditions. As mentioned above, both EbA and-Eco-DRR make use of environmental management approaches. By definition, they both involve sustainable land management and conservation and restoration of ecosystems. Eco-DRR addresses climatic and non-climatic hazards, while EbA addresses climatic hazards and adaptation to long-term climatic change and its impacts (**Figure 2.2**).

EbA: The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (CBD, 2009).

Eco-DRR: The sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development (Estrella and Saalismaa, 2013).

FIGURE 2.2.

Overlap between ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR).



A recent review of commonalities and differences between EbA and Eco-DRR found that in practice it is difficult to distinguish between the two – there are more commonalities than differences due to the basic shared underlying principle of utilizing the ecosystem approach and increasing the resilience of people and communities (Doswald and Estrella, 2015). Participation of indigenous peoples and local communities is often promoted as a guiding principle of EbA and Eco-DRR implementation. The equivalent of community-based adaptation in disaster risk reduction is community-managed disaster risk reduction, an approach that can help communities identify the hazards they are exposed to and design effective measures to promote resilience to them (Fitzgibbon and Crosskey, 2013). Differences between EbA and Eco-DRR mirror those of general climate change adaptation and disaster risk reduction (DRR) activities. The key differences include the following:

EbA

EbA largely addresses climate-related hazards, although there are examples of EbA interventions, such as implementing protection forests to stabilize the soil and prevent landslides, that can be climate and non-climate related. EbA interventions aim to address slow-onset climate change impacts and adjusting to a specific set of conditions, such as changing precipitation patterns, rising mean temperatures and sea level rise. They also counter other impacts of climate change, such as the changing distribution of species, invasive species mediated by climate change and biodiversity loss, which have not been a traditional focus of DRR.

Eco-DRR

In contrast, Eco-DRR addresses both non-climate, for example, earthquakes, tsunamis, technological accidents triggered by a natural event – natural hazard-triggering technological disasters (NATECH) – and climate-related natural hazards (e.g. hurricanes, heat waves), along with other kinds of hazards (see **Figure 2.1**). Eco-DRR tends to focus on rapid- and slow-onset events from which a system is expected to recover, rather than chronic and irreversible stressors to which systems must adapt, such as gradually warming temperatures, rising sea levels and glacial melt. Coming from the field of DRR, Eco-DRR is undertaken during all phases of disaster risk reduction, including relief, recovery, reconstruction and prevention (see section 3.1.4).

see section 3.1.4

Despite their differences, EbA and Eco-DRR have many similarities because of their shared focus on ecosystem management, restoration and conservation to increase resilience of people (or to reduce risk or reduce vulnerability). At the project/operational level, they are often indistinguishable.



Forest landscape restoration and the Bonn Challenge – A global effort.

The Bonn Challenge is a global effort to bring 150 million hectares of the world's deforested and degraded land into restoration by 2020, and 350 million hectares by 2030.
The forest restoration landscape approach is the means leveraged by the Bonn Challenge to restore ecological integrity at the same time as improving human well-being through multifunctional landscapes.

Source: https://www.bonnchallenge.org/content/challenge



LANDSCAPE RESTORATION

Landscape restoration includes afforestation and revegetating land with grasses, shrubs or trees. Doing so in the context of EbA and Eco-DRR aims to curb erosion and landslides through the stabilizing effect of roots, as well as improve water filtration and water resources. Species choice is extremely important and is dependent on climatic, geological and ecological conditions, as well as purpose (i.e., is the species needed to stabilize the slope? does it need to be a food source?). Protected areas can also be a useful tool, along with sustainable land management. Forest landscape restoration plays an important role in adaptation and mitigation by increasing climate change resilience, reducing disaster risk and combating desertification (IUCN, 2017).



WETLAND RESTORATION

This covers management activities in a very wide range of ecosystems – from freshwater to marine. In the context of EbA and Eco-DRR, the aim is to prevent or reduce the impact of flooding and drought, as well as land subsidence as a result of unsustainable development. It also covers restoration and management of coastal ecosystems, such as mangroves or lagoons, to reduce the impacts of sea level rise, wave surges, cyclones, coastal erosion, saltwater intrusion and coastal flooding.

In arid regions, the wetland-dryland inter-dependencies are crucially important. Wetlands restoration benefits the health of dryland ecosystems and therefore reduces risk of drought and flash floods.



CLIMATE SMART AGRICULTURE/ AGROFORESTRY

According to the Food and Agriculture Organization of the United Nations (FAO), climate-smart agriculture is "an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate."[5] It aims at increasing productivity and incomes, building resilience and reducing greenhouse gas (GHG) emissions. One strategy to reach these goals is "the use of trees and shrubs as part of agricultural systems", which is called agroforestry (FAO, 2013).

5 http://www.fao.org/climate-smart-agriculture/en/



URBAN GREENING

Urban greening covers adding 'green' and 'blue' elements, such as trees, parks and wetlands, into the urban landscape, as well as many hybrid approaches – a combination of green/blue and grey (human engineered) infrastructure, such as green roofs, bioswales, permeable pavements and sustainable drainage systems. Urban greening helps combat urban heat island effects, in which metropolitan areas can be significantly warmer than surrounding rural areas, as a result of human activities, by cooling temperatures. It is also effective in reducing impacts from flooding.



BLUE-GREEN INFRASTRUCTURE (BGI)

The term green infrastructure (GI) originated in the 1990s and its usage overlaps with NbS, EbA and Eco-DRR. It is often contrasted with grey infrastructures. UNDRR defines GI as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services, such as water purification, air quality, space for recreation and climate mitigation and adaptation, and management of wet weather impacts that provides many community benefits" (UNISDR, 2017). GI refers to land-based elements , such as forests and parks, some of which might be hybrid (e.g. part engineered), such as green roofs or facades. Blue infrastructure (BI) is a relatively new concept and aims to highlight the water-based elements in the landscape. BI includes coastal areas, rivers, and lakes but also hybrid elements, such as artificial channels and urban wastewater networks (Nesshöver et al., 2017) (see **Figure 2.3**).



PRE- AND POST- DISASTER MANAGEMENT

Ensuring environmental considerations in pre- and post-disaster management is a key aspect of Eco-DRR. It involves ensuring environmental contingency plans are in place pre-disaster, to avoid impacting sensitive ecosystems during relief operations, and post-disaster clean-up and rehabilitation of ecosystems. **Section 3.1.4** goes into more detail on this topic.

see section 3.1.4

HYBRID INFRASTRUCTURE

Hybrid infrastructure is blue and/or green infrastructure (BGI) combined with grey infrastructure or – ecologically engineered infrastructure (**Figure 2.3**) made to reduce disaster risk and help develop climate resilience (Browder et al., 2019). Hybrid infrastructures can provide a maximum of protection benefits as a combined approach benefits from the potential of both measures to address multiple hazards (Sebesvari et al., 2019; Sudmeier-Rieux et al., 2019). For instance, the strategy of ecosystem restoration to reduce risk may be combined with an engineered structure to protect the natural infrastructure at its early stages when the restored ecosystem still needs to take hold (Sudmeier-Rieux et al., 2019). Similarly, natural infrastructure can protect built infrastructure and reduce the impact of hazards on grey infrastructure (Sutton-Grier et al., 2015), thereby reducing maintenance costs, supporting lifespans and enhancing the sustainability of grey infrastructure (Sebesvari et al., 2019).

Hybrid infrastructure designs require engineers to work with other disciplines, such as ecologists, to develop artificial, human-made ecosystems (see Browder et al., 2019). Many urban NbS are hybrid solutions, such as green roofs and permeable pavements. Brink et al. (2016) analysed 110 articles, reporting on BGI and hybrid infrastructure undertaken in 112 cities. Heatwaves and the urban heat island and flooding are the hazards most NbS solutions address in the urban area.

Ecological engineering.
Ecological engineering is used to "design […] sustainable ecosystems, consistent with ecological principles, which integrate human society with its natural environment for the benefit of both"

(Bergen, Bolton, & Fridley, 2001; Mitsch, 2012).

FIGURE 2.3

Examples of green and blue infrastructure and hybrid counterparts



Green infrastructure

Forests
Parks
Trees
Plants
Sand dunes

Hybrid green infrastructure

Green roofs
Green facades
Green dykes





Blue infrastructures

Rivers
Lakes
Marshes
Floodplains
Mangroves
Peatland
Coral reefs
Seagrasses

Hybrid blue infrastructure

Sustainable drainage systems
Permeable pavements
Bioswales
Urban wetlands
Building with nature for costal protection



Climate change mitigation

Ecosystem-based mitigation (EbM) aims to decrease GHG emissions, such as carbon dioxide, methane and nitrous oxide, into the atmosphere by sequestering and storing greenhouse gases in ecosystems through conservation, restoration and sustainable management. For example, sustainable management and restoration of tropical peatlands can prevent emissions from drainage.

LANDSCAPE RESTORATION

Landscape restoration (see above) can promote carbon storage and sequestration. Protecting areas and using sustainable management can also help avoid release of carbon through ecosystem loss and degradation.



WETLAND RESTORATION

As explained above, wetland restoration can be undertaken in different ways and can contribute to climate change mitigation. Examples of wetland restoration include, but are not limited to, increasing interconnectivity of water flows, seagrass or weed/grass coverage, mangroves or peatlands restoration, etc.

Mangroves, as coastal habitats, account for 14% of carbon sequestration by oceans. If mangrove carbon stocks are disturbed, resultant GHG emissions are very high. Studies indicate that mangroves can sequester four times more carbon than rainforests. Most of this carbon is stored in the soil beneath mangrove trees (Sanderman et al., 2018).

Peatlands are the world's largest terrestrial organic carbon stock. Greenhouse gas emissions from drained or burned peatlands are estimated to amount 5% of global carbon emissions – in the range of two billion tons of CO2 per year. These emissions can be reduced by preventing drainage for alternate land usages (such as oil palm plantations) and by rewetting drained peatlands and implementing alternative forms of use, such as paludiculture (Günther et al., 2020).

Conserving peatlands intact and restoring degraded peatlands will prevent the release of vast amounts of methane and nitrous-oxides and effectively result in reducing GHG emissions.



Other concepts related to nature-based solutions

There are several other concepts that relate to NbS (**Table 2.1**).

TABLE 2.1

Concepts related to nature-based solutions

CONCEPT	NETWORK	DESCRIPTION
Building with Nature (BwN)	Ecoshape	Using natural processes and providing opportunities for nature while building hydraulic infrastructure.
Engineering with nature (EWN)	US Army Corps of Engineers	Intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits.
Working with nature (WWN)	PIANC	Approach that considers project objectives from a conservation/environmental perspective rather than as solely a question of technical design.
Working with Natural Processes (WwNP)	Environment Agency (United Kingdom)	Protect, restore and emulate the natural functions of catchments, floodplains, rivers and the coast.
Ecological engineering	No specific network; emerged from research and put into practice	The design of sustainable ecosystems that integrate human society with the natural environment for the benefit of both.
Natural capital	Natural Capital Protocol	Stock of renewable and non-renewable natural resources, (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of "services" to people. In turn, these flows provide value to business and society.
Natural capital accounting	European Union (EU)	A tool "to measure the changes in the stock of natural capital at a variety of scales and to integrate the value of ecosystem services into accounting and reporting systems at (European) Union and national level."[6]
Ecosystem approach	CBD/UNEP	A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.
Ecosystem-based management	No specific network; emerged in the United States in the 1970s	Ecosystem-based management that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation (Christensen et al., 1996). This is an approached embraced by NbS, like EbA or Eco-DRR.
Natural (sometimes called green) infrastructure	No specific network; emerged from research and practice	Frequently used in engineering sciences and landscape planning; similar or synonym to green and blue infrastructure NI or GI intentionally and strategically preserves, enhances, or restores elements of a natural system, such as forests, agricultural land, floodplains, riparian areas, coastal forests (e.g. mangroves), among others, and combines them with grey infrastructure to produce more resilient and lower-cost services.

In addition, there are various concepts that relate to specific applications of nature-based solutions. For example, in the context of protection forests, to reduce the risk of shallow landslides concepts such as soil bio-engineering and naturalistic engineering – the use of living vegetation as building material – are applied (Arce et al., 2019).

6 https://ec.europa.eu/environment/nature/capital_accounting/index_en.htm

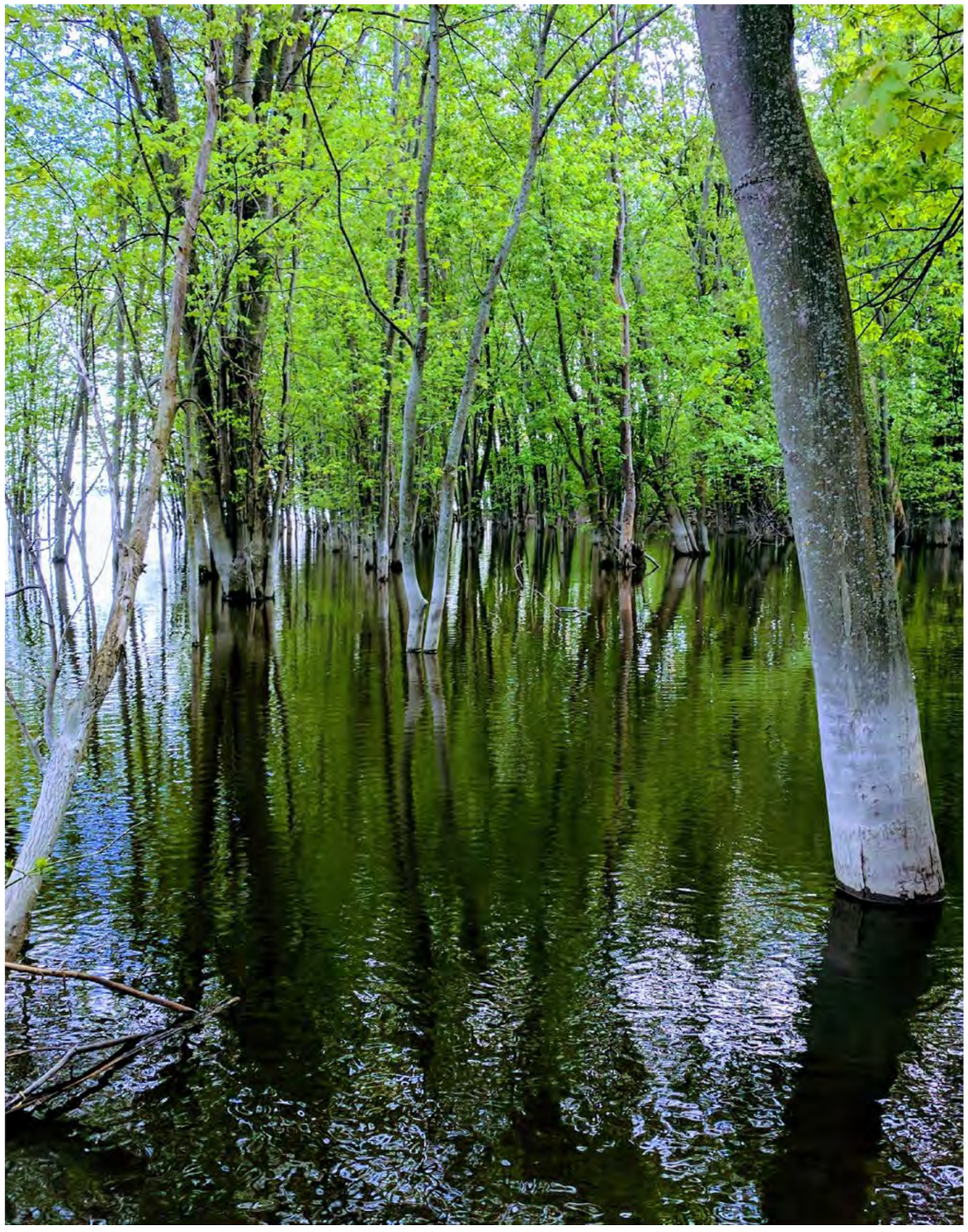
Principles of nature-based solutions

The NbS definitional framework of IUCN and its Commission on Ecosystem Management (CEM) includes eight principles. Cohen-Shacham et al. (2019) have added a description to each of the principles, which is shown in abbreviated form in **Table 2.2**.

TABLE 2.2:

NBS principles defined by IUCN (2016), with brief description adapted from Cohen-Shacham et al. (2019)

No.	Principle	Short description
	NbS embrace nature conservation norms (and principles)	NbS area not an alternative or substitute for nature conservation but can complement and benefit from conservation efforts in a landscape. In some cases, NbS closely address biodiversity conservation priorities, but not always.
	NbS can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions)	NbS promote the provision of a full range of ecosystem services or complement other measures, such as a mixture of sea walls and mangroves to protect a coastline from sea surf. Principle 2 requires policy coherence and is therefore linked to NbS Principle 8.
	NbS are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge	NbS are evidence-based approaches that build on a thorough understanding of specific ecosystems. Evidence can come from various sources, including science, traditional knowledge, or a combination of both. NbS should take into account natural and cultural contexts and also include local knowledge. Furthermore, this principle refers to the need for full participation in the development of a NbS measure.
	NbS produce societal benefits in a fair and equitable way in a manner that promotes transparency and broad participation	NbS interventions to secure food and water supplies or disaster risk reduction often provide services to governments and communities far from the source of the services but can mean loss of opportunity for those living in or near the source of the services. There is a need to ensure that different categories of stakeholders are involved in NbS, that the NbS in place provide benefits to affected actors – from local communities to infrastructure managers/private sector up to the national level –– and that loss of local opportunities is avoided. Payment for ecosystem services (PES) schemes can be an instrument to initiate a fair, transparent and participative process.
	NbS maintain biological and cultural diversity and the ability of ecosystems to evolve over time	NbS need to be developed and implemented in a way that is compatible with the temporal dynamics and complexity of ecosystems to support biodiversity and cultural diversity so that ecosystem services are sustainable and, as far as possible, as resilient as possible to future environmental change.
	NbS are applied at a landscape scale	Many NbS are implemented on a large spatial scale – such as watersheds or large forests – usually linking several ecosystem types (agriculture, inland waters, coastal and forest areas, etc.), and that might in some cases be transboundary. Even when an NbS is implemented at a specific site level, it is important to take into account the wider landscape-scale context and consequences, aiming at upscaling where appropriate.
	NbS recognize and address the trade-offs between the production of a few immediate economic benefits for development and future options for the production of the full range of ecosystem services	NbS should avoid changing or simplifying an ecosystem in favour of a particular service or resource, such as replacing natural mixed forest with a monoculture tree plantation. Instead, a thorough understanding of the trade-offs between current and future benefits is important when deciding between different NbS. Understanding and providing a process for fair and transparent negotiation of compromises is essential for successful NbS implementation. Landscapes can contain different stakeholder groups that use resources for their livelihoods, which can lead to complex and conflicting relationships that need to be identified and negotiated. It is therefore necessary that Principle 7 goes in line with Principle 8.
	NbS are an integral part of the overall design of policies and measures or actions to address a specific challenge	In order for NbS interventions to have a broad impact, it is important to ensure that they are not only carried out practically on the ground but are also integrated into policies and related actions. The implementation of this principle will support interventions on a large scale and includes the potential for adaptive management, as the results of interventions can inform and adapt natural resource management policies.



In addition, there are various principles for individual ecosystem-based concepts. For instance, the Convention on Biological Diversity (CBD) guidelines for EbA and Eco-DRR[7] list 10 principles, grouped in four main categories:

Principles for building resilience and enhancing adaptive capacity through EbA and Eco-DRR

1. Consider a full range of ecosystem-based approaches to enhance resilience of socio-ecological systems as a part of overall adaptation and disaster risk reduction strategies.
2. Use disaster response as an opportunity to build back better for enhancing adaptive capacity and resilience and integrate climate-resilient ecosystem considerations throughout all stages of disaster management.
3. Apply a precautionary approach in planning and implementing EbA and Eco-DRR interventions.

Principles for ensuring inclusivity and equity in planning and implementation

4. Plan and implement EbA and Eco-DRR interventions to prevent and avoid the disproportionate impacts of climate change and disaster risk on ecosystems as well as vulnerable groups, indigenous peoples and local communities, women and girls.

Principles for achieving EbA and Eco-DRR on multiple scales

5. Design EbA and Eco-DRR interventions at the appropriate scales, recognising that some EbA and Eco-DRR benefits are only apparent at larger temporal and spatial scales.
6. Ensure that EbA and Eco-DRR are sectorally cross-cutting and involve collaboration, coordination, and co-operation of stakeholders and rights holders.

Principles for EbA and Eco-DRR effectiveness and efficiency

7. Ensure that EbA and Eco-DRR interventions are evidence-based, integrate indigenous and traditional knowledge, where available, and are supported by the best available science, research, data, practical experience, and diverse knowledge systems.
8. Incorporate mechanisms that facilitate adaptive management and active learning into EbA and Eco-DRR, including continuous monitoring and evaluation at all stages of planning and implementation.
9. Identify and assess limitations and minimize potential trade-offs of EbA and Eco-DRR interventions.
10. Maximise synergies in achieving multiple benefits, including for biodiversity, conservation, sustainable development, gender equality, health, adaptation, and risk reduction.

The CBD and IUCN principles are similar. Aspects in the CBD principles that go beyond the eight NbS principles of IUCN include, among others, the explicit mention of indigenous peoples' participation and the incorporating of mechanisms that facilitate adaptive management and active learning, monitoring and evaluation, and identifying and assessing limitations under category four. Moreover, all the CBD principles are more closely related to the respective objectives of CCA and DRR since they are for EbA and Eco-DRR.

7 https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf

IUCN global standard for nature-based solutions

Sustainable solutions are needed to meet societal challenges; solutions that benefit both human well-being and biodiversity. When seeking to address food and water security, economic and social development, human health, disaster risk reduction or climate change challenges, NbS offer an approach that can be both sustainable while offering multiple benefits to people and nature alike.

To benefit from the full potential of NbS, a standard is required to create a common language and understanding, engage relevant stakeholders, safeguard nature from overexploitation, increase demand and supply of interventions and incentivize positive sustainable change.

To address these needs and mainstream NbS, IUCN developed the first-ever Global Standard for the design and verification of NbS[8]. To achieve this, the IUCN Global Programme and Commission on Ecosystem Management have engaged with hundreds of relevant stakeholders from 100 countries, both within and outside IUCN, while building upon previous work on defining NbS (Cohen-Shacham, 2016). The Standard consists of 8 criteria and 28 indicators, see **Figure 2.4.** The Standard is intended to be a facilitative framework that enables the translation of the NbS concept into targeted actions for implementation, reinforcing best practices.



	Issue being addressed	Criteria
1	Societal challenges	NbS effectively address societal challenges.
2	Design at scale	Design of NbS is informed by scale.
3	Biodiversity net gain	NbS result in net gain to biodiversity and ecosystem integrity.
4	Economic feasibility	NbS are economically viable.
5	Inclusive governance	NbS are based on inclusive, transparent and empowering governance processes.
6	Balance trade-offs	NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits.
7	Adaptive management	NbS are managed adaptively, based on evidence.
8	Mainstreaming and sustainability	NbS are sustainable and mainstreamed within an appropriate jurisdictional context.

In this document, we will use the generic umbrella term of nature-based solutions (NbS), unless a more specific term (e.g. Eco-DRR or green infrastructure) is warranted by the context.

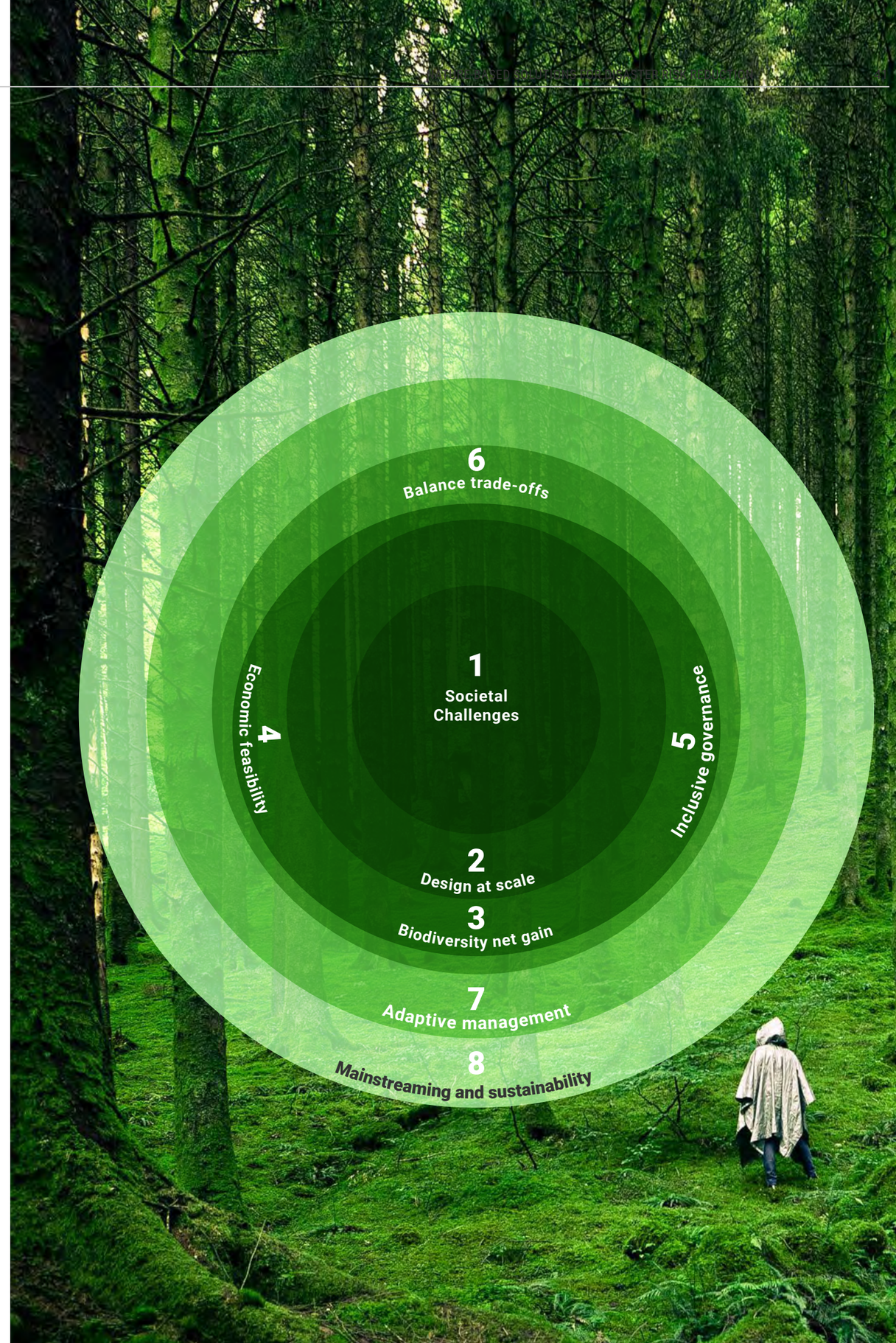


FIGURE 2.4

The IUCN global standard for nature-based solutions framework.

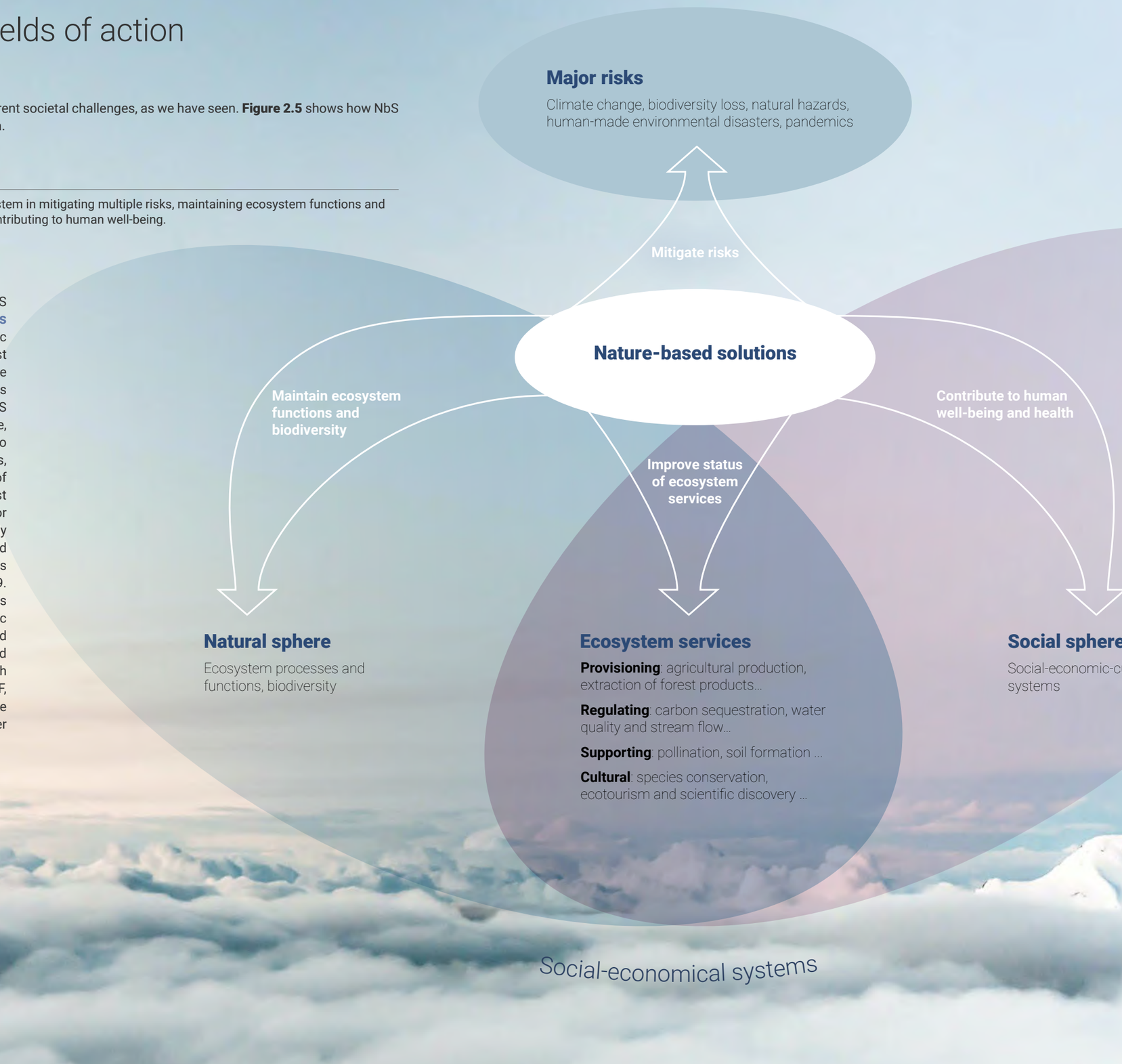
8 See https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs

Nature-based solutions: fields of action

NbS provide multiple benefits through addressing many different societal challenges, as we have seen. **Figure 2.5** shows how NbS work in four fields of action within a social-ecological system.

FIGURE 2.5

Nature-based solutions and their role in the social-ecological system in mitigating multiple risks, maintaining ecosystem functions and biodiversity, improving the status of ecosystem services and contributing to human well-being.



In the first field of action through Eco-DRR and EbA, NbS can **mitigate the risks of negative external impacts or provide buffers against shocks**. The World Economic Forum's Global Risk Report 2020 showed that the five most likely risks facing humanity today are environmental: extreme weather, biodiversity loss, climate action failure, natural hazards and human-made environmental disasters (WEF, 2020). NbS can reduce the frequency of hazard occurrence. For example, forests can prevent landslides, which often occur due to environmental degradation in conjunction with other factors, such as heavy rainfall. NbS can also reduce the magnitude of hazard impacts (e.g. sand dunes can offer a buffer against large waves). In addition, NbS also provide natural habitats for wildlife, so they do not encroach on urban areas, potentially reducing animal-human conflict and the risk of diseases and pandemics in urban areas. In a study, the WWF discusses how habitat loss affects the rise of pandemics like Covid-19. The paper concludes, among other things, that "the chances of pathogens like viruses passing from wild and domestic animals to humans may be increased by the destruction and modification of natural ecosystems, the illegal or uncontrolled trade of wild species and the unhygienic conditions under which wild and domestic species are mixed and marketed" (WWF, 2020). The extent to which NbS can contribute to reducing the risk of disease in individual cases, however, still requires further scientific investigation.

The second field of action refers to the **maintenance of ecosystem functions and biodiversity**. The restoration of mangrove ecosystems, for example, improves the ecological status of reforested coastal areas. Important ecosystem processes and functions, such as sediment fixation, are restored and biodiversity is increased, leading to a stabilization of the entire system. Through the ecological upgrading of mangrove areas, lost ecosystem services are restored for people, such as protection against coastal hazards and erosion, and carbon sequestration rises (**see case study 2.2**). This happens naturally without further human intervention after successful implementation of the reforestation measure.

Within the framework of NbS, individual ecosystem services can also be created or improved in a targeted manner. In this third field of action, **improve status of ecosystem services**, we find, for example, ecological engineering measures that pursue a very specific objective, such as flood protection, by creating retention areas or coastal protection by artificial dunes. Here, the focus is on a very specific ecosystem service without necessarily achieving a very high restoration status of the entire ecosystem. However, ensuring good biodiversity and ecological principles is essential to avoid unintended negative consequences, as in planting monocultures, which may be harmful to the environment and also are more vulnerable to disease.

Finally, the fourth field of action aims at **improving living conditions and human well-being and health**. In the case of mangrove restoration mentioned in the case study below one target was to implement sustainable shrimp farming systems to secure the income of the local population. Retention areas for flood protection or artificial coastal dunes can act as both protective buffers and high-quality recreation areas.





CASE STUDY 2.2
Mangroves for coastal defense in Viet Nam: double dividend.

The Mekong Delta Integrated Climate Resilience and Sustainable Livelihoods Project in Viet Nam, supported by the World Bank Group (WBG), World Resources Institute (WRI), Global Facility for DRR (GFDRR) and Global Water Security and Sanitation Partnership (GWSP), embedded nature-based solutions in its design to shift away from traditional 'hard' infrastructure towards solutions adapted to natural conditions in the Mekong Delta. The government of Viet Nam is moving strongly towards initiating climate-resilient projects that involve combinations of green and grey infrastructure, with corresponding benefits in local livelihoods. The project has restored and expanded mangroves and rehabilitated sea dikes. This has a double dividend for local communities. Firstly, it helps protect them from flooding and coastal erosion. Secondly, it offers new and innovative economic opportunities, better aligned with the subregion's natural soil and water conditions. These include promoting mangrove shrimp systems, which are less intensive, more organic, and can help farmers become internationally certified as sustainable seafood operations. This means they can fetch a premium price in the market, therefore increasing their revenues.

Source: Bowder et al. 2019.



NbS offer win-win situations by countering environmental degradation, biodiversity loss and climate change (through mitigation and adaptation) and helping to reduce the risk and impact of disasters. This can also be the case when they are combined – when appropriate – with grey infrastructure. NbS may not always be silver bullets, but they are an important part of a strategy for long-term sustainable development.

2.1.2 The need for nature-based solutions

Growing importance in politics, practice and research

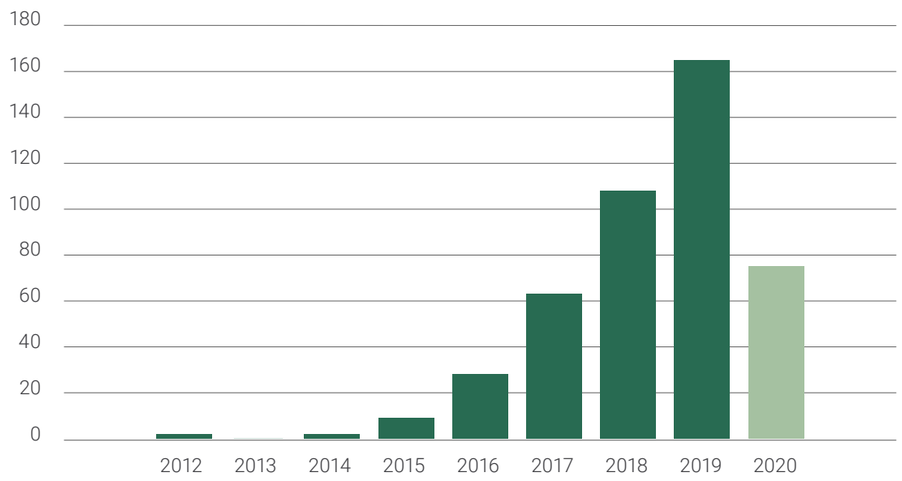
After the term NbS was first used in the late 2000s by the World Bank and IUCN in the context of climate change mitigation and adaptation (World Bank, 2008; IUCN, 2009), it took several years before the term became established in science and practice. This becomes clear from any search for NbS in publications listed in the Scopus abstract and citation database. **Figure 2.6** shows that the term was first mentioned in 2012 in peer-reviews, with a significant increase only visible after 2015. The increase is most likely due to the term being adopted in 2015 by European policymakers and included in the European Commission report "*Towards an EU research and innovation policy agenda for nature-based solutions and re-naturing cities*" (EC, 2015). The EU's Horizon 2020 Framework Programme for Research and Innovation funded NbS projects that resulted in numerous citations. The term subsequently found its way into various international agendas and appeared in mainstream media during the Global Climate Action Summit, held in San Francisco in 2018.

Eco-DRR and EbA emerged as terms in 2008 and 2009, respectively, in the context of international framework agreements (e.g. the Hyogo Framework for Action implementation and the United Nations Framework Convention on Climate Change (UNFCCC) negotiations). Today, there is political consensus that NbS and its operational parts of EbA and Eco-DRR can contribute to achieving many of the goals of the UN's Agenda 2030 for Sustainable Development (Seifollahi-Aghmiuni et al., 2019) and other international policy commitments, such as the Sendai Framework, the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, the UN Convention on Combating Desertification (UNCCD) and the UNFCCC, among others. For instance, 109 of the 189 intended nationally determined contributions (INDCs), countries' commitments under the 2015 Paris Agreement on climate change, and which in most cases cover adaptation as well as mitigation, include ecosystem considerations in their visions for adaptation. Twenty-three countries explicitly refer to EbA.[9] Section 4.1 goes into more detail on these commitments and how NbS can foster coherence.

see Section 4.1

FIGURE 2.6:

Number of NbS mentions in title, abstract or keywords in the Scopus database (for 2020: January to April).



9 UNEP, EbA Briefing Note 6. Integrating EbA into national planning, http://wedocs.unep.org/bitstream/handle/20.500.11822/28179/Eba6.pdf?sequence=1&isAllowed=y

Better climate and environmental resiliency through ecological engineering

Engineered structures have often been used as either the only or the first line of defence against hazards such as cyclones, flooding, landslides, droughts, storm surges and sea level rise. However, engineered structures also have their limits. First, they have a limited life cycle; they need to be maintained and replaced after a certain period. Second, their capabilities are limited to protection against hazards whereas living structures are more adaptable to changing environments and serve multiple purposes. For example, mangroves are more able to keep up with sea level rise in areas with high rates of sediment flows, provide vital habitat for species and store carbon. Coastal dynamics can be rapidly altered through inappropriate coastal engineering projects, for example, the damming of rivers, which create new hazards elsewhere. Shore structures should be designed so that they allow longshore sediment transport, and dams on rivers should be carefully planned to reduce their impact on sediment flows to coastal mangrove areas (see Spalding et al., 2014, for more information).

This highlights some of the unintended consequences of grey infrastructure, or engineered structures, especially hydraulic infrastructure. Another example is coastal bulkheads, which can increase erosion, especially downstream, impacting natural vegetation and increasing saltwater intrusion in agricultural lands. Dams can restrict natural sediment loads, water flow downstream and fish migration, and even create land subsidence, which causes flooding (Currin, 2019; Powell et al., 2019; see **case studies 2.3 and 2.4**). Grey infrastructure may be needed to protect areas with high population density, but not if the trade-off includes a transfer of risks to coasts and populations elsewhere.



CASE STUDY 2.3:
Unintended consequences of hydraulic infrastructures

The Mahanadi delta in Odisha, India is home to millions of farmers and fishers who used to benefit from the dynamic and nutrient-rich floods within the landscape. The wetlands in the delta formerly served the important function of buffering excess flood waters and acted as water reservoirs during dry periods. However, many of these areas have been degraded or reclaimed for agriculture and settlements, interrupting and fragmenting the natural water flows and putting additional pressure on the ecosystem. This, alongside a changing climate, has resulted in increased floods downstream and more droughts upstream.

Hard infrastructure that was built as a short-term solution for flood defence has disrupted the natural linkages between wetlands and water. The delta is now marked with persistent water logging, low agricultural productivity, loss of migratory fisheries, declining incomes, social conflicts, migration and health hazards due to limited availability of safe drinking water and sanitation. Due to climate change, rainfall patterns have altered, and extreme hydrological events are more frequent. This makes the life and livelihoods of communities even more vulnerable to flooding.

For more please visit: https://www.wetlands.org/casestudy/towards-vibrant-wetlands-mahanadi-delta-kosi-gandak-floodplains-indian/

CASE STUDY 2.4:
Land subsidence in north coast Java, Indonesia

Land subsidence occurs when water is extracted from the earth's crust, lowering the land surface potentially to even below river or sea level, leading to increased risks of disasters, like flooding. Indonesian coastal lowlands, such as mangroves, peatlands, river estuaries and lagoons, which are estimated to cover a total of 30 million hectares, are mostly situated at around 30 meters above sea level. Drainage and conversion of these wetlands for housing, fishponds, plantations and industrial development, along with the massive extraction of ground water, are among the main causes of land subsidence in Indonesian coastal lowlands. The Land Subsidence Declaration of March 2018 was a response to the realization that action was needed to reduce land subsidence, thereby reducing the risk of flooding and loss of land. It called for urgent control of ground water extraction and peatland drainage, wetland-friendly development, and a joint Roadmap and Action Plan for regional and national government levels to mitigate land subsidence.





In Demak, in north-central Indonesia, the root causes of coastal erosion problems were addressed by rehabilitating a mangrove greenbelt. First, the sediment balance was restored by using temporary permeable structures to create sheltered zones, thereby facilitating accretion of suspended sediments. The permeable structures stopped the erosion, which is a big gain for the villagers and promising for other villages along northern Java's shorelines, where millions of people face similar coastal erosion problems

Photos: Left Sedimentation behind permeable dams in a village along the coastline of Demak. Photo by Kuswantoro, Wetlands International

Top: Drone picture showing permeable structures to restore the eroded coastline in Demak.

©Wetlands International

For more please visit: https://www.wetlands.org/news/first-national-workshop-held-indonesia-address-land-subsidence-problems/

Blue and green infrastructure (BGI) can complement, be a substitute for engineered structures or safeguard infrastructural assets (Browder et al., 2019). A complement would be, for example, a protection forest or gabion walls to help stabilize a slope, or an urban wetland complementing a storm water system. A substitute reduces the need for engineered infrastructure. For example, having a healthy forest filtrating water can substitute the need for a filtration plant (Browder et al., 2019). Safeguards protect people and assets, such as coral reefs, seagrasses and mangroves, protect the coastline.

Combining engineered structures with BGI can sometimes be an optimal mix. In addition, BGI and hybrid measures need to be implemented alongside other measures of risk reduction, including avoidance of high-risk zones and implementation of building codes and early warning and evacuation procedures. BGI can be used to close infrastructure access and quality gaps in a climate-resilient manner and contribute to increased environmental and climate resiliency (IDB, 2020).

The window to use ecosystems as natural buffers is closing as many, such as wetlands, are in decline. The result is increased disaster risk, in particular for the poorest communities which depend directly on healthy ecosystems for their livelihoods. So, BGI should be prioritized where possible. Furthermore, existing and new infrastructure assets have to be enhanced to withstand projected climate impacts and ensure environmental sustainability.



Cost-benefit and cost effectiveness of nature-based solutions

When comparing green, blue or hybrid solutions with grey infrastructure, a cost-benefit analysis of the different alternatives is often used, showing costs and benefits in monetary terms for a given lifetime of the measure, often 30 years. In contrast, in cost-effectiveness analysis, only costs are recorded in monetary terms, whereas benefits are evaluated in terms of their outcomes (effects). When comparing NbS with grey infrastructure, one can therefore arrive at very different results depending on which of the two economic methods is used.

EXAMPLE: MANGROVE RESTORATION VERSUS DYKE CONSTRUCTION

Let us take coastal protection measures in tropical regions as an example and compare as a technical measure the construction of a dyke that protects against storm surges with mangrove restoration as a natural buffer. For both measures, the investment costs and the maintenance costs can be calculated and discounted for a defined period of time. There would certainly be significant differences in the investment costs, as the technical planning and execution of the dyke would probably cost more than the planning and execution of the mangrove afforestation measure. On the other hand, mangrove restoration requires larger areas of land, which have to be purchased. For example, if we reforest in an urban or peri-urban area with high land values, the purchase of land can very quickly result in high investment costs. Moreover, afforestation is labour intensive, so that labour costs, which vary greatly from region to region, are also a significant factor. Similar differences also apply to maintenance costs. However, Harari et al. (2017) have demonstrated that green and blue infrastructure can be cost effective in the long run, with low(er) maintenance costs and a longer lifetime.

However, if we focus on the benefits achieved by the two measures to be compared – the dyke and the mangrove restoration – much more obvious differences become apparent. The aim of both measures is to protect the coastal zone from storm surges. Within the framework of the cost-benefit analysis, this benefit can be expressed in monetary terms by calculating the total value of the protected goods (settlements, infrastructure, usable areas, etc.) in the risk area. Such a calculation is based on the avoided-cost method. If one carries out such a calculation, one can come to the conclusion that both measures offer equally high protection, but that the dyke offers this protection immediately after completion, while the mangroves only provide effective protection after a few years when the ecosystem has reached an advanced stage of succession. From the benefit side, this calculation speaks against mangrove planting. If, however, the objectives of the measure were defined more broadly to include the improvement of local living conditions, further monetarizable benefits could be added to the calculation. For example, the mangrove ecosystem provides wood and habitat for crustaceans and fish, which in turn provide the basis of life for coastal inhabitants. These values can also be expressed in monetary terms and would clearly shift the cost-benefit ratio towards the mangrove. The ratio would shift even further if, for example, values of carbon storage to mitigate climate change impacts were also included.

At some point, however, monetarization is no longer possible, either for methodological or ethical reasons. Prominent examples are the monetary valuation of biodiversity or that of a human life. Here, cost-effectiveness analysis offers a suitable alternative to circumvent the utilitarian concept of benefit and to place benefits in a broader social-ecological context. This would then reveal further benefits of nature-based solutions, such as their contribution to human health and well-being or the strengthening of social-ecological resilience. Of course, such a qualitative assessment also reaches its limits at some point, but it reflects the benefits of a measure much more comprehensively than a cost-benefit analysis geared to a specific objective and thus allows a much more comprehensive weighing of benefits.

Against this background, two real-life NbS examples illustrate the above: the 'room for the river' programme in the Netherlands and green infrastructure programmes in the United States. The programmes are described in **case studies 2.5 and 2.6**. Projects under these programmes have proven that NbS are effective, cost-efficient and in social-ecological respects superior to purely technical measures.

CASE STUDY 2.5

Room for the river programme in the Netherlands

Large parts of the Netherlands are only just above sea level and around a quarter of the country's surface is even below it. After numerous flood events in the 1990s, the Dutch government decided on a large-scale flood protection programme, which was implemented in 2007. The room for the river programme included over 30 projects along four major rivers and was completed in 2018. The individual projects aimed to reduce the risk of flooding and at the same time to make the landscape sustainable and ecologically valuable. Hybrid solutions were used, combining classical engineering with landscape design and environmental management. Among other things, dykes were extended and retention areas and flood plains were created, which not only reduce the risk of flooding, but also provide valuable habitats and offer high potential for tourism and recreation. The high investment costs of 2.2 billion EUR are thus offset by extensive benefits that go far beyond flood protection.

For more please visit: https://www.dutchwatersector.com/news/room-for-the-river-programme

CASE STUDY 2.6

Green infrastructure programmes in the United States

Green infrastructure programmes have been implemented in several U.S. cities under the management of the Environmental Protection Agency (EPA), with the aim of improving water quality through more comprehensive management of stormwater runoff. Elements of green infrastructure design include rain gardens, permeable pavements, bioretention systems, constructed wetlands, green roofs, green walls and others. These measures reduce the stress on the conventional water drainage infrastructure, in particular the storm sewer system, by storing more water in the soil and vegetation and reducing runoff and infiltration rates. In this example, too, habitats are created, for example, for insects and birds and leisure activities, such as urban gardening, are also supported. Already in 2010, New York City released a Green Infrastructure Plan combining grey and green infrastructure, and it has been shown that the hybrid solution is more cost-effective in the long term than a purely grey solution.

For more please visit: https://www.epa.gov/green-infrastructure/green-infrastructure-design-and-implementation and https://www1.nyc.gov/assets/dep/downloads/pdf/water/stormwater/green-infrastructure/nyc-green-infrastructure-plan-2010.pdf



Nederrijn River, Rhenen, Netherlands. © M. van Staveren

Several studies of comparative cost-benefit analysis of NbS across the world show that NbS pays off. For example, the Swiss government has set a target to restore 4,000 km of rivers in the country by 2090 (FOEN, 2012), with an estimated cost of 1.2 million Swiss francs/km (Logar et al., 2019). Cost-benefit analyses suggest that the benefits outweigh the cost of river restoration projects (Becker & Katz, 2017; Logar et al., 2019, Lui et al., 2020).

The Swiss NGO DRR Platform and World Overview of Conservation Approaches and Technologies (WOCAT) undertook a comparative analysis of costs and benefits of 24 green and hybrid interventions, both for setting up and maintenance. While the setting up costs are varied, the vast majority have very low maintenance costs. The benefits are also seen as very positive overall (Harari et al., 2017). Comparison of the cost-benefit of ecosystem-based and engineering options was undertaken for flood avoidance in Lami, Fiji. It showed that hybrid measures provided the best option in terms of both avoiding flood damage and cost (Rao et al., 2013).

The International Institute for Sustainable Development (IISD) developed the sustainable asset valuation tool (SAVi) that provides policymakers and investors with a comprehensive analysis of how much their infrastructure projects and portfolios will cost throughout their life cycles, taking into account risks that are overlooked in a traditional valuation (see **case study 2.7**).



CASE STUDY 2.7

Assessing the economic value of restoration interventions for the Beira Lake, Colombo, Sri Lanka

The Beira Lake in Colombo suffers from hypertrophic conditions; algae growth, poor water clarity, fish mortality and odor due to several pollution sources. A sustainable asset valuation was applied to assess the value of restoring and preserving the southwestern part of the lake. The SAVi results highlight that a long-lasting improvement of water clarity to a depth of 1.4 metres creates economic benefits for the city. A cumulative property value increase of US$ 43.2 million in the surrounding area by the end of year 2025 and additional recreational spending of US$ 19.6 million by people visiting that part of the lake between 2020 and 2025 can be achieved by investing in two interventions. These are: (1) an upgrade of wastewater treatment facilities that currently release ineffectively treated wastewater with high nutrient loadings into the lake, and; (2) a one-time dredging of the lakebed to remove phosphorus deposits. The cost-benefit analysis of this combined investment scenario yields a net result of more than US$ 56.5 million and demonstrates to property owners, real estate investors and public authorities that investing in restoring this natural asset would pay off and provide opportunities for long-term value capture.



More info: https://www.iisd.org/savi/project/beira-lake-colombo-sri-lanka/

Multiple benefits

As shown in the previous examples, NbS are beneficial because they accommodate multiple goals and benefits in one solution. For example, the protection or restoration of coastal dunes or even the creation of artificial dunes can provide ecosystem services and contribute to biodiversity and geodiversity, which a dyke cannot provide. This is illustrated in **Table 2.3**, where ecosystem services of an intact coastal dune system in the Netherlands are compared to those of a dyke covered with soil and plants (a 'planted' dyke). Both the dunes and the dyke protect the coast from hazards and erosion, but the dune system offers many additional benefits that the dyke does not or only partially offers. These are, in particular, regulatory services, such as water purification and carbon sequestration, supporting services, such as nutrient cycling and soil formation, and a contribution to biodiversity and geodiversity.

However, to demonstrate a positive business case, the values of these services must be quantified and at least partially monetized so that they can be appreciated by financiers, stakeholders and the local population. The valuation of ecosystem services, the certainty of the service and its appreciation by stakeholders who benefit from the solution remain challenging. NbS solutions also require a different approach to cost calculation than traditional solutions, as shown above. Notwithstanding this, further work is needed on standardization and assessment of ecosystem services in order to include them in planning and decision-making.

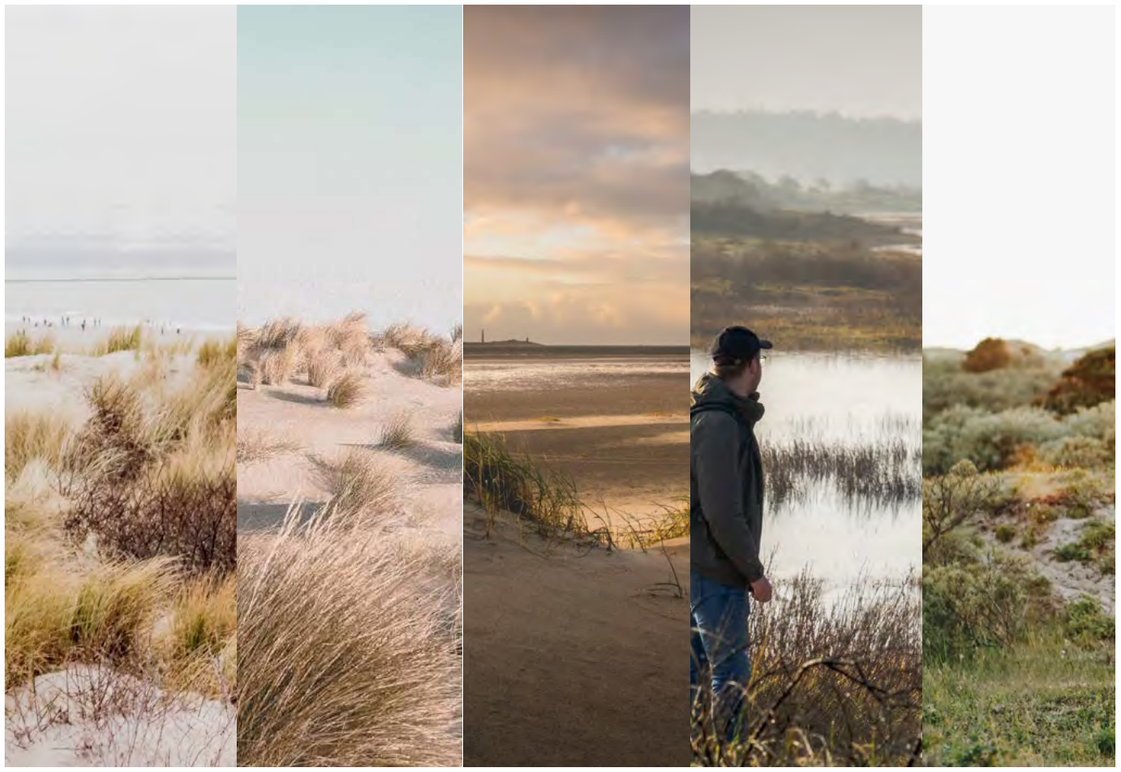


TABLE 2.3:

Ecosystem services, biodiversity and geodiversity of a coastal dune system in the Netherlands, compared to a planted dyke (ecosystem services of coastal dune systems modified from Nehren et al., 2016, and Alfonso de Nehren, 2020; classification according to the authors' assessment.)

Ecosystem service	Coastal dune system	Planted dyke
Regulating		
Hazard mitigation	High	High
Prevention from coastal erosion	High	High
Water storage and purification	High	Low
Carbon storage and sequestration	Medium-High	Low
Stabilization of local climate and air quality	High	Medium
Pollination	High	Low-Medium
Supporting		
Habitat for species	High	Medium
Maintenance of genetic diversity, primary production, nutrient cycling, soil formation	High	Low
Provisioning		
Food	Medium	Low
Living space	Medium	Low
Fresh water	High	Low
Mineral raw materials	High	None
Renewable resources	Medium	Low
Medicinal resource	Medium	Low
Cultural		
Tourism and recreation	High	Medium
Aesthetic appreciation and inspiration for science, education, culture and art, spiritual experience and local identity, cultural heritage	Strongly location-dependent	
Biodiversity and geodiversity	High	Low



THE NEED FOR SYSTEM CHANGE

For large-scale uptake and implementation of NbS a radical reform of the global economic system is needed. We need to develop new sustainable finance systems that would ensure investments in NbS and examine whether investments risk leading to maladaptive developments. We need to ensure that new trade deals and 'perverse' subsidies (such as for palm oil plantations on peatland) do not undermine progress. We need to actively involve the local population in the planning because communities are often responsible for the long-term operation of NbS and thus their support is critical to a project's viability. Properly implemented, NbS may generate not only ecological but also significant social co-benefits in terms of community empowerment. However, NbS have to be designed for each specific context, based on sound knowledge of how factors such as changes in water flows, sedimentation, infrastructure, vegetation, land use and climate change influence the ability of ecosystems to support society's demands. They are not a panacea and cannot always replace grey infrastructure. Often, they achieve their greatest impact when they act as hybrids to complement and enhance grey infrastructure.

2.2 The current status of nature-based solutions

2.2.1 Paradigm shift

The world is at a turning point. Sustainable development cannot be achieved through a 'business as usual' approach. Drastic changes to the ways we do sustainable development are needed. We need a paradigm shift. NbS for disaster risk reduction and climate change adaptation offer these drastic changes, contribute to the paradigm shift and are/should be an inherent part of future sustainable development.

Sustainable development is a long-term planning process that aims for economic progress without causing damage to the environmental and socio-economic spheres. Ecologically and socially inclusive development enables a safe future for coming generations as they continue to develop their economies and societies and care for the environment. Disaster risk reduction and climate change adaptation are part of this inclusive sustainable development process (Renaud et al., 2013). In this respect, Nbs have emerged from the recognition that not only can they provide viable solutions for community resilience and adaptation, but also increase care for the environment as a pillar of sustainable development.

As the World Bank states in its 2019 report *Putting Nature to Work: Integrating Green and Gray Infrastructure for Water Security and Climate Resilience*: "21st century challenges require innovative solutions and utilizing all the tools at our disposal. Integrating 'green' natural systems, like forests, wetlands and flood plains, into 'grey' infrastructure systems shows how nature can lie at the heart of sustainable development." (Browder et al., 2019).

As interest in the role of NbS for climate change adaptation and mitigation, disaster risk reduction and sustainable land management grows, a more systemic approach and understanding is required. NbS have become a major area of interest to global leaders looking to ramp up their adaptation and resilience efforts. Asian countries, in particular, are leading the way. China plans to "proactively promote" the expansion of grasslands and wetlands as part of its climate efforts, while Indonesia has emerged as a frontrunner in coastline restoration, leveraging natural sediment flows and mangroves. Such solutions hold much promise for other countries but require innovative collaborations and integrated approaches to change the current way nature is planned and utilized in development.



By relying on grey or 'hard' infrastructure only, we have been creating a technological lock-in that is unsustainable, costly and that doesn't meet the needs and challenges of the 21st century, including climate change and population growth. For example, in coastal areas, 'hard' infrastructure solutions alone are not feasible anymore: due to unplanned urbanization, coastal soils are eroding and subsiding, while sea levels rise and salt water intrudes onto agricultural lands. Hence, the need for a 'paradigm shift' in designing infrastructure solutions.

In many developed countries, previous grey infrastructural solutions to DRR are being combined with or changed for blue and green solutions. For example, many rivers which were canalized in order to reduce flooding in the last century are now being restored to their natural form, and in other cases, dams and levees are being taken down and floodplains revived to improve flood management (Département du territoire, 2009; Partners of the Restore Project, 2013; Logar et al., 2019; **see case study 2.8** 'Building with nature').

This trend for river restoration in Europe and the United States is also motivated by the need to enhance water quality, manage riparian zones, improve in-stream habitat, allow fish passage and stabilize stream banks. In Europe, the 2000 European Union's Water Framework Directive is the legal instrument behind many of these restorations with its requirement that all rivers be returned to a "good status" by 2015 (EU, 2000). It remains an important legal instrument, although Europe is still far from restoring all its rivers to a good status. Furthermore, an evaluation undertaken in 2019 suggests that while the directive, and its associated directives, are fit for purpose, implementation by member states and sectors is lagging (EC, 2019).

One measure that has been used successfully in different European countries is managed realignment/retreat in which old sea walls at risk are breached in order to restore or create mudflats and salt marsh habitat. These habitats provide additional coastal protection while protecting new seawalls that are constructed landward (Roman and Burdick, 2012). Other successful coastal hybrids have been implemented, such as living shoreline techniques (NOAA, 2015; Currin, 2019) or sandy foreshores, part of the Dutch flood protection programme[10] .

10 https://www.ecoshape.org/en/projects/hybrid-flood-defence-houtribdijk-sandy-foreshore/



CASE STUDY 2.8

Building with nature

Building with nature is an innovative, participative approach to hydraulic engineering that makes use of nature to benefit society. Building with nature solutions work by making use of natural processes and ecosystem services. For example, by allowing river flows and sea currents to reinforce the coastline with sediment; or by restoring ecosystems so that they provide protection against extreme events and offer valuable 'natural capital' in the form of shellfish, timber and recreational opportunities.

These solutions are adaptive and typically cheaper to construct and maintain compared with conventional infrastructure solutions like dams and sea walls, which are incapable of adapting to climate change and are ineffective as a single solution as they fail to provide economic, environmental and social services. Building with nature is an inclusive approach where several disciplines and stakeholders are involved in the design, construction and maintenance of measures. Environmental co-benefits enable more productive and multi-functional land use as well as climate change mitigation.

This approach is the one used in the Netherlands (see **case study 2.5**). Internationally, building with nature projects are being implemented in Indonesia, Singapore, Florida (United States), Surinam and Panama.

For more information: https://www.ecoshape.org/en/

see case studies 2.5

The creation of natural shoreline barriers or restoring wetlands to tame dangerous storm surges and floodwater is increasingly tested and upscaled. For example, the 'woods versus waves' (Netherlands) research project, which is assessing the power of trees to protect from floods[11]. The 'sand motor' project, also in the Netherlands, is testing whether depositing a large amount of sand in a single operation can be a sustainable method for coastal protection for sandy beaches[12].

This trend towards NbS in developed countries, even if this terminology is not used, marks a paradigm shift and stems from lessons learned from years of development, which demonstrated the need to work with nature to ensure sustainability. The paradigm shifts from the idea that we need to be protected from nature (hazard events) to one that nature can (help to) protect us.

Similarly, building on this paradigm shift, the UN announced in 2019 its Decade on Ecosystem Restoration (2021-2030), which aims at restoring degraded landscapes and accelerating existing global restoration goals. One example of the latter is the already mentioned Bonn Challenge.

However, restoration is a harder and more costly process than conservation of a fully functioning ecosystem (Jones et al., 2018). Besides creating more protected areas, working with nature and reducing degradation of ecosystems require novel ways of reshaping urban landscapes. For example, China's 'sponge' cities are built to absorb rainwater through a combination of BGI and permeable pavements. Rainwater is naturally filtered by the soil and fills the urban aquifer while providing many other co-benefits (Wang et al., 2018). Furthermore, it is essential to invest in green infrastructure measures to reduce disaster and climate risks, while considering the scale at which green investments are made. By considering the wider watershed landscape – from 'ridge to reef' – public and private investors can invest in a variety of large- to small-scale reforestation projects, riverbed restoration and early warning systems. However, it is important that there be an overarching mechanism, such as an integrated watershed management forum where stakeholders from the upper and lower watershed can coordinate activities.

Perceptions on NbS versus grey infrastructure can be varied depending on background, education, life experiences and interests. Some people may prefer grey infrastructure if it is perceived as safer for protecting against certain hazard events (especially when they do not understand the protective capacity of NbS). But grey infrastructure can also offer a sense of false security, encouraging the construction of houses, for example, right behind river dykes, which may fail. Nevertheless, support for NbS is growing, even in younger generations (see the video "Nature Now" by Conservation International, featuring Swedish environmental activist Greta Thunberg[13]). Furthermore, there is evidence to suggest that the co-benefits of NbS, including increased greenery and provisioning of services, make them more attractive to the public (Mell et al., 2013; Derkzen et al., 2017; Wolf et al., 2020). Hence, the paradigm for development is shifting: NbS are indispensable for ecologically and socially inclusive sustainable development that supports people to be resilient to all types of disasters. The next section will go into the growing evidence base of NbS.

11 http://woodsversuswaves.com/
12 https://dezandmotor.nl/en/
13 https://www.conservation.org/video/nature-now-video-with-greta-thunberg

2.2.2 The evidence base

There have been several systematic reviews cataloguing and reviewing the evidence of nature-based solutions for DRR and CCA. Systematic reviews are more reliable than normal reviews, because they reduce bias and look at a wide selection of studies. Thus, their conclusions are also more reliable than single studies (Mallet et al., 2012).

The evidence from nine of these reviews – cited below – provides a strong case for the integration of NbS into DRR and CCA strategies and plans. **Table 2.4** summarizes their findings. There is ample evidence from many different ecosystems, although some of the most detailed studies have been conducted in mountain and mangrove areas. Mountain ecosystems are particularly impacted by climate change (see **case study 2.9**). It is clear from the literature that each situation requires an assessment before an appropriate option is chosen. While on the whole NbS/ecosystem-based approaches mitigate risks (and provide benefits), their effectiveness is dependent on the social and environmental conditions of the area. NbS approaches demand profound site-specific understanding of the natural and socioeconomic and institutional systems.

see case study 2.9

Sound NbS require both detailed and large-scale system knowledge to determine the driving natural processes as the basis of a solution. There is often a mismatch between preparatory studies, that traditionally focus on a limited area, and the necessary knowledge about relevant processes at the landscape scale.

However, this would be true for any measure implemented and all measures should be assessed against risk and vulnerability appraisals undertaken prior to implementation.

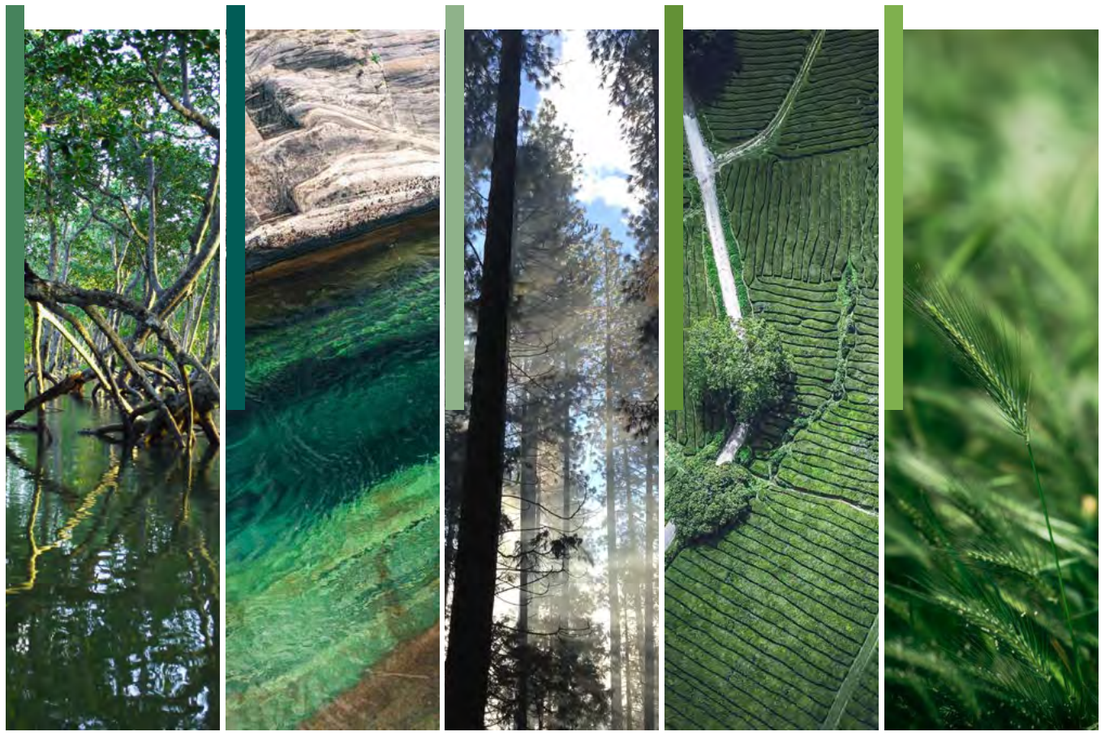


TABLE 2.4:

Evidence base on NbS for DRR and CCA

Author/date	Topic	Findings
Sudmeier et al. (accepted)	The role of ecosystems to reduce disaster risk (Eco-DRR)	There is good evidence that forest and vegetation management can reduce a variety of hazards, notably wildfires, erosion and flooding. There is good evidence that urban ecosystems and green infrastructure design (e.g. green rooftops, permeable sidewalks, constructed wetlands) are effective for attenuating urban flooding, pollution and heat waves. There is good evidence that mountain ecosystems can reduce landslides. There is medium evidence that coastal ecosystems can reduce hazards but relatively good evidence that they can stabilize shorelines and protect against storm surges. There is medium evidence of inland wetland ecosystem's role in reducing flooding. The main gaps in the literature relate to the role of ecosystems for earthquake hazards, as well as the role of dryland and agro-ecosystems in disaster risk reduction.
Ruangpan et al. (2020)	NbS for hydro-meteorological risk reduction	Small-scale NbS (green roofs, rain gardens, rainwater harvesting, dry detention ponds, permeable pavements, bio-retention, vegetated swales and trees) can be very effective at reducing peak flows, depending on the magnitude and frequency of rainfall events. Large-scale NbS (river restoration, floodplain lowering, flood storage basins, green floodway, wetlands, sand dunes, forest preservation and restoration, mountain forestation) can reduce flood risk and provide co-benefits (biodiversity, recreation, livelihoods), but more research is needed.
Arce-Mojica et al. (2019)	NbS for landslides	Vegetation can help control or reinforce slope stability through root systems. Different species have been researched for their effectiveness. However, in some conditions, vegetation (heavy trees on fragile slopes) can also be a trigger for landslides.
Moos et al. (2018)	Eco-DRR (protection forests) in mountain areas	Avalanches: tree density, gap size and proportion of evergreen to broadleaf species influence the probability of onset of avalanches. Furthermore, avalanches which start within 100-200 metres of forests can be stopped by forests. Avalanches which occur above the treeline: "the effect of different forest structures along the avalanche path is negligible, but forests in general are still able to slow avalanche speeds and limit runout distances" (Teich et al., 2012). Rockfall: under certain circumstance, forests can create the hazard through weathering (when tree roots wear down the soil) or leveraging (trees are uprooted by strong winds). However, forests can be a protective barrier reducing rockfall probability and intensity to boulders up to 20m3. Flood risk: forests can reduce flood onset and intensity, depending on scale and magnitude of both rainfall and forest. Landslides: forests have a protective effect against the onset and intensity of landslides.

Sierra-Correa & Kintz (2015)	EbA for sea level rise	EbA in mangrove ecosystems is one way to deal with seal level rise. Actions involve integrated river basin and coastal zone management, mangrove management planning.
Spalding et al. (2014)	NbS for coastal defence and DRR	Mangroves for coastal defence against waves, storm surges, tsunamis, erosion and sea level rise. Wind and swell waves are rapidly reduced as they pass through mangroves. Wide mangrove belts can be effective in reducing the flooding impacts of storm surges occurring during major storms (cyclones, typhoons). Wide areas of mangroves can reduce tsunami heights. Mangroves can actively build up soils which may be critical as sea level rise accelerates. If they are integrated appropriately, mangroves can contribute to risk reduction in almost every coastal setting, ranging from rural to urban and from natural to heavily degraded landscapes. Mangroves, and their coastal risk reduction function, can recover in most places where appropriate ecological and social conditions are present or restored.
Hutchinson et al. (2014)	NbS for fisheries enhancement (co-benefits of NbS)	Fish productivity from mangroves will be highest where mangrove productivity is high, where there is high freshwater input from rivers and rainfall and where mangroves are in good condition. Mangrove conservation and restoration in areas close to human populations will render the greatest return on investment with respect to enhancing fisheries.
Doswald et al. (2014)	EbA effectiveness	EbA measures have been used to address sea level rise, water scarcity, flooding and water quality, erosion, landslides and avalanches, soil quality, biomass cover and productivity, pests and diseases, loss of ecosystem goods and urban heat. The majority of EbA activities were deemed successful in the reviewed articles.
Shepard et al. (2011)	Protective role of coastal marshes	Salt marsh vegetation reduces wave power and stabilizes the shore.

CASE STUDY 2.9

Adaptation at altitude: nature-based solutions in mountain areas

Mountain regions are home to more than one billion people and healthy mountain ecosystems are fundamental to ensuring the provision of ecosystem services to upland communities as well as billions more living downstream. In particular, mountains provide 60%-80% of the world's freshwater for irrigation and domestic use, including for some global megacities.

As evidence from Intergovernmental Panel on Climate Change (IPCC) shows, mountains feature some of the clearest indications of climate change: rising temperatures, melting glaciers and changing precipitation patterns are disrupting water flows and affecting ecosystems, creating and worsening natural hazards and threatening livelihoods and communities, both within the mountains and downstream. Human settlements and related infrastructure in mountainous areas are highly exposed to natural hazards, such as debris flow and flooding. These hazards impact not only the area of occurrence but often also affect communities downstream. For example, earthquakes destabilize slopes and snowpacks, leading to landslides, mudflows and avalanches that in turn can block waterways and increase flood risks downstream.

NbS offer high potential for addressing these challenges. The scientific proof for NbS in mountain areas is vast and mounting. One study on the effects of forest cover in the eastern Alps (Sebald et al., 2019), covering 3,768 torrential hazard events in almost 11,000 watersheds over the last 31 years, provides clear evidence about the importance of forest cover. This large-scale analysis concluded that increasing forest cover to 88% from the average 63% decreased torrential hazard probability by almost 9%.

References (Hock et al., 2019; Sebald et al., 2019). See: Adaptation at Altitude www.adaptationataltitude.org



Knowledge gaps

There are still a few knowledge gaps that require further research.

- More small-scale NbS than large-scale NbS have been evaluated and thus there is a need to understand how to scale-up and have more evaluation frameworks for large-scale solutions, whether they be blue, green or hybrid approaches (Ruangpan et al. 2020).
- While tools and methodologies for planning and implementing NbS exist, there are still many challenges, especially because each case is context specific. Furthermore, ecological engineering is not as widespread and developed as traditional engineering, or at least not as commonly implemented, which also limits implementation.
- The limits of NbS, i.e. under what conditions do they fail, are less well known and require more research.
- Ecosystems behave in different ways depending on the location, requiring locally specific knowledge of ecosystem parameters (i.e. a mangrove in Jamaica may not have the same water and nutrient requirements as a mangrove in Indonesia). However grey infrastructure design and parameters are more likely to be similar, regardless of the location. This requires ecologists and engineers to work together to develop locally specific ecological engineering solutions. More systematic research should focus on developing ecological engineering performance standards that provide a similar basis for design decisions as grey infrastructure.

Enablers and barriers

- ✓ Policy, regulations and subsidies encouraging the use of NbS (see **case study 2.10**).
- ✓ Stakeholder consultation and participation are essential for local ownership and buy-in.
- ✓ Knowledge, including a strong science and evidence base and capacity on NbS.
- ✓ Multidisciplinary public-private partnerships enable moving beyond business-as-usual and aligning the realms of engineering, ecology and social sciences.
- ✓ Availability of standards for NbS.
- ✓ Inclusion of NbS in curricula & training for engineers and environmental scientists.
- ✓ Greater use and promotion of NbS for disaster control infrastructure.

- ✗ Limited knowledge and awareness among government agencies about the potential of NbS to contribute to diverse development goals, which limits the uptake of NbS.
- ✗ Data availability is an issue that needs to be addressed for implementing NbS projects. Alongside that institutional analytical capacity would need to be strengthened.
- ✗ Land requirement and ownership can be big issues in utilizing NbS. NbS often requires a lot of land, e.g. space for floodplains. Land ownership and opportunity costs can also cause difficulties, especially when most land is privately rather than state owned.
- ✗ Weak governance: unclear jurisdictions, competition between government agencies and lack of structures that foster cross-sectoral collaboration hinder the uptake of NbS. Furthermore, current administrative budgets often do not allocate enough to environment and/or disaster risk reduction.
- ✗ Lack of protocols by financing institutions to incentivize NbS and absence of protocols for participative tender design, or lack of commitment among corporates towards integration of NbS in their core business, presents a barrier to NbS.
- ✗ Ecosystems are very local specific. One NbS that may work well in one location and at a particular scale may not work well in another ecosystem and scale. Guidelines on NbS implementation need to be adapted locally to fit the context. This requires working in multi-disciplinary teams which include ecologists, engineers, planners and DRR specialists.

CASE STUDY 2.10

Swiss law on the protection of water resources

Swiss law on the protection of water resources was amended in 2011 to ensure rivers and lakes return to their natural state, where feasible. In order to do so, renaturation is necessary in many cases to restore their natural state, including characteristic fauna and flora.

https://www.bafu.admin.ch/bafu/fr/home/themes/eaux/dossiers/jalon-pose-matiere-protection-eaux/renaturation-des-cours-deau-et-des-lacs.html



Further information sources:

CASE STUDY COLLECTIONS

There also exist many compendia and online platforms of NbS case studies, which provide practical insights and lessons learned.

- Doswald, N. and Osti, M. (2011) Ecosystem-based approaches to adaptation and mitigation – good practice examples and lessons learned in Europe. BfN Skripten 306. https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript306.pdf
  This document analyses 101 mitigation and adaptation case studies spanning projects conducted in more than 17 European countries and outlines the lessons learned.
- Harari, N., Galvilano, A. and Linger, H.P. (2017). Where people and their land are safer. A compendium of good practices in disaster risk reduction. Berne & Lucerne, Switzerland: Centre for Development and Environment, University of Bern and Swiss NGO Disaster Risk Reduction Platform, with Bern Open Publishing. https://www.wocat.net/library/media/122/
  This document analyses 44 documented DRR practices from around the world, 30 of which are presented in some detail.
- Bridges, T. S., Bourne, E.M., King, J.K., Kuzmitski, H.K., Moynihan, E.B. and Suedel, B.C. (2018). Engineering with Nature: an atlas. ERDC/EL SR-18-8. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/27929 https://ewn.el.erdc.dren.mil/atlas.html
  Presents 56 projects to show the diversity of applications and benefits that can be achieved through Engineering with Nature.
- Kapos, V., Wicander, S., Salvaterra, T., Dawkins, K. and Hicks, C. (2019). The Role of the Natural Environment in Adaptation, background paper for the Global Commission on Adaptation. Rotterdam and Washington, D.C.: Global Commission on Adaptation https://gca.org/reports/the-role-of-the-natural-environment-in-adaptation/
  Gives details of 25 case studies as well as sectoral analysis and a good summary of the barriers and enablers of nature-based solutions.

- PIANC; Working with Nature: Collection of Waterborne Infrastructure Projects Acknowledged by PIANC https://www.pianc.org/uploads/files/EnviCom/WwN/WwN-Booklet.pdf
  Booklet describing nine projects submitted to the Working-with-Nature Database by project managers between 2012 and 2014 .

- Nature-based solutions compendium, UNEP https://www.unenvironment.org/sw/node/25257
  This online platform (also found in a pdf format) currently contains 96 initiatives and best practices on NbS which were submitted for the Climate Summit in 2019.

- PEDRR https://pedrr.org/
  The Partnership for Environment and Disaster Risk Reduction (PEDRR) is a global alliance of 27 UN agencies, NGOs and specialist institutes working together towards a mutual goal of promoting and scaling up the implementation of ecosystem-based disaster risk reduction (Eco-DRR). In 2019, PEDRR launched the Global Virtual Support Center, which is an EU-funded platform that aims to host more than 1,000 knowledge products on nature-based solutions, including scientific papers and case studies. Its goal is to be an online hub and the go-to place when looking for expertise in this topic.

- PANORAMA https://panorama.solutions/en/explorer
  PANORAMA – Solutions for a Healthy Planet is a partnership initiative that aims to share solutions across a range of conservation and sustainable development topics, enabling cross-sectoral learning and inspiration. This website currently contains more than 550 nature-based solution across five thematic areas.

- OPPLA https://oppla.eu/case-study-finder
  A knowledge platform composed of over 60 universities and with over 270 case studies, OPPLA is an open knowledge marketplace on natural capital, ecosystem services and nature-based solutions.

- Nature-based Solutions Initiative https://www.naturebasedsolutionsinitiative.org/
  This is an interdisciplinary programme of research, policy advice and education based at the University of Oxford. The multidisciplinary programme aims to increase awareness of the capacity of nature-based solutions to address global challenges.

- Nature4Climate https://nature4climate.org/
  Nature4Climate (N4C) is an initiative of the UN Development Programme (UNDP), the UN Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD), the UN Environment Programme (UNEP), the CBD, the IUCN, Conservation International (CI), The Nature Conservancy (TNC), Wildlife Conservation Society (WCS), Woods Hole Research Center, World Business Council for Sustainable Development (WBCSD), World Resources Institute (WRI) and WWF. The main goal of this initiative is to enhance investments on nature-based solutions through partnerships between governments, civil society, business and investors in support of the 2015 Paris climate agreement.

- UNEP EbA project pages https://www.unenvironment.org/explore-topics/climate-change/what-we-do/climate-adaptation/ecosystem-based-adaptation
  The map is a navigation tool that leads to descriptions, project factsheets and media & resources for 18 to 20 of UNEP's EbA projects (continuously updated).

GUIDES AND GUIDELINES

There exist many guides and guidelines on NbS (Eco-DRR & EbA). Here we mention the latest ones out in the field.

- Inter-American Development Bank (IDB) (2020). Increasing infrastructure resilience with nature-based solutions (NbS). A 12-step technical guidance document for project developers. IDB. https://publications.iadb.org/publications/english/document/Increasing-Infrastructure-Resilience-with-Nature-Based-Solutions-NbS.pdf

- IUCN (2020) A Global Standard for Nature-based Solutions https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs

- EcoShape (2020). Building With Nature - Creating, Implementing And Upscaling Nature - Based Solutions. Nai Publishers https://www.nai010.com/en/publicaties/building-with-nature/245844

- Mainstreaming Ecosystem-based Adaptation Knowledge Products: https://www.adaptationcommunity.net/download/20201308-EbA-Knowledge-Outputs_2.pdf

- Sudmeier-Rieux, K., Nehren, U., Sandholz, S, and Doswald, N. (2019). Disasters and Ecosystems, Resilience in a Changing Climate – Source Book. Geneva: UNEP and Cologne: TH Köln - University of Applied Sciences. https://postconflict.unep.ch/DRR/EcoDRR_Source_Book.pdf

- Secretariat of the Convention on Biological Diversity (2019). Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information. Technical Series No. 93. Montreal, 156 pages. https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf

- Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T. and Lange. G. (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. Washington, DC: World Bank and World Resources Institute. https://www.wri.org/research/integrating-green-and-gray-creating-next-generation-infrastructure

- Somarakis, G., Stagakis, S. and Chrysoulakis, N. (Eds.) (2019). ThinkNature Nature-Based Solutions Handbook. ThinkNature project funded by the EU Horizon 2020 research and innovation programme under grant agreement No. 730338. doi:10.26225/ jerv-w202 https://platform.think-nature.eu/system/files/thinknature_handbook_final_print_0.pdf

- UNEP-WCMC (2019) The EbA briefing note series https://www.unenvironment.org/gan/news/press-release/unep-wcmc-release-briefing-note-series-ecosystem-based-adaptation

- The World Bank, UNDP, the Global Facility for Disaster Reduction and Recovery (GFDRR), Ecoshape and Deltares (2017). Implementing nature-based flood protection. Principles and implementation guidance. https://documents1.worldbank.org/curated/en/739421509427698706/pdf/Implementing-nature-based-flood-protection-principles-and-implementation-guidance.pdf

03

IMPLEMENTING THE SENDAI FRAMEWORK WITH NATURE-BASED SOLUTIONS



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As we have seen in Chapter 2, ecosystems function as natural or blue-green infrastructure that offer solutions for reducing disaster and climate risks. Sustainable ecosystem management is thus an integral part of disaster risk reduction. In this chapter we will explore how nature-based solutions, in particular Eco-DRR, can support the implementation of the Sendai Framework.

3.1 Sendai Framework priorities for action and ecosystems

The Sendai Framework is the global policy guiding disaster risk reduction (DRR) and resilience-building efforts over the period 2015 to 2030. Its goal is to achieve substantial reductions of disaster risk and losses in lives, livelihoods and health, as well as in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

As stated in Chapter 1, the Sendai Framework recognizes and promotes the role of ecosystems and environment as a cross-cutting issue.

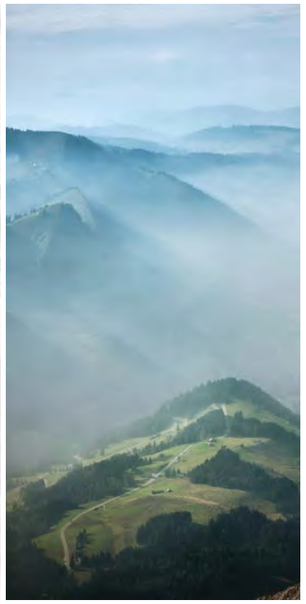
Ecosystems and the sustainable management of land and water resources are pertinent for achieving all four priorities of the Sendai Framework and need to be taken into account in **understanding disaster risk** (Priority for action 1), **disaster governance** (Priority for action 2) and **investing in disaster risk reduction for resilience** (Priority for action 3). While not explicitly mentioned in **enhancing disaster preparedness for effective response, and to "build back better" in recovery, rehabilitation and reconstruction** (Priority for action 4), using Eco-DRR/EbA will more effectively reduce future disaster risk. For instance, the Framework calls for the "incorporation of disaster risk management into post-disaster recovery and rehabilitation processes" and using recovery as an opportunity to reduce risk. Fully functioning ecosystems build local socio-economic resilience against disasters by sustaining livelihoods and providing important products to local populations in times of crisis (PEDRR, 2016).

The following section demonstrates how Eco-DRR/EbA can support achieving the four priorities for action of the Sendai Framework.





Priority 1
Understanding disaster risk





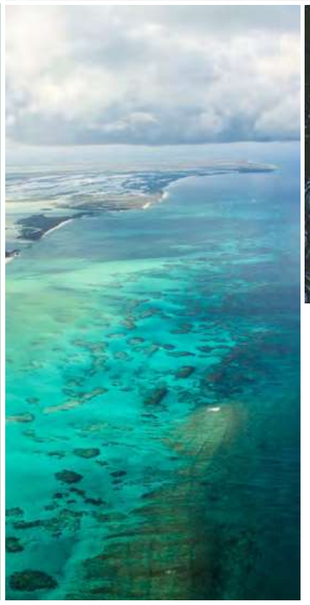
Priority 2
Strengthening disaster risk governance to manage disaster risk



ECOSYSTEMS AND DISASTERS

- Unsustainable land and natural resource management and use, as well as land degradation, are underlying drivers of risk
- Disasters cause environmental impacts
- The sustainable use and management of ecosystems builds resilience

(PEDRR, 2016)







Priority 3
Investing in disaster risk reduction for resilience





Priority 4
Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction

3.1.1 Priority 1 for action: Understanding disaster risk

Under Priority for action 1, "policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions". Paragraph 24 (clauses b and d) encourages the assessment of disaster risks and possible effects on ecosystems.

Risk comprises **hazard,** **exposure** and **vulnerability**, as illustrated in **Figure 3.1** (IPCC, 2014), and is manifested through its pluralistic nature and comes in many forms and sizes (GAR, 2019). These three risk components can be influenced by ecosystems (Munang et al., 2013; Renaud et al., 2013). Evidence shows that ecosystems can regulate and mitigate hazards, control exposure, and reduce vulnerability (Sudmeier-Rieux et al., 2006; Renaud et al., 2013).

Reducing exposure:

Mangrove ecosystems, for instance, regulate and mitigate the impact of coastal hazards such as storm surges, sea level rise, flooding, erosion and salt intrusion (Spalding et al., 2014).

Reducing vulnerability:

Additionally, mangroves provide a source of food, timber, pharmaceuticals and habitat for fisheries, which reduces the vulnerability of neighbouring communities (Hutchinson et al., 2014; Mukherjee et al., 2014).

Reducing hazards:

Degraded ecosystems may increase risk. Restoring ecosystems, through replanting trees and maintenance of habitats on slopes, for example, can reduce the risk of landslides after heavy rain (Peduzzi et al., 2013; Maes et al., 2014; Sebesvari et al., 2016; Walz et al., forthcoming).

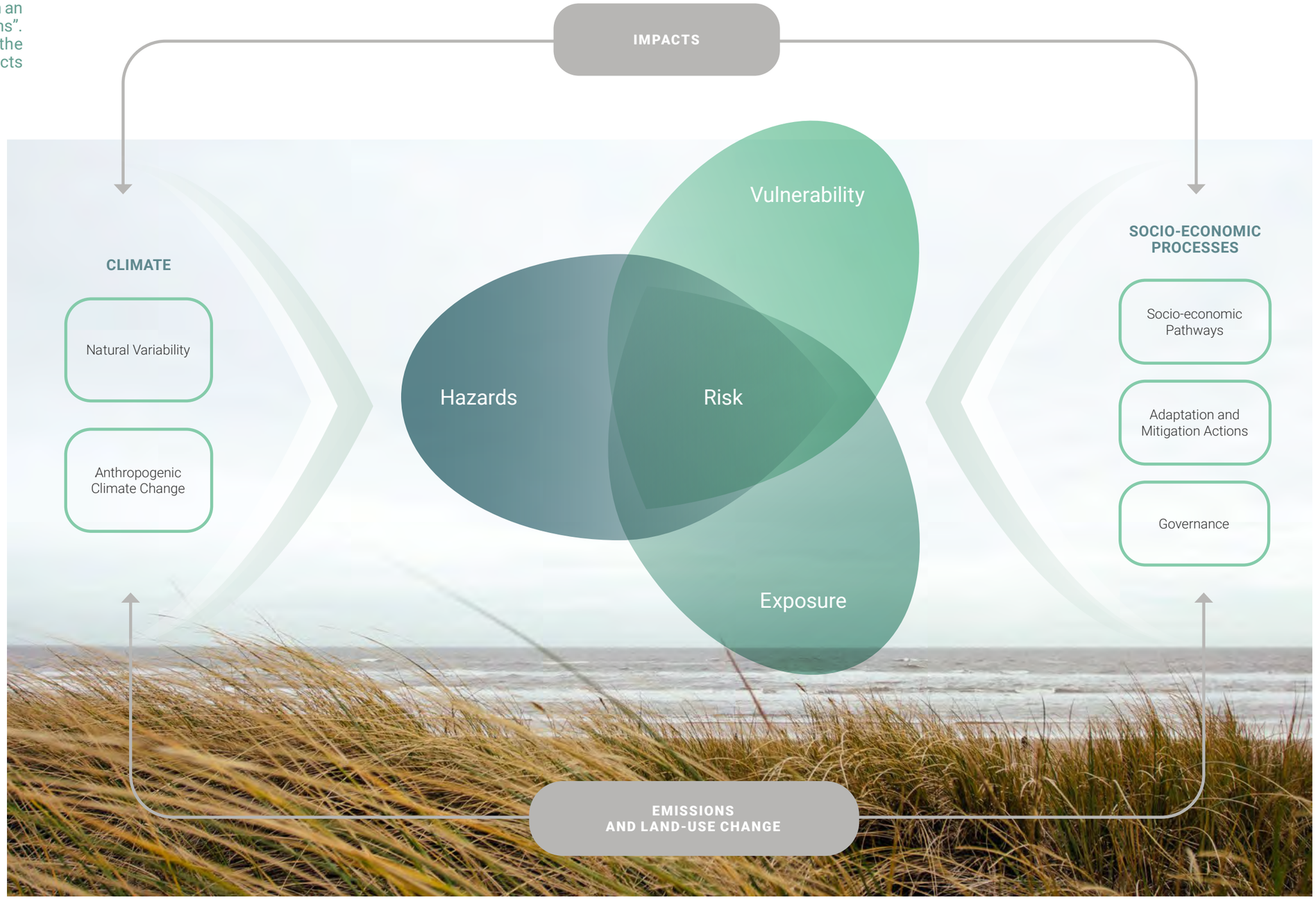


FIGURE 3.1

Risk framework. Source: IPCC AR5, 2014.

Environmentally informed risk assessments



Most risk assessments are conducted by those involved in DRR and do not usually include environmental considerations. Conversely, environmental assessments do not usually include risk assessments. Because of the role of ecosystems in altering risk, it is important to look at social-ecological systems (see section 2.1.2) and include information on ecosystems in terms of ecosystem susceptibility and robustness in risk assessments in a transdisciplinary manner (Sebesvari et al., 2016; Sudmeier-Rieux et al., 2019).

The scale of the assessment is an important factor to consider because local and regional dimensions and root causes of risk and vulnerability are better captured through landscape-scale assessments (PEDRR, 2016). Furthermore, it is important to include temporal scales in assessments, as hazard frequency and magnitude are likely to increase under climate change scenarios and impacts on ecosystems may take time to show. Including temporal scales allows for better understanding of risk as well as for strategic ecosystem management (Keith, 2015).

- For detailed instructions on how to conduct an ecosystems-based risk assessment, please see GIZ, EURAC & UNU-EHS (2018): Climate Risk Assessment for Ecosystem-based Adaptation – A guidebook for planners and practitioners. Bonn: GIZ, available at https://www.adaptationcommunity.net/wp-content/uploads/2018/06/giz-eurac-unu-2018-en-guidebook-climate-risk-asessment-eba.pdf

- Post-Disaster Needs Assessment Guidelines Volume B on Environment (guidelines to assess disaster damage to natural assets and environmental services) https://documents.worldbank.org/en/publication/documents-reports/documentdetail/773111493642626075/post-disaster-needs-assessment-guidelines-environment

CASE STUDY 3.1

Understanding and addressing risk in an urban context: water dialogues in Panama – Wetlands International

Panama's most vulnerable area is Panama City's densely populated subdistrict of Juan Diaz. This subdistrict is a low-lying area separated from the sea by a large strip of mangroves, officially protected by law as a Ramsar Site of International Importance. A large river runs through it alongside small streams and creeks. Most of them have been encroached upon and channeled into gutters and drainage systems that are poorly maintained and have become urban garbage dumps. Meanwhile, much of the floodplains, wetlands and surrounding mangroves have been landfilled up to a height of six metres. When heavy rains fall, these landfills divert the water to Juan Diaz where, in the period 1990-2013, 155 flooding events were recorded, and since 2008 flooding has further intensified. The situation is made worse by upstream urbanization, which has caused sedimentation of the river and streams and reduced rainwater infiltration. The result? Increased surface water runoff and a reduced drainage capacity.

Upon request by the municipality, a Dutch risk reduction team, supported by Wetlands International, organized a scoping mission in 2015 to further assess and understand the different drivers of risk and evaluate ways to address the flood problems in Panama City. A key recommendation from the mission to the municipality was to start multi-stakeholder water management dialogues. These so-called 'water dialogues' provide a platform to facilitate inter-sectoral learning, opportunities for cooperation between different stakeholders to initiate a new process of water management and help to optimize water governance. Community groups and representatives of the Juan Diaz neighbourhood, private developers, national and local authorities, universities and NGOs all participated in the dialogues. The main result of the dialogue process was an action plan, including grey and blue-green infrastructural works, such as dykes, walls and wetland reservoirs, to reduce the flood risk. To prevent inadequate and unplanned construction in flood risk zones, the action plan details various regulatory adjustments, including municipal agreements, legal tools and a risk zone map.

For more information: https://www.wetlands.org/casestudy/living-water-wetlands-flood-risk-reduction-panama-city/ and https://www.ramsar.org/

To perform the risk assessment, relevant local and regional ecosystems and their ecosystem services (see **Figure 2.3** in section 2.1.2) contributing to disaster risk reduction, either by reducing hazard, exposure or vulnerability, need to be identified. To be able to provide those services, ecosystems need to be in good condition, thus the assessment should also refer to the ecosystem's state. In a next step, indicators and respective data are needed to assess ecosystem service distribution and condition.

see Figure 2.3

Indicators and data

Once ecosystems and their services are identified by those undertaking a risk assessment as relevant for DRR/CCA, data and information on their distribution and condition become crucial to support risk assessments; however, sourcing data for an assessment is often challenging. Establishing a national database of environmental assessments, studies and monitoring systems would be helpful. It might be necessary to develop an operational monitoring system for environmental factors not currently monitored.

Important environmental and ecosystem factors to take into account in a risk assessment:

- Distribution of ecosystems (and services) are mostly retrieved from land use or land cover maps;
- Status of ecosystems (and services) are mostly assessed based on indicators, which are frequently retrieved from land use maps;
- The status of ecosystem service provision is often assessed referring to the quality of the ecosystem, such as its fragmentation, biodiversity status, degradation, net primary production and carbon stocks, etc;
- Further, higher level proxies include the distribution of conserved or protected areas, the availability of respective regulations or funds, the area of restored ecosystems, etc.

Satellite imagery, geographic information system (GIS) assessments and existing monitoring data may help to identify changes in land use, ecosystem functioning and/or water flows and their impacts. Further information may be collected from **Table 3.1**:

TABLE 3.1

Further sources of information on data and indicators for environmental risk assessments

Information	Source
National biodiversity strategies, including indicators submitted for the Convention on Biological Diversity	https://www.cbd.int/kb/record/recommendation/12968?RecordType=recommendation
Indicators submitted for the Sustainable Development Goals (e.g. indicators 14.2.1, 14.5.1, 15.1.1, 15.1.2, 15.2.1, 15.3.1 and 15.4.2).	https://unstats.un.org/sdgs/dataContacts/
Post-disaster needs assessments and baseline studies	https://reliefweb.int/updates?format=5&search=post-disaster#content https://www.recoveryplatform.org/pdna/key_documents_on_country_pdnas
World Atlas of Desertification	https://wad.jrc.ec.europa.eu/
FAO forest assessments	http://www.fao.org/forest-resources-assessment/en/
Freshwater ecosystem explorer	https://map.sdg661.app/

Indicators form the basis of risk assessments. In order to incorporate an ecosystem approach in such assessments, indicators should be included that relate to the state of the ecosystem, its distribution, soil properties, water systems, etc. A list of generally relevant indicators is provided in **Table 3.2**:

TABLE 3.2

List of generally relevant indicators to include ecosystems in risk assessments

Category	Indicator	Sources
Land use	Protected/restored areas (%) Digital observatory for protected areas	https://www.iucn.org/theme/protected-areas/our-work/world-database-protected-areas https://dopa.jrc.ec.europa.eu/en/mapsanddatasets
Land use change	Area affected by land use change (%) e.g. deforestation	http://www.oecd.org/env/indicators-modelling-outlooks/monitoring-land-cover-change.htm
Health of ecosystem	Ecosystem degradation (%) e.g. ecosystem fragmentation (%); soil erosion (%); changes in water quality and quantity	https://esdac.jrc.ec.europa.eu/content/global-soil-erosion https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=stelprdb1041925 https://wad.jrc.ec.europa.eu/geoportal
Ecosystem functioning	Increase of net primary production (NPP) or carbon sequestration or biomass or productivity / synthetic organic contaminants (SOC) / water quality (%)	https://modis.gsfc.nasa.gov/data/dataprod/mod17.php https://esdac.jrc.ec.europa.eu/content/global-soil-organic-carbon-estimates
Biodiversity	Species richness (number/area)	https://www.cbd.int/2010-target/framework/indicators.shtml http://www.eubon.eu http://www.biosos.eu
Dependency on ecosystem services	People depending on ecosystem services, such as raw materials, food, freshwater, tourism, etc. (%)	de Andrade et al., 2010
	Contribution of ecosystem-related sector to GDP (%) e.g. contribution of forestry/ fishery/ tourism to GDP (%)	Islam et al., 2014
Governance **(local/regional/national scale)**	Existence of integrated development plans for protection of ecosystem (yes/no) (local /regional / national) Government expenditure on environmental protection	Country-specific, check for instance https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans Check local / regional / national authority or office for statistics
Ecosystem protection	Ecosystem area protected by structural measures such as sea dykes, dams, sea defence etc. (km²) e.g. density of structural measures (km²)	Country-specific
Insurance	Ecosystem insured (%)	https://data.world/datasets/insurance https://www.unepfi.org/ecosystems/ecosystems/



Further indicators may be obtained from:

Mapping and Assessment of Ecosystems and their Services
https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm

Assessing the impact of nature-based solutions
https://op.europa.eu/en/publication-detail/-/publication/6da29d54-ad4e-11eb-9767-01aa75ed71a1/language-en/format-PDF/source-search



Environmental assessments

There are two formal types of environmental assessments, which in some countries are obligatory prior to implementing a project or public plans and programmes. These are: environmental impact assessments (EIA) for individual projects and strategic environmental assessments (SEA) for public plans and programmes (EC, 2020). Environmental assessments should cover hazards and related risk, targeting DRR in development planning (ProVention, 2007).

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

EIA, the process to assess the impacts of certain public and private projects on the environment, has the primary purpose to inform decision-makers, stakeholders and the general public of the environmental implications of a proposal as the basis for consultation and debate (Morrison-Saunders and Arts, 2004; Scottish Natural Heritage, 2018).

The information relating to a project's impact on the environment is gathered through a detailed EIA report, which contains the steps elaborated in **Table 3.3** below:

TABLE 3.3

Steps involved in an environmental impact assessment with related activities and exemplary application.

Steps	Description	Activities	Application
Information regarding the project	Provide an overview of: • the location, site, design, size, etc.; • the physical characteristics of project (including any demolition or land use requirements); • the characteristics of the operational phase of the project; • any residues, emissions, or waste expected during either the construction or the operational phase.	Collect information of the project	
The baseline scenario	Define the baseline scenario by providing: • a description of the current state of the environment in the EIA report; and • an outline of what is likely to happen to the environment should the project not be implemented, known as 'do-nothing' scenario.	Have experts collect and assess the following data (or use proxy indicators where data is difficult to find): • Physical: topography, geology, soil types and quality, surface, ground and coastal water quality, pollution levels, • meteorological conditions, climate trends, etc.; • Biological: ecosystems (both terrestrial and aquatic), specific flora and fauna, habitats, protected areas (Natura 2000 sites), agricultural land quality, etc. • Socio-economic: demography, infrastructure facilities, economic activities (e.g. fisheries), recreational users of the area, etc.; • Cultural: location and state of archaeological, historical, religious sites, etc. Write up a detailed and comprehensive baseline assessment to allow for an understanding of the extent of environmental impacts if the project goes ahead and in case of the ´donothing´ scenario.	
Environmental factors	Identify and assess the direct and indirect effects of the project on population and health, on biodiversity, on land, soil, water, air and climate, on climate change, on natural resources, on risk of major accidents, and on material assets, cultural heritage and landscapes.	Collect information regarding the effects of the project and integrate these considerations into the EIA. For the integration, consult guidance material provided in the useful links.	In Germany, the Environmental Impact Assessment Act (2001) envisages the description and assessment of a project on human beings, animals and plants; on soil, water, air, climate and landscape; and incorporates the assessment associated to natural hazards.

Effects on the environment	Impact analysis to identify, predict and evaluate the significance of the project´s effects and consequences for the environment.	Select clear criteria for the significance of the project effect on the environment, taking both the characteristics of an impact and the values associated with the environmental issues affected into account. Determine its significance, considering cumulative effects over spatial and temporal scales. Define significance thresholds and criteria for the assessment through a collaborative approach, involving all of the interested parties in the process of data collection and analysis. Prepare EIA/risk assessment report.	India's guidelines for EIA of river valley projects, for instance, require analysing impacts on forests and wildlife, on water logging potential, on upstream and downstream aquatic ecosystems and fisheries, as well as water-related diseases, climatic changes, risk and displacement.
Assessment of alternatives	Provide a description of the reasonable alternatives studied and an indication of the main reasons for selecting the chosen option with regards to environmental impacts.	Identify alternatives that can accomplish the objectives of the project and are feasible in terms of technical, economic, political and other relevant criteria. Assess alternatives by comparing the environmental effect of all alternatives. Consult both with partners and the public to identify and assess alternatives.	In Botswana's EIA guidelines, the section on "consideration of project alternatives" incorporates the following information: sources of water; waste disposal; housing sites; land use options after rehabilitation; alternatives to river diversions.
Mitigation and compensation measures	Based on identified adverse effects on the environment, envisage measures to avoid, prevent, reduce or, if not possible, offset these impacts.	Identify measures to avoid, prevent, reduce or offset adverse environmental effects of the project, promoting a long-term approach and giving priority to avoiding impacts (remediation and compensation should only be considered as a last resort).	In the case of a septage treatment facility project in the Philippines, based on an impact analysis showing adverse environmental impacts during the construction period, environmentally sound engineering and construction practices were used to prevent or minimize impacts.
Monitoring	Monitoring of adverse effects on the environment and/or measures taken to mitigate them to ensure the project construction and operation does not exceed projected impacts.	Define monitoring measures. Systematically monitor ex-post impact of adverse significant effects on the environment and hazard-related features to check if forecasted impacts are developing as predicted. If impacts should not correspond to the forecasted ones, take steps to rectify. Make monitoring results available to the competent authority and to the public.	The monitoring stage of EIA in the Philippines assesses performance of the proponent against the environmental compliance commitment (the certificate received upon project approval) to ensure actual impacts of the project are adequately prevented or mitigated.

(based on ProVention, 2007; OECD, 2010; Gupta and Nair, 2013; European Union, 2017)

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

SEA is defined as: "A systematic process for evaluating the environmental consequences of proposed policy, plan or programme initiatives in order to ensure they are fully included and appropriately addressed at the earliest stage of decision-making on a par with economic and social considerations" (European Commission, 2019a). The steps involved in SEA are similar to EIA, only that they evaluate a policy, plan or programme rather than a project.

The main functions of SEA in relation to DRR may include:

- assessing the vulnerability of different ecosystems, habitats, land uses and livelihoods to given types of natural disasters, and preparing spatial plans and maps to show vulnerability zones;
- helping to quantify the rates and magnitude of environmental changes that are taking place from various causes (i.e. human-induced or natural processes) and interpreting the effects of these changes on disaster risk;
- assessing how development goals may be threatened or optimized by particular types of disaster risk;
- mainstreaming specific disaster reduction measures in public-private partnerships prepared at international, national and regional levels;
- identifying ways of strengthening mitigation measures and improving disaster preparedness plans and early warning systems (OECD, 2010).



POST-CRISIS INTEGRATED STRATEGIC ENVIRONMENTAL ASSESSMENTS

Post-crisis integrated strategic environmental assessment (post-crisis integrated SEA) is an approach that emerged from the post-crisis settlement and development process of the northern province of Sri Lanka after 33 years of conflict. There was an urgent need to facilitate the process to 'build back better' and an opportunity to ensure environmental sustainability and reduce disaster and climate risks through an information-led, multi-stakeholder dialogue. The process was carried forward by UNEP in two additional countries (Nepal and Côte d'Ivoire). A guidance note for integrating disaster risk reduction and climate change adaptation in sustainable reconstruction and development planning was drafted to document lessons learned from the experiences and to outline key methodological principles for conducting integrated SEAs in post-crisis countries (UNEP, 2018).

The guidance note covers basic principles and reasons for conducting integrated SEA in post-crisis contexts, namely:

- Provides an initial screening tool of potential projects for fast-tracking decision-making;
- Guides resources in order to collect more relevant data for sustainable reconstruction and development;
- Gives an overview of key environmental and hazard-related issues;
- Directs attention to areas or projects requiring more detailed study and environmental impact assessments (EIAs) rather than conducting EIAs piecemeal;
- Leads to greater protection of valued environmental assets while safeguarding against potential hazards and climate change impacts;
- Creates ownership of the planning process in order to ensure longer-term sustainability of integrated SEA recommendations and outcomes;
- Provides a platform for inter-sectoral dialogue and builds trust to reduce potential conflicts over development projects;
- Turns the impetus of post-crisis situations into opportunities for more resilient and sustainable planning processes.

More information here: https://www.unenvironment.org/explore-topics/disasters-conflicts/what-we-do/risk-reduction/ecosystem-based-disaster-risk

ENVIRONMENTAL CONSIDERATIONS IN POST-DISASTER NEEDS ASSESSMENTS

Environmental assessments are also needed in post-disaster needs assessments (PDNA) to explore whether proposed relief, reconstruction and rehabilitation efforts will have acceptable environmental impacts and whether they will strengthen resilience to future natural hazards. Furthermore, they need to ensure that the response and recovery process addresses environmental problems caused by the disaster as well as by any response and recovery processes (ProVention, 2007). See chapter 3.1.4 for more details.





see chapter 3.1.4

OTHER TOOLS TO INTEGRATE ECOSYSTEMS INTO RISK ASSESSMENTS

The integrated valuation of environmental services and tradeoffs (InVEST), created by the international partnership Natural Capital Projects, is a suite of models used to assess and map ecosystems and their services. The habitat risk model and the urban flood risk mitigation model are useful in the DRR context, modeling ecosystem exposure to different types of hazard and how these changes affect the provision of ecosystem services (Bayani & Barthélemy, 2016; Doswald & Estrella, 2015; UNEP, 2016). InVEST scenarios thus help to assess tradeoffs of different management choices and to identify where investment in natural capital can enhance livelihoods (Bayani & Barthélemy, 2016). They offer decision-support tools for considering ecosystem-based solutions for DRR and CCA. The example of Haiti (**case study 3.2**) shows the application of InVEST to identify where and to what extend ecosystems can protect the community.

GUIDANCE AND LINKS RELATED TO THE TOOL

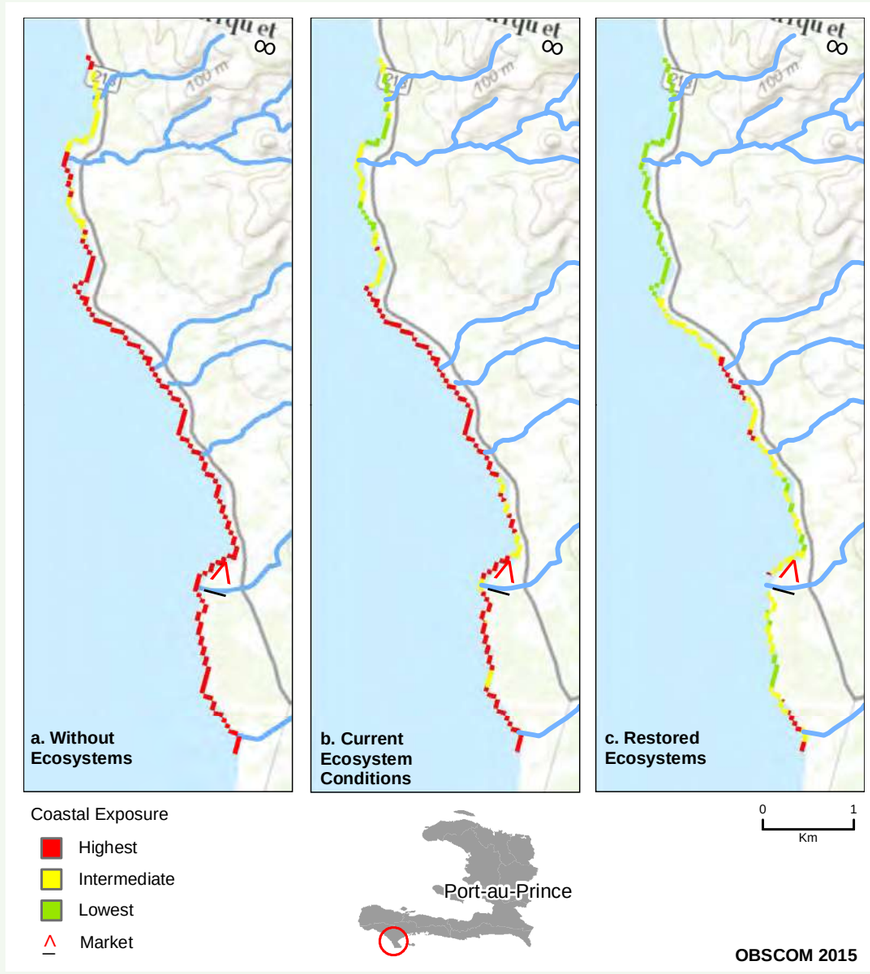
- InVEST user guide (English): http://releases.naturalcapitalproject.org/invest-userguide/latest/;
- Download InVEST 3.8.0 (Windows): http://releases.naturalcapitalproject.org/invest/3.8.0/InVEST_3.8.0_x86_Setup.exe
  Download InVEST 3.8.0 (Mac): http://releases.naturalcapitalproject.org/invest/3.8.0/InVEST-3.8.0-mac.zip
- Relevant models:
  Habitat risk assessment
  https://naturalcapitalproject.stanford.edu/software/invest-models/habitat-risk-assessment
  User guide
  http://releases.naturalcapitalproject.org/invest-userguide/latest/habitat_risk_assessment.html;
  Urban flood risk mitigation
  https://naturalcapitalproject.stanford.edu/software/invest-models/urban-flood-risk-mitigation

CASE STUDY 3.2

Application of InVEST in Port Salut, Haiti

To identify areas most exposed to storm surge and coastal flooding and determine the role of coastal ecosystems in protecting communities against these hazards, the InVEST coastal vulnerability model was applied in Port Salut, Haiti.

Coastal ecosystems are mapped via remote sensing to establish their current conditions. Exposure is modelled under different ecosystem management scenarios (ecosystem degradation / restoration). This results in maps showing the impact of ecosystems on exposure (see figure below), which supports decision-making (Bayani & Barthélemy, 2016).



Model of results of exposure under different ecosystem conditions. Source: UNEP, 2016.

UNEP's Eco-DRR opportunity mapping tool supports the visualization of areas where large numbers of people are at risk and could benefit from restoration or protection of ecosystems. The mapping tool overlays global data on ecosystem coverage with exposure to various hazards and a global dataset on population, thereby helping to identify areas at risk and the role of ecosystems. The tool includes a global dataset on protected areas to identify opportunities for using protected areas for DRR.

GUIDANCE AND LINKS RELATED TO THE TOOL

- **Eco-DRR opportunity mapping tool** technical report http://ecodrrmapping.unepgrid.ch/documents/94
- **Mapping tool dataset** https://pedrr.org/mapping-eco-drr-opportunities/

The capacity assessment and planning tool for disaster risk management (CADRI) is an approach to DRM capacity development that informs and facilitates the setup of a DRR framework. It includes a wide range of services and technical advice to optimize national systems for DRR. This tool, however, is not specific to NbS.

CADRI´s capacity assessment and planning tool covers 10 sectors, including the environment. Its checklist includes questions under different capacity requirements around:

- Environmental monitoring and assessment
- Raising awareness on environmental issues
- Training and education on environmental issues and DRR
- Research on environmental emergencies
- Multi-hazard assessments
- State of the environment baseline studies

GUIDANCE AND LINKS RELATED TO THE TOOL

- **CADRI tool**: http://cadri.net/en/cadri-tool

The ecosystem services shared-value assessment (ESSVA) produced by the International Lake Management Committee (ILEC), Japan, is a tool to assess community perceptions, preferences and attitudes towards ecosystem services. This can link ecosystem management with local/regional-level DRR planning. Communities living within an ecosystem evaluate their relationship with the ecosystem on current and future values. This questionnaire-based tool provides an ecosystem perception profile of populations at different locations under a single framework. A segmented and spatially nuanced understanding of ecosystem services, as enabled by the ESSVA tool, provides the basis for broadening stakeholder engagement in ecosystem management (see **case study 3.3**).

GUIDANCE AND LINKS RELATED TO THE TOOL

- https://south-asia.wetlands.org/news/ecosystem-services-shared-value-assessment-for-wetland-catchments/

CASE STUDY 3.3

ESSVA in India

Wetlands International South Asia used the ecosystem services shared-values assessment (ESSVA) tool in 2018 to engage with communities living around the upstream and downstream reaches of the Tampara wetland, a freshwater lake on the east coast of Odisha State, India, prone to floods, droughts, heatwaves and cyclones. The use of the tool has led to including the community in drafting the wetland strategy and resulted in a community-led management plan.

Some examples of how the ESSVA results are used:

- To develop stakeholder-differentiated messages for participation in wetland management.
- As a monitoring tool to assess changes in preferences for ecosystem services over a period of time.
- To address disaster threats through ecosystem services within DRR plans, e.g. to include:
  (i) Provisioning services and cultural services as resilient building measures;
  (ii) Regulating services as DRR mitigation measures.

Gaining a nuanced understanding through the use of tools such as ESSVA is crucial to engage communities systematically in management for wise use of wetlands to reduce disaster risks for enhanced resilience.

See for more information p. 26-28 of :
https://south-asia.wetlands.org/wp-content/uploads/sites/8/dlm_uploads/2019/02/Sarovar-Vol-4.pdf



To summarize, the following **Table 3.4** illustrates activities, outputs, required expertise, strengths and weaknesses of each tool presented above:

TABLE 3.4

Summary of available tools to support the integration of ecosystems in risk assessment with their respective activities, outputs, required expertise, strengths and weaknesses.

Option	InVEST	Opportunity mapping tool	ESSVA
Activities	• Map ecosystems through satellite imagery and identify areas most exposed to hazards. • Determine the role of ecosystems for DRR. • Develop scenarios, altering the conditions of ecosystems to model the role of ecosystems in exposure.	• Use mapping tool to overlay ecosystem coverage, exposure to hazards and population in the area of interest. • Identify risk and the role of ecosystems.	• Questionnaire to assess community perception, preferences and attitudes towards ecosystem services.
Output	Qualitative assessment of exposure to hazards, ranking ecosystem segments based on relative exposure.	Map of ecosystem distribution and of ecosystem opportunities to reduce risk.	Segmented and spatially nuanced perception profile.
Required expertise	GIS and remote sensing Statistics and modeling	GIS	/
Strengths	• Less data intensive software • Opensource toolset • Simple, visuals easy to interpret • Highlights tradeoffs of different decisions • Applicable at different scales	• Mapping tool with datasets • Highlights restoration and protection opportunities	• Communities understand and supports stakeholder engagement. • Identifies opportunities of linking ecosystem management and DRR planning.
Weaknesses	• Potential oversimplification • Modular setting for ecosystems does not allow for an overall assessment.	• No complete risk assessment nor feasibility analysis.	• Time consuming

Action plan template for incorporating Eco-DRR into national DRR strategies

The Words into Action on Developing National Disaster Risk Reduction Strategies (UNDRR, 2019) provides an action plan template to help countries plan their DRR priorities. **Table 3.5** provides an example of what outcomes, indicators and activities could be used to include Eco-DRR in such national action plans under **Priority for action 1 (understanding disaster risk)** of the Sendai Framework. The outcomes and indicators are to be decided at the national level as to what is most relevant. More explanation on the Eco-DRR template can be found in **Annex 1**.

TABLE 3.5

Filled in UNDRR template (2019) to exemplify how to include the environment in an action plan for achieving Priority for action 1.

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Increase awareness of the environmental drivers of risk of disasters and the impact of disasters on ecosystems *Contributes to SDG target 13.3 and indicators 13.3.1 and 13.3.2*			
RESULT/IMPACT INDICATOR	National policies/programmes/projects to reduce disaster and climate risks incorporate environmental management measures /ecosystem-based solutions			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
To evaluate the environmental drivers of risk and the impact of disasters on the environment	• Number of studies and assessments on environment and risk • Area of critical ecosystems lost due to disasters (and value)	• National risk assessment methodology incorporates ecosystem coverage/ health if available, environmental degradation, losses • Postdisaster needs assessment (PDNA) includes a chapter on environment • Map of environmental degradation and loss	• Conduct an environmental assessment or studies • Establish a database of sources of environmental data and monitoring • Mapping	• Previous environmental assessments and PDNAs • UNCCD and CBD focal points • Satellite imagery • National land cover maps • FAO forest and mangrove cover data • National environmental outlook reports

Recommendations for incorporating NbS in Sendai Framework Priority 1:

- Assess disaster risks at different spatial and temporal scales, collaborating when necessary at the transboundary level to assess risk at landscape scale
- Incorporate ecosystems in risk assessments, considering hazard mitigation and services provided by ecosystems
- Develop hazard, exposure, vulnerability and risk maps and operational monitoring systems
- Complement national-level risk assessments with community-level hazard, vulnerability and risk assessments, using a social-ecological approach
- Make use of information, indicators and tools to support the integration of ecosystems in risk assessments
- Develop environmental indicators for Priority 1 to support monitoring of the Sendai Framework implementation

(PEDRR, 2016)

USEFUL RESOURCES

- UNISDR (2017): Words into Action Guidelines on National Disaster Risk Assessment. https://www.undrr.org/publication/words-action-guidelines-national-disaster-risk-assessment
- Enhanced Vulnerability and Capacity Assessment: the Red Cross and Red Crescent Movement approach to assess risk and identify actions to reduce that risk https://www.ifrcvca.org/
- CBD voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information: provides material on principles, safeguards, tools, and a flexible framework for planning and implementing ecosystem-based approaches into risk assessments https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf
- MOOC (Massive Open Online Courses)Incorporating ecosystems in risk assessments https://www.youtube.com/watch?v=UQujLi591AM&list=PLH___LL2LODuduh-dhLSFKOhyJZtRnIc_&index=12
- Deltares' Risk Assessment of the North Coast of Java, Indonesia https://www.wetlands.org/download/18264/
- OECD Strategic Environmental Assessment and Disaster Risk Reduction: comprehensive overview of major SEA activities https://www.oecd.org/dac/environment-development/42201482.pdf
- Tools for Mainstreaming DRR – Environmental Assessment: elaborates on critical factors contributing to the successful mainstreaming of disaster risk reduction into development policy and practice https://www.preventionweb.net/publications/view/13226
- CDB (Caribbean development bank/CARICOM) – Sourcebook on the Integration of Natural Hazards into the Environmental Impact Assessment Process: provides guidelines for integrating hazards into EIA https://www.preventionweb.net/files/8263_Source20Book51.pdf
- ODI (Overseas Development Institute) – A how-to handbook for integrating disaster risk reduction, environment and climate change adaptation and mitigation in projects, programmes and investments: provides guidance to integrate DRR, environment and CCA into policies and programmes https://cdn.odi.org/media/documents/8930.pdf
- European Commission Guidance on Integrating Climate Change and Biodiversity into EIA: addresses the specific issues that climate change and biodiversity bring to EIA https://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf
- Republic of the Philippines – Environmental Impact Assessment: technical guidelines incorporating disaster risk reduction and climate change adaptation concerns in the Philippines http://eia.emb.gov.ph/wp-content/uploads/2020/08/DRR-CCA-EIA-Technical-Guidelines.pdf

3.1.2 Priority for action 2: Strengthening disaster risk governance to manage disaster risk

Priority for action 2 of the Sendai Framework, paragraph 27 b), states the importance of the development, adoption and implementation of strategies and plans aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of environmental resilience.

Ecosystems play an important role in disaster risk management (DRM) (PEDRR, 2010; Renaud et al., 2013; Sudmeier-Rieux et al., 2019). As mentioned in chapter 3.1.1., ecosystems can influence risk factors and thereby increase/reduce risk (Sudmeier-Rieux et al., 2019). It is, thus, important to recognize the potential of NbS for DRR and to strengthen environmental governance and natural resource management accordingly. Disaster risk governance plays an important role in the uptake of NbS for DRR (Furuta et al., 2016; Doswald & Estrella, 2015) and sets the basis for DRM.

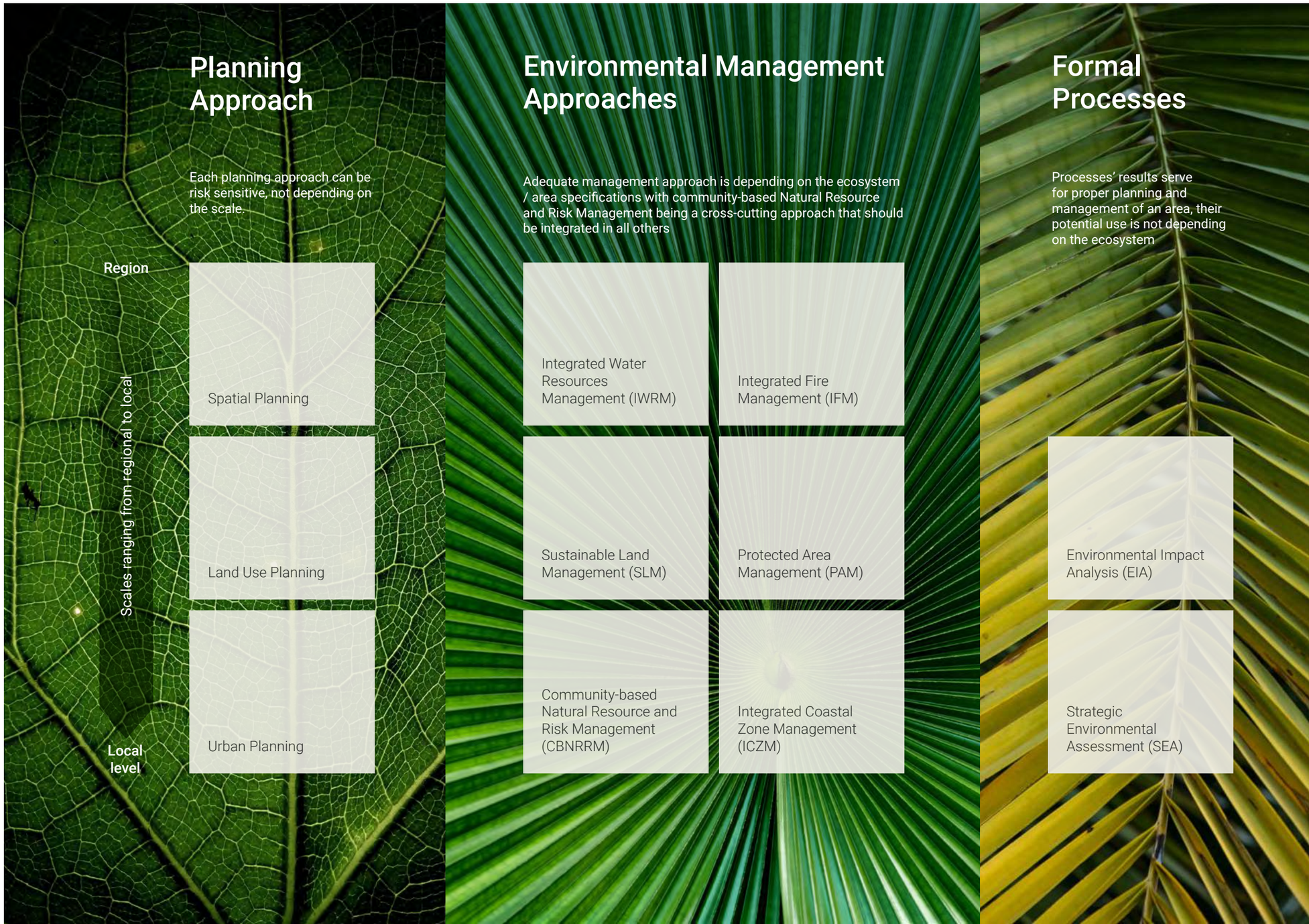
To ensure the uptake of NbS for DRR, participatory, multi-stakeholder processes and dialogues between different stakeholders are important to help facilitate mutual understanding of disaster risk, joint consideration of solutions and collaboration between all stakeholders in a specific landscape (also see **case study 3.1 on water dialogues**).

Strengthening disaster risk governance to include NbS for DRR can build on existing ecosystem management principles and instruments. A range of tools and instruments are available to integrate ecosystem-based approaches into DRR, including planning approaches, environmental management approaches and formal processes (see **Figure 3.2**).

see case study 3.1

FIGURE 3.2

Planning and management ecosystem-based approaches for disaster risk reduction (Sudmeier-Rieux et al., 2019).



Planning approaches

Among experts, planning approaches are recognized as the main way to integrate ecosystems into DRR strategies (see **Annex 2: Survey on NbS**).

Behind spatial planning is the idea of the landscape approach, which builds on an understanding of the relationship between landscape-scale drivers of disaster risk and community vulnerability and capacity (Kumar et al., 2016).

see Annex 2

The landscape approach is an interdisciplinary, cross-sectoral and holistic approach. For disaster risk reduction purposes, the approach facilitates an inclusive and participatory learning process for shared risk understanding and risk intervention scenario planning. An inclusive and participatory process allows for more innovative and integrated, and therefore more impactful, solutions to risk (e.g. ecosystem-based or hybrid measures and optimized initiatives on water governance as part of DRM strategies and investments). Applying the landscape approach helps to overcome barriers by sector and contributes to effective risk management by connecting all stakeholders involved, starting with the communities at risk in the landscape. It can help planning Eco-DRR (and/or EbA) interventions at local level and landscape scale.

- For an overview of the landscape approach for DRR, see https://www.wetlands.org/publications/landscape-approach-disaster-risk-reduction-7-steps/

Spatial planning refers to "the methods used […] to influence the future distribution of activities in space" (EC, 1997; EU, 2018). As high exposure to hazards mainly results from economic and demographic pressures on land use (Sudmeier-Rieux et al., 2013), land use planning presents an essential element to reduce disaster risk (Sutanta et al., 2010; Sudmeier-Rieux et al., 2019). It is recognized as one of the most effective strategies for reducing disaster risk (EMI, 2015). Risk-sensitive land use planning (RSLUP), encompassing comprehensive, coordinated planning at all scales, adds DRR objectives and parameters to the conventional approach of land use planning (World Bank and Earthquake and Megacities Initiative, 2014) and can include ecosystem management (Sudmeier-Rieux et al., 2013; Sudmeier-Rieux et al., 2019).

Such DRR considerations can also be mainstreamed into urban planning. This is crucial considering the level of urban risk due to rapid and unplanned urbanization, the vulnerabilities of cities, the challenges to environmental sustainability and weak public policies (Sudmeier-Rieux et al., 2013; JICA, 2018; Enoguanbhor et al., 2019). Risk-informed urban planning helps cities promote controlled and sustainable urban growth, reduce disaster risks and reduce vulnerable conditions of people and places (World Bank and EMI, 2014). This contributes to making them more resilient (see UNISDR Making Cities Resilient, 2019).

GOALS OF SPATIAL PLANNING IN THE CONTEXT OF DRR

- Organize land uses and the basis for subsequent urban planning or land use planning in rural/semi-rural areas (which is then more detailed);
- Promote sustainable development (social, environmental, economic);
- Develop access to information and knowledge;
- Enhance and protect natural resources and cultural heritage;
- Find a balance among multiple demands and competing interests;
- Reduce the impacts of hazard events by: restricting development in hazard-prone areas; accommodating and planning land use according to levels of risk; zoning and coding; designing infrastructures for hazard reduction.

Sudmeier-Rieux et al., 2019



The following urban risk indicators can support the process of risk-informed urban planning:

- UNDRR's Making Cities Resilient (MCR) Disaster Resilience Scorecard for Cities provides indicators on "safeguard natural buffers to enhance the protective functions offered by natural ecosystems" (Essential 5). https://www.unisdr.org/campaign/resilientcities/toolkit/article/disaster-resilience-scorecard-for-cities
- *Urban Disaster Risk Index* developed by Carreño (2006) assesses disaster risk taking into account a city's physical exposure and the socioeconomic fragility and coping capacities of the population and institutions. It helps identify risk-prone localities and their specific social, institutional, and organizational vulnerabilities (Dickson et al., 2012; Khazai et al., 2015).
- *Risk Management Index* assesses a city´s risk management performance and its effectiveness based on predefined qualitative targets (Khazai et al., 2015), which should also include ecosystem-based approaches (PEDRR, 2016).
- *Disaster Resilience Index* (DRI) serves as monitoring and evaluation tool for benchmarking and measuring progress (or lack of progress) on the mainstreaming of risk reduction approaches in a city's development policies and processes (Khazai et al., 2015).

In general, a spatial approach requires a broad assessment of current land uses as well as limitations and opportunities for development. This necessitates the collection and analysis of a substantial amount of information, including:

- biophysical information
- infrastructure, including critical green infrastructure
- population
- land use
- hazards and risks
- land ownership, land tenure
- legal context

With this information, a land use plan can be formulated following the process illustrated in **Figure 3.3**.

FIGURE 3.3

Integrating disaster risk considerations in the land use plan formulation process (ADB, 2016).

Land Use Plan Formulation Stages	Actions to integrate disaster risk considerations	Outcome
Situation Analysis	Identify hazards and environmental resources. Identify underlying factors contributing to vulnerability from hazards.	A situation analysis report presents an objective statement on how hazards will impact projected demands for land, housing, infrastructure, transportation, employment and waste management and what the key causal factors are (covering physical, social, economic conditions).
Visioning and Goal Setting	Raise awareness and initiate dialogue among stakeholders on the future performance of the city in the context of changing disaster risk. Formulate risk-informed goals and, where relevant, develop explicit land use goals aiming at reducing disaster risk.	Vision statement and goals informed by disaster risk considerations.
Land Development Scenario Analysis	Examine the implications (within geographical and time frames) of disaster risk on proposed land use scenarios. Highlight areas at risk and develop policy measures to ensure that all occupancy types can be safely undertaken.	Maps developed for various growth scenarios show development constraints posed by disaster risks.
Land Use Policy Formulation	Promote policy measures that support disaster-risk-sensitive growth by (i) protecting hazard-prone and environmentally sensitive areas; (ii) reducing disaster risk in development that has already encroached onto hazard-prone areas, and factoring in future alternative land use options; and (iii) promoting development in areas not prone to hazards, through regulations and incentives.	Land use policy statements factor in disaster risk considerations.

Spatial analysis through remote sensing is frequently used to provide information, in a geographic information systems (GIS) environment, for land use planning at different scales. In cities, for instance, remote sensing is used to inform land use planning and reduce the impact of urban growth on the environment or prevent sprawl into hazard-prone areas (Sudmeier-Rieux et al., 2019). Similarly, it can serve to identify environmentally sensitive areas to protect the environment, regulate development activities and promote sustainable land use planning (Leman, Ramli, & Khirotdin, 2016).

- For its inclusion of the environment, ecological and economic zoning (EEZ) presents a useful tool for NbS. EEZ is a form of land use planning that takes into account all elements of the physico-biotic environment on the one hand and the socio-economic environment on the other to match and provide the optimal use or non-use of land. It is a neutral tool which supports finding a consensus among different stakeholders and land users. The step-by-step zoning procedure is available at http://www.fao.org/3/w2962e/w2962e-06.htm

USEFUL RESOURCES

- UNDRR (2020): Words into Action guidelines: Implementation guide for land use and urban planning, https://www.preventionweb.net/go/67430
- FAO: Steps in land use planning http://www.fao.org/3/t0715e/t0715e04.htm
- Risk-Sensitive Planning Guidebook, jointly owned by World Bank and EMI: provides an overview of how to achieve risk sensitive planning https://www.geonode-gfdrrlab.org/documents/423/download

Environmental management approaches

At the heart of environmental management approaches lies the ecosystem approach, which is "a strategy for the integrated management of land, water and living resources" (Sudmeier-Rieux et al., 2006) that promotes the balance of conservation and use of biodiversity. Applying the ecosystem approach to DRR advocates for sustainable ecosystems management as a strategy to reduce exposure and vulnerability, while enhancing livelihood capacities and resilience. By conserving and enhancing ecosystem structure and functioning, the tools and instruments listed in **Figure 3.2** support maximizing ecosystem services for risk reduction (PEDRR, 2010).

Chapter 2.1 lists the main management approaches. Here, ICZM and IWRM will be further elaborated to exemplify the ecosystem approach in a DRR context. For a full discussion of ecosystem management instruments, please see PEDRR, 2010 and Renaud et al., 2013.

INTEGRATED COASTAL ZONE MANAGEMENT (ICZM)

Coastal zones are among the most productive areas in the world and often host a high concentration of people, economic assets and biodiversity (Renaud et al., 2013; EC, 2019). Under increasing coastal disaster risk (Duxbury and Dickinson, 2007; Renaud et al., 2013), it is important to maintain the environmental status and biodiversity of areas upon which the viability of coastal zones depend. **Case study 3.4** provides an example using ICZM.

ICZM provides a framework for the sustainable management and development of coastal zones and resources, which ensures the continued functions and services of the ecosystem (Renaud et al., 2013; Sudmeier-Rieux, 2013). ICZM is a process and instrument which allows addressing coastal risks in a holistic manner by using a multi-stakeholder and multi-sectoral approach (Schernewski, 2002; PEDRR, 2010). It aims for the coordinated application of policies affecting the coastal zone and its related activities, thereby ensuring its sustainable development (EC, 2019b). It is an effective way to strengthen coastal resilience and strongly encouraged by the Global Platform for Disaster Risk Reduction[14].

The main goals of ICZM, as identified by Thia-Eng (1993), are to:

- maintain functional integrity of coastal resource systems;
- reduce conflicts on resource use;
- maintain a healthy environment; and
- facilitate multi-sectoral development (Whelchel et al., 2018).

This is achieved using a range of instruments, such as ecosystem-based measures (sand dunes, coastal wetlands, coastal forests, coral reefs, etc.) and non-structural measures (regulatory frameworks, plans, economic instruments, awareness raising, etc.), making ICZM an integrated approach to addressing risk (Renaud et al., 2013).

ICZM covers the full cycle of information collection, planning, decision-making, management and monitoring of implementation (EC, 2019b), with proper considerations of spatial and temporal scales (Ruppercht Consult, 2006).

14 https://www.preventionweb.net/files/53439_thecancunhighlevelcommuniquof24may2.pdf

CASE STUDY 3.4

Water as Leverage: multi-stakeholder and holistic approaches to address coastal flooding in Semarang – Wetlands International

Like many coastal cities across Southeast Asia, Semarang (Java, Indonesia) faces an uncertain future. The city has experienced coastal flooding and will soon reach a tipping point: unsustainable water extraction is leading to aquifer depletion and land subsidence, increasing the city's vulnerability to flooding in lowland and upland areas (see **case study 2.4**).

As part of 'Water as Leverage for Asian Resilient Cities: Asia' (https://waterasleverage.org/), led by the Netherlands' Special Envoy for International Water Affairs, Henk Ovink, the two design teams of ONE Resilient Semarang design team, including Wetlands International, and Cascading Semarang brought their knowledge and expertise of other coastal regions worldwide together. In order to leverage existing and planned developments for coastal resilience and utilize the abundance of water, the teams embarked on developing innovative concepts to restore the city's coastal mangrove 'green belt' and other blue and green infrastructure (BGI) measures, such as 'spongy' mountain terraces, a Green Port and natural water reservoirs. These were developed through a series of local and regional workshops, where all stakeholders were involved from local communities to multilateral development banks.

In the next phase, 'Water as Leverage for Asian Resilient Cities: Asia' is developing the concepts into bankable projects for implementation in Semarang, as well as Chennai (India) and Khulna (Bangladesh).

For more information: https://www.wetlands.org/casestudy/future-proofing-cities-asia-water-leverage-resilient-cities/

see case study 2.4



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INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

As noted in Chapter 2, IWRM is a cross-disciplinary coordination and governance process to manage water, land and related resources to maximize economic and social welfare while ensuring ecosystem sustainability (Renaud et al., 2013; Sudmeier-Rieux, 2013). Mainstreaming Eco-DRR into IWRM is particularly relevant (Sebesvari et al., 2017), including the use of ecosystems to improve catchment and watershed management and their sustainable management (Renaud et al., 2013). Conserving and enhancing the natural characteristics of water-dependent ecosystems increases their ability to retain water. This in turn minimizes water-related risks, such as floods or droughts (Taramelli et al., 2019).

Making use of institutional frameworks for IWRM implementation (such as the UN Economic Commission for Europe´s (UNECE) 'model provision on transboundary flood management'[15]) is a quick way of operationalizing parts of DRR strategies (UNDRR, 2018). The case studies of the Lukaya Basin, Democratic Republic of the Congo (DRC) **(3.5)**, and Ecuador **(3.6)** illustrate how Eco-DRR can be applied in IWRM.

CASE STUDY 3.5

Applying Eco-DRR in IWRM in the Lukaya Basin, DRC – UNEP

In the Lukaya river basin of the Democratic Republic of Congo, UNEP worked with government and community partners to promote ecosystem-based measures, such as revegetation on degraded slopes, to mitigate hazards, namely gully erosion and floods, and address ecosystem degradation, which is a driver of disaster risk in the basin. It also ensured more diversified local livelihoods and augmented household incomes and established local risk monitoring systems. Central to the work was bringing different stakeholders together in a planning process (IWRM) which openly recognized the multiple and conflicting priorities for water and land use and to work towards a shared development vision for the Lukaya basin. This process generated an action plan implemented by the Association of the Users of the Lukaya River Basin. Women, as community leaders, farmers and income earners, demonstrated high interest and showed strong engagement throughout the project. Several women in local leadership positions played an influential role in Eco-DRR activities.





Revegetation on degraded slope before and after. Source: UNEP, 2016.

CASE STUDY 3.6

Ecuador's National Water Secretariat (SENAGUA) – IUCN

Water has been historically neglected in Ecuador. However, with increasing risk of flood and poor coverage and quality of water and sanitation services, Ecuador established in 2008, by executive decree, the National Water Secretariat (SENAGUA) – a regulatory body dedicated to water.

This decree provided fundamental elements to enable the integrated management of water resources, for instance, through decentralizing management with river basin management committees. The decree emphasized an ecosystem vision, promoting policies for watershed protection, focusing on the conservation of native forests and paramos, and the maintenance of water quality at the source. SENAGUA clearly supports the IWRM and ecosystem approach (IUCN, 2008).

USEFUL RESOURCES

- UNDRR (2019) Words into Action guidelines: Implementation guide for addressing water-related disasters and transboundary cooperation: https://www.undrr.org/publication/words-action-guidelines-implementation-guide-addressing-water-related-disasters-and

Environmental laws

Environmental laws can support planning and management of ecosystems for DRR. The case of Colombia, for instance, illustrates how the country enabled NbS for DRR through legislation (see **case study 3.7**).



15 More information available from https://digitallibrary.un.org/record/645887/

CASE STUDY 3.7

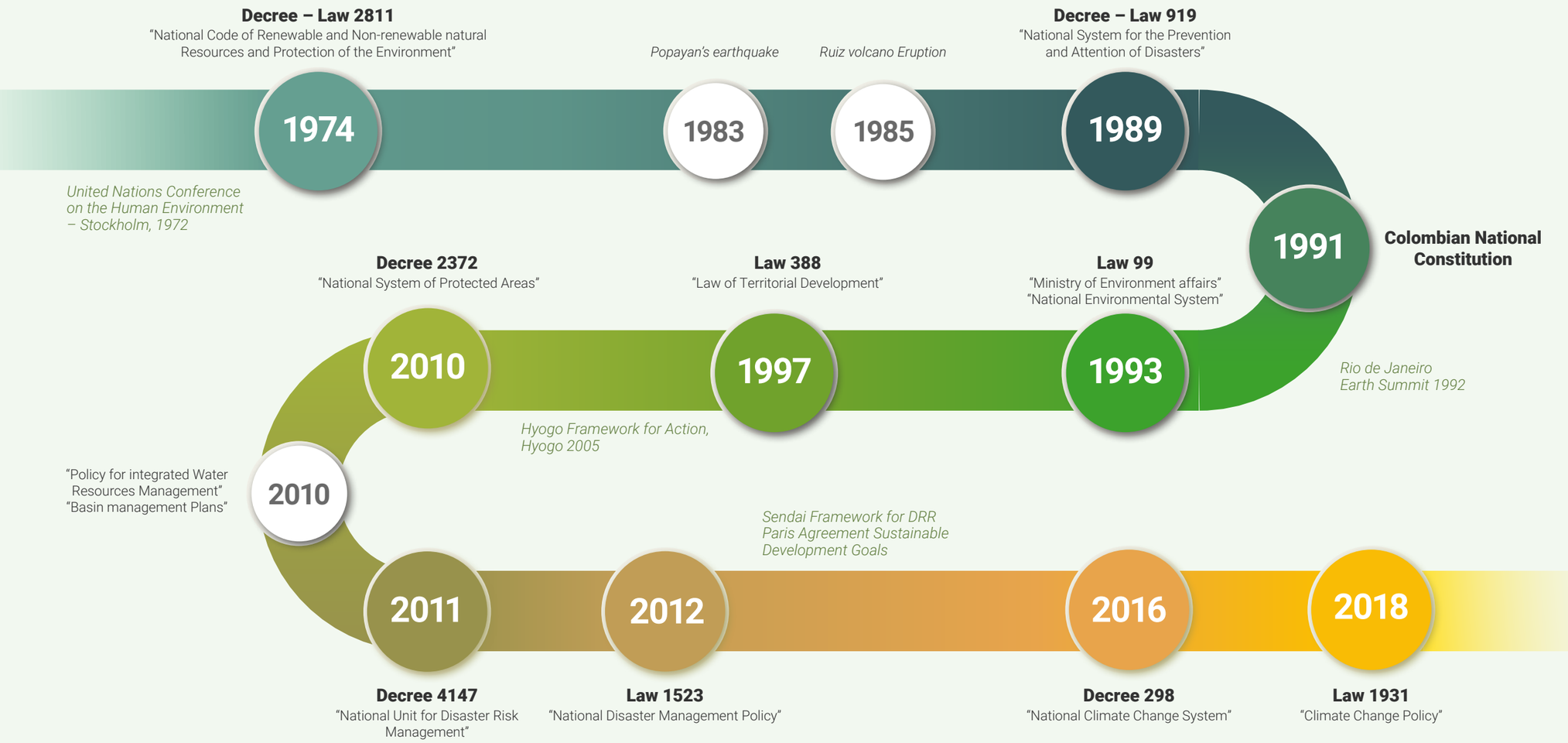
Colombia's environmental legal framework and DRR

The Colombian environmental legal framework has evolved over time (see **Figure 3.4**), strengthening disaster risk governance and highlighting legal instruments that, although not directly addressing NbS, support or enable their inclusion through diverse planning and management approaches.

A starting point was the establishment in 1974 of the National Code of Renewable and Non-renewable Natural Resources and Protection of the Environment through Decree–Law 2811. It defined the environment of Colombia as a shared heritage to preserve and manage, using planning and management instruments for its resources (Minambiente, 2014).

FIGURE 3.4

Colombia's environmental legal roadmap strengthening DRR and enabling NbS (Narvaez, 2020).



After two major natural disasters, the National System for the Prevention and Attention of Disasters (SNPAD), under Decree – Law 919 of 1989, highlighted the need for understanding the nature of hazards and assessing vulnerability and risk, providing the basis for sustainable land use planning (World Bank, 2012). In 1991, with the introduction of the Colombian National Constitution (also known as the "Ecological Constitution") (Macias, 2020), the country adopted the principles of sustainable development, further protecting the environment (Blackman et al., 2006; Sanchez-Triana, 2007). This was reinforced through the establishment of the Ministry of Environment (Minambiente) and the National Environmental System (SINA), under Law 99 in 1993, Decree 2372 on the National System of Protected Areas and the Policy for Integrated Water Resources Management (PNGIRH) in 2010. These ensure that ecosystems function and continue to provide essential services and that resources are managed in a way to reduce future risk.

With Decree 4147 of 2011, the National Unit for Disaster Risk Management (UNGRD) was established. This office will later become the Sendai focal point in Colombia. In 2012, Law 1523, known as the National Disaster Management Policy, was adopted and the National Disaster Management System was established as an update of the SNPAD. Outlining its principle of environmental sustainability, this key law states that "the risk of disaster derives from processes of unsustainable use and occupation of the territory, therefore the rational exploitation of natural resources and protection of the environment constitute irreducible characteristics of environmental sustainability and contribute to the management of disasters".

This is complemented by Law 1931 of 2018, known as the "Climate Change Policy", which declares "the aim of reducing the vulnerability of the population and the country's ecosystems to the effects of climate change and promoting the transition towards a competitive, sustainable economy and low-carbon development". In addition, it suggests synergies between DRR, CCA and ecosystems, stating that "integrated territorial climate change management plans should include the development of ecosystem-based adaptation actions for inland, coastal marine and island ecosystems".

Action plan template for incorporating Eco-DRR into national DRR strategies

The Words into Action on Developing National Disaster Risk Reduction Strategies (UNDRR, 2019) provides a template to help countries plan their DRR priorities. **Table 3.6** provides an example of what outcomes, indicators, and activities could be used to include NbS for DRR in such a national action plan under **Priority for action 2 (disaster risk governance**). The outcomes and indicators are to be decided at the national level as to what is most relevant. More explanation on the Eco-DRR template can be found in **Annex 1**.

TABLE 3.6

Filled in UNDRR template (2019) to exemplify how to include the environment in an action plan for achieving Priority for action 2.

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Environmental legislation is enacted to reverse / reduce environmental degradation and increase ecosystem restoration *Contributes to SDG target 14.5 and 15.3 and indicator 14.5.1* *Contributes to SDG targets 15.1 and 15.3 and indicators 15.1.1, 15.1.2 and 15.3.1*			
RESULT/IMPACT INDICATOR	Land degradation neutrality is achieved (see UNCCD) or disaster risk is reduced (Sendai indicators A-D)			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
To reduce risk of environmental degradation and loss through protection/ restoration of key areas	• Impact of land use and other policies on ecosystem services • Number of environmental assessments (SEA, EIA) registered • Area of protected/ restored ecosystem • Proportion of land that is degraded over total land area	• Strategic environmental assessments (SEA) • Environmental impact assessments (EIA) • Management plans for protected areas • Implementation of plans for ecosystem restoration	• Identify policies and plans that support or hinder the environment • Promote the use of SEAs and EIAs • Prioritize areas for protection and restoration • Conduct stakeholder workshops and awareness campaigns • Develop implementation plan for ecosystem restoration • Develop or ensure that protected areas have management plans	• UNEP-WCMC protected area database • National land cover maps • Satellite imagery • UNEP's opportunity mapping • National biodiversity action plans • UNCCD national action programmes

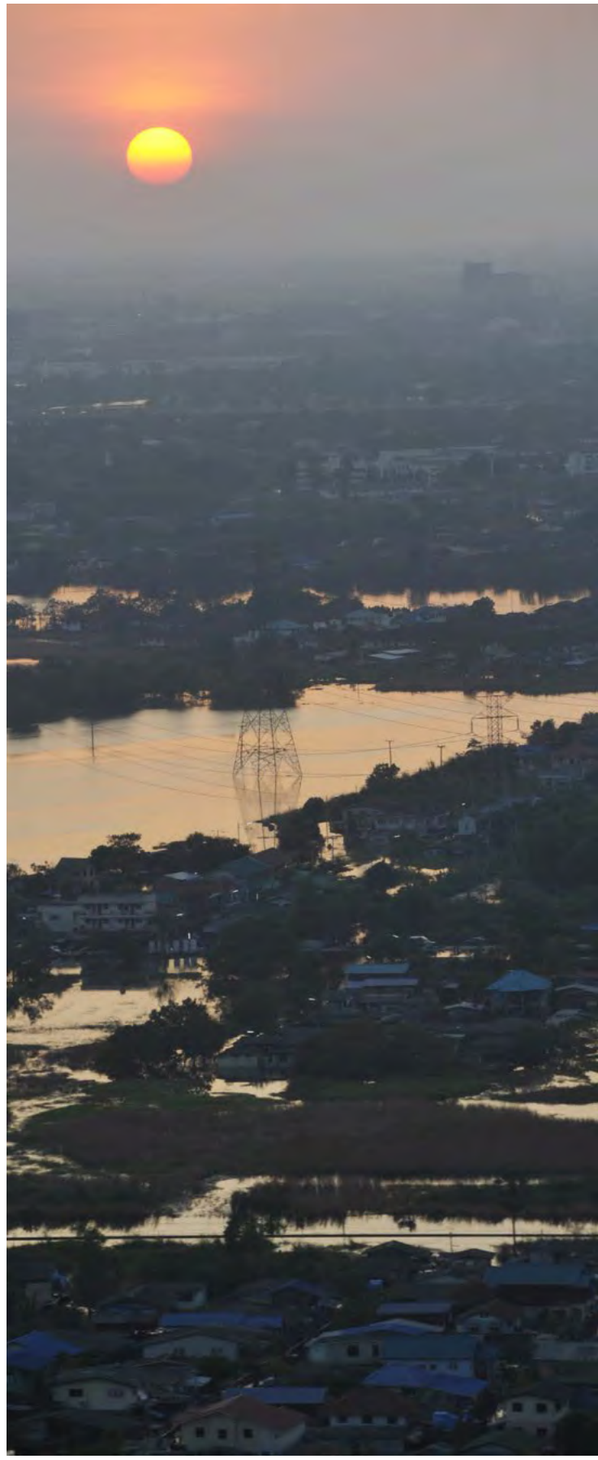
Recommendations for incorporating NbS in Sendai Framework Priority 2:

- Strengthen multi-stakeholder processes for planning and implementation of nature-based solutions for DRR/CCA
- Include ecosystem-based approaches in risk-informed, land use planning (as part of risk management strategies in rural and urban development plans and in sectoral development plans)
- Create an enabling public and private policy environment for using an ecosystem approach through
  - assessing existing national DRR policies, plans and non DRR-specific environmental, land use and development policies and plans for entry-points for NbS
  - include environmental, social and risk reduction safeguards in development policies and planning
  - include DRR/CCA lens in EIAs and SEAs
  - remove environmentally harmful subsidies

(PEDRR, 2016)

USEFUL RESOURCES

- Reid, H., Seddon, N., Barrow, E., Hicks, C., Hou-Jones, X., Kapos, V., Rizvi, A.R., Roe, D., Wicander, S. (2017). Ecosystem-based adaptation: question-based guidance for assessing effectiveness. International Institute for Environment and Development, London, United Kingdom: provides methods, tools and guidelines for assessing the effectiveness of ecosystem-based approaches https://pubs.iied.org/pdfs/17606IIED.pdf
- ADB (2016). Reducing disaster risk by managing urban land use: provides a guidelines on land use formulation https://www.adb.org/sites/default/files/publication/185415/disaster-risk-urban-land.pdf



3.1.3 Priority for action 3: Investing in disaster risk reduction for resilience

Sendai Framework Priority for action 3 calls for investing in DRR to achieve resilience. Resilience as defined by the Sendai Framework is "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions"[16].

Investment in DRR can drive innovation, growth and the creation of jobs. For example, as pointed out in the GAR 2013 and 2015, the rise of demand for green resilient urban development has driven the development of many innovative urban hybrid NbS, such as green roofs or sustainable drainage systems (UNDRR, 2013, 2015). These investments are cost effective since they can reduce energy costs, improve air quality, reduce flood risks, mitigate urban heat islands and contribute aesthetic and environmental values to urban areas (UNDRR, 2013). These greener areas also attract more income from rents and businesses (Burgmann, 2012). Investments in DRR need to come from both public and private fronts. Chapter 4.2 deals with the engagement of the private sector in investing in NbS for DRR.

Cost-benefit and/or cost-effectiveness analyses can be an important tool to help decide which activities to invest in. A cost-benefit analysis (CBA) is the process used to measure the benefits of a decision, or taking action, minus the costs associated with taking that action. Benefits and costs in CBA are expressed in monetary terms. The Economics of Ecosystems and Biodiversity (TEEB) series is one of the most comprehensive studies of ecosystem values and led greater awareness about ecosystem valuation (see **box 3.1**). A cost-effectiveness analysis (CEA) is an alternative to CBA and compares the relative costs to the outcomes. CEA is most often used when benefits or outcomes are difficult to monetize. Many environmental benefits and outcomes from implementing NbS, such as those related to aesthetic and cultural values, are difficult to monetize. Nevertheless, methods have been developed to value ecosystems in their entirety and cost-benefit analyses exist (see **section 2.1.2**).

Implementing NbS for resilience

Investment in DRR includes not only the allocation of funds, but to strengthen DRR measures in various settings. In terms of the environment, paragraph 30 g) of Priority for action 3 suggests promoting the mainstreaming of disaster risk assessment, mapping and management into rural development planning and management of, inter alia, mountains, rivers, coastal flood plain areas, drylands, wetlands and all other areas prone to droughts and flooding. Suggested actions include the identification of areas that are safe for human settlement and preserving ecosystem functions that help to reduce risks. Paragraph 30 n) suggests strengthening the sustainable use and management of ecosystems and implementing integrated environmental and natural resource management approaches that incorporate disaster risk reduction.

To strengthen the sustainable use and management of ecosystems, it is important to invest in NbS for DRR measures. Such measures can take many forms. Examples of specific interventions managing ecosystems for DRR as well as CCA are provided in Table 3.7.

see box 3.1

see section 2.1.2

BOX 3.1

Ecosystem Valuation

One often used framework for assessing cost-benefit involving ecosystem values is that of Total Economic Value (TEV), which typically splits the value of ecosystems into two categories: use values and non-use values.

Use Values

- Direct use: for resources that are directly used such as those coming from provisioning services
- Indirect use: for resources that are indirectly used such as those coming from regulating services
- Option value: for the potential future ability to use a resource even though it is not currently used

Non-use Values

- Bequest value: for the ability of future generations, ability to use a resource
- Existence value: for resources that will never be used by current individuals, derived from the value of satisfaction from preserving a natural environment or a historic environment

There are several different approaches for valuing these in monetary terms:

- Direct market valuation (e.g. market price-based approaches, cost-based approaches and approaches based on production functions) use data from actual markets, such as agricultural prices, costs that would be incurred if ecosystem service benefits needed to be recreated through artificial means, or through estimates of how much a given ecosystem service contributes to the delivery of another service or commodity which is traded on an existing markets.
- Indirect market valuation is based on the observation of individual choices in existing markets that are related to the ecosystem service being evaluated.
- Survey-based valuation asks people to state their preferences such as through asking how much people would be willing to pay for a certain ecosystem service.

Sources: Emerton, 1998; de Groot et al., 2010; Pascual et al., 2020.

16 Sendai framework, pg 9



TABLE 3.7

Non-exhaustive list of different NbS for disaster risk reduction and climate change adaptation categories with corresponding measures and interventions per ecosystem type.

ECOSYSTEM TYPE	NBS CATEGORY (see legend at bottom)	NBS MEASURE	SPECIFIC INTERVENTIONS
Coastal		Mangrove, salt marsh, wetland restoration	Nurseries
			Planting
			Protection zones
			Hydrology amelioration
		Restoration of reefs	Coral nurseries
			Coral transplant
			Artificial reef creation
		Managed realignment	Hydrology amelioration
			Replacing defense further away from coast
		Sustainable resource use/fisheries	No-take areas;
			Zoning
			Education / awareness raising
		Integrated coastal zone management	Use of a combination of approaches ideally in partnership with local communities
		Conservation	Creation and management of protected area(s)
		Alternative livelihoods	Ecotourism, honey production, etc.
		Sand management	Beach nourishment
			Dune rehabilitation
			Artificial dune construction
		Watershed management	Upstream management to protect water quality (see Forest/Agriculture/Slopes)

Forest		Reforestation	Nurseries
			Planting
		Alternative livelihoods	Use of manure instead of firewood, ecotourism, etc.
		Agroforestry	Intercropping
			Alley or strip cropping
			Shade systems
			Crop diversification
			Soil and water management
		Sustainable management	Zoning
			Use of a combination of approaches ideally in partnership with local communities
		Conservation	Creation and management of protected area(s)
River		Living weirs	Bamboo or log grids across river with biodegradable sacks containing elements for soil
			Planting and natural regeneration of stabilizing plants on the river bank whose roots will also colonize the bamboo/log grid.
		Watershed management	Use of a combination of approaches at the watershed scale through integrated water resource management, ideally in partnership with local communities
		Renaturation	Recreating natural river forms
			Planting vegetation
		Removal invasive species	Removal of species
		Conservation	Creation and management of protected area(s)
Wetland		Conservation	Creation and management of protected area(s)
		Restoration	Hydrological landscape shaping
			Planting
		Removal invasive species	Removal of species
		Sustainable resource management	Use of a combination of approaches, ideally in partnership with local communities

Agricultural		Agrobiodiversity	Seed banks
			Nurseries
			Mixed farming
			Intercropping
		Integrated nutrient management	For e.g. using nitrogen-fixing species
		Rainwater harvesting	Collect rainwater
		Community gardens	Creation of community gardens and biomanure
		Agroforestry	See Forests
		Ecological pest management	Use local species to manage pests (e.g. ducks in vineyards)
		Soil practices	Terracing
			Conservation tillage
			Indigenous practices
			Irrigation
		Sustainable agriculture/husbandry	Creation of protected zones
			Rotation
		Alternative livelihoods	Ecotourism, etc.
		Revegetation	Planting of areas on degraded land
Grassland/ pasture		Revegetation	Nurseries
			Planting and natural regeneration
		Conservation	Creation of protected zones
		Bush control	Fire management regimes
		Sustainable grazing management	Use of a combination of approaches, ideally in partnership with local communities
			Zoning
		Removal invasive species	Removal of species

Slopes (mountain, river banks, etc.)	Revegetation	Planting and natural regeneration
	Bio-engineering (e.g. brush mattressing)	Nurseries
		Planting of deep-rooted plants
	Conservation	Creation of protected zones
	Sustainable use of resources	Use of a combination of approaches, ideally in partnership with locals
		Zoning
Urban areas	Urban green areas	Tree planting
		Park creation and management
		Community gardens
		Green roofs and facades
	Urban wetlands	Pond creation
		River renaturation
	Sustainable drainage systems	Bioswales
		Permeable pavements
		Retention basins
	Urban nature reserves	Conservation and management
		Educational areas

- Green infrastructure
- Blue infrastructure
- Landscape restoration
- Wetland restoration
- Climate smart agriculture/ agroforestry
- Urban greening
- Sustainable land & integrated fire management
- Integrated water resource management
- Integrated coastal zone management
- Protected areas

Ecological engineering

Traditionally, practitioners employ engineering measures, such as dykes and levees, to protect people from threats. However, these grey infrastructure measures come with important costs and impacts on the environment (Renaud et al., 2013). BGI has emerged as a result and gained increasing attention as resilient infrastructures (see Chapter 2). BGI involves ecologically engineered structures or the application of ecosystem management approaches, including conservation, restoration and sustainable management of ecosystems. Some crossover exists between ecological engineering and ecosystem restoration.



Ecological engineering can be approached in different ways; by modifying built infrastructure through structural complexity, such as building with more eco-friendly material; by replacing built infrastructure with restored or created habitats; or by combining built infrastructure with restored or created habitats (Morris et al., 2019; Strain et al., 2019). The selected approach, depending on the ecological objectives and type of environment, contributes to building multi-functional infrastructure to the benefit of both humans and nature (Mitsch, 2012).

In general, ecosystems are built along a set of design principles:

(1) design consistent with ecological principles;

(2) design for site-specific context;

(3) maintain the independence of design functional requirements;

(4) design for efficiency in energy and information, and;

(5) acknowledge the values and purposes that motivate design (Bergen et al., 2001; Kangas, 2005).

'Building with nature' (see **case study 2.7**) can be applied to all hydraulic engineering settings (sandy coasts, muddy coasts, lowland lakes, rivers and estuaries, cities and ports (see **case study 3.8**).

see study 2.7

see study 3.8

see Chapter 2

CASE STUDY 3.8

Building with nature, Indonesia: reaching scale for coastal resilience – Wetlands International

In Demak, central Java, Indonesia, some 20 km of coastline have been inundated, affecting 3,000 villages. The problems largely result from the removal of mangrove belts for aquaculture development, unsustainable coastal infrastructure and sinking land caused by groundwater abstraction. The Indonesian government tried to rectify the situation by installing breakwaters and seawalls, but these blocked sediment input and were found to be too expensive and unable to adapt to climate change. Furthermore, they failed to bring back the economic, environmental and social benefits that healthy mangrove coastlines offer. Restoring the mangrove belt by planting mangroves also failed, since the trees could no longer thrive in the deeper waters. The initiative 'building with nature' (see **case study 2.7**), managed by Wetlands International, EcoShape and the Indonesian government, aimed to address these issues. The project included the construction of temporary permeable structures made of brushwood that capture sediment and reduce wave impact, thereby facilitating accretion of suspended sediments (see **case study 2.4**). Once the near-shore bed level has sufficiently risen, mangroves will regenerate naturally, developing a natural water defence protecting the hinterland against flooding and further erosion. While land subsidence has limited mangrove restoration in villages close to Semarang (see **case study 3.4**), the permeable structures have stopped erosion. Since 2015, the ministry of Marine Affairs and Fisheries, government partner in the project, has replicated this approach in up to 23.5 km of permeable structures throughout Indonesia.

see case study 2.7

see case study 2.4

see case study 3.4

To address the causes of mangrove loss, the project also put a mangrove aquaculture model into place that provides space for coastal and riverine mangrove restoration, requires less use of chemicals and boosts income and self-reliance of communities. After one year, the areas covered by the project, naturally filled up with sediments and showed natural recruitment of mangroves.

Through 'coastal field schools' (see Chapter 4) traditional farmers were trained with innovative best practices and more than tripled their shrimp yields and doubled their margins. The project also introduced the innovative mixed mangrove-aquaculture (MMA) system, in which part of the aquaculture pond is given up to make space for riverine mangroves. These areas are naturally filling up with sediments and show natural recruitment of mangroves, within one year.

Design, implementation and maintenance of technical and socio-economic measures are done by local communities as much as possible. Fishermen and women play a vital role. This was facilitated by the 'biorights' approach, an innovative financing mechanism created by Wetlands International, which enables local communities to invest in sustainable practices and be actively involved in environmental conservation and restoration. These measures are governed under community by-laws and funding mechanisms and are rooted in community development plans and integral government master planning for sustainable development. Local community groups also organized themselves in an ocean management forum, which allows networking with government officials and offers a mechanism to secure funding for the sustainability of interventions.

For more information: www.indonesia.buildingwithnature.nl;
Brochure: www.ecoshape.org/uploads/sites/2/2016/07/building-with-nature-in-indonesia-1.pdf

Conservation, restoration and sustainable management of ecosystems

As stated in Paragraph 30 n) of Priority for action 3 of the Sendai Framework, strengthening the sustainable use and management of ecosystems and implementing integrated environmental and natural resource management approaches that incorporate disaster risk reduction will be important. The main approaches used in different types of ecosystems to help reduce disaster risk will be conservation, restoration and sustainable management. This is because degraded ecosystems and loss of natural ecosystems is a large driver of disaster risk.

CONSERVATION

Ecosystems provide essential goods and services on which humanity depends. In a changing world, with pressures related to land uses, increasing population and climate change, it is essential to ensure the continued existence and delivery of ecosystem services (Mukherjee et al., 2014). The function of ecosystem conservation is to protect or restore the structure, function and species within an ecosystem. Similarly, when natural defences are in danger of degradation, conservation is essential to enhance their capacity to protect (Renaud et al., 2013). Conservation of ecosystems offers a cost-effective and scalable way to strengthen natural systems and with that the resilience of people (World Bank, 2019). Protected areas or conservation areas are the main legal tool for conserving ecosystems. Protected areas differ in how they are governed and managed. Most are state owned, but private individuals, trusts, communities and indigenous people also manage protected areas.

Guidance on conservation:

- A Handbook for Practitioners on Protected Areas and DRR https://www.iucn.org/content/protected-areas-tools-disaster-risk-reduction-a-handbook-practitioners

USEFUL RESOURCES AND TOOLS:

- IUCN Red List of Ecosystems: allows for assessments of ecosystem risk and losses of ecosystem functions and services to prioritize conservation and/or restoration areas https://www.iucn.org/theme/ecosystem-management/our-work/red-list-ecosystems
- Protected Planet World Protected Area Database: provides global spatial dataset on terrestrial and marine protected areas https://www.protectedplanet.net/
- The Green Buck: Using economic tools to deliver conservation goals – a WWF field guide: provides an introduction for the non-specialist to some of the approaches that economics can contribute to conservation. https://www.cbd.int/financial/doc/several-several-wwf.pdf
- Ecosystem management: lessons from around the world. A guide for development and conservation practitioners: presents the current state of knowledge about the management of a selected number of ecosystem types https://portals.iucn.org/library/sites/library/files/documents/2000-051.pdf
- The Nature Conservancy Natural Solution Toolkit: provides spatial decision tools and web apps to catalyze conservation https://coastalresilience.org/natural-solutions/toolkit/
- The International Blue Carbon Initiative: is a global programme focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems https://www.thebluecarboninitiative.org/

RESTORATION

Degraded environments are less able to provide ecosystem services and are more prone to creating hazards than healthy ecosystems (Peduzzi et al., 2013; Maes et al., 2014; Sebesvari et al., 2016; Walz et al., forthcoming; Sudmeier-Rieux et al., 2019). Ecosystem restoration (or rehabilitation) thus aims at assisting the recovery of an ecosystem that has been degraded, damaged or destroyed[17] to improve its ecological status and thereby ensure the provision of ecosystem services and reduce disaster risk (sees **case study 3.9**).

CASE STUDY 3.9

Restoration at river-basin level for resilience to floods

After the decline of the traditional mining industry in the area, the Emscher valley, Germany, a total length of 340 stream km of the Emscher and its tributaries are being restored (Gerner et al., 2018). The restoration process aimed to deal with the impacts of climate change by harnessing ecosystem services to offer buffers against floods and dry periods (Faivre et al., 2018). The first measures were to separate surface water from wastewater to restore the morphology and connectivity of the Emscher and its tributaries (Gerner et al., 2018). The images below compare a non-restored (left) and restored section (right) of the Emscher.

The project enhanced both the quality of life in the Ruhr metropolitan area and the resilience of the area to climate change impacts (Wuppertal Institut für Klima, Umwelt, Energie, 2013; Faivre et al., 2018).

Comparison of non-restored (left) and restored section (right) of the Emscher. Source: Gerner et al., 2018.



17 Society for Ecological Restoration International Science and Policy Working Group 2004.pg 3.

Ecosystem restoration entails a wide array of activities, including post-disaster clean-up and replanting or natural regeneration of forests or mangroves. Decisions at the field level require detailed knowledge of local environmental conditions (e.g. planting regimes, species choices, etc.) and competing community needs (UNEP, 2010).

Guidance on restoration:

- The Food and Agricultural Organization guidance and tools for forest and landscape restoration (FAO, 2020) http://www.fao.org/sustainable-forest-management/toolbox/modules/forest-and-landscape-restoration/basic-knowledge/en/)
- The Society for Ecological Restoration contains a wealth of resources https://www.ser-rrc.org/

Box 3.2 highlights principles for successful restoration, for the example, of mangroves.

USEFUL RESOURCES AND TOOLS:

- International Union for Conservation of Nature (IUCN) and the World Resources Institute (WRI): The Restoration Opportunities Assessment Methodology (ROAM): provides a framework to identify and analyse areas of restoration https://portals.iucn.org/library/node/44852
- UNEP´s Eco-DRR Mapping Tool: provides a visual tool to identify potential areas for ecosystem conservation and/or restoration as a means to reducing exposure to hazards for the highest number of people https://pedrr.org/mapping-eco-drr-opportunities/
- The International Blue Carbon Initiative is a global programme focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems https://www.thebluecarboninitiative.org/
- Wetlands International 'Mangrove restoration: To plant or not to plant': discusses natural mangrove regeneration versus mangrove planting https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/

BOX 3.2

Principles for successful mangrove restoration

The following two principles are of key importance in channelling mangrove restoration to those interventions that are most effective:

- *Ensure biophysical conditions are appropriate for mangrove recovery*: Mangroves may have been lost or degraded through conversion for other land uses, or as a result of changes in freshwater supply, loss of sediments or other causes. These in turn might be linked to local infrastructure developments and engineering works along coasts and rivers further away. Consequently, mangroves may no longer be able to thrive where they used to. Regeneration of a healthy mangrove forest can only happen if the enabling biophysical conditions for mangrove growth are put back in place. This can be hard – but very rewarding – work. In former aquaculture land, ground-levelling and restoration of hydrological flows are needed. Flows can be regenerated by strategically breaching pond bunds and restoring old creek systems. On rapidly eroding muddy coasts in Indonesia, Viet Nam and Suriname (see **case studies 2.2, 2.7, 3.4** and **3.8**), permeable structures are being applied to reduce wave impact, trap sediment and then allow natural mangrove recovery.
- *Ensure that socio-economic conditions allow mangrove recovery*: If mangroves have been removed by people, they could easily remove them again. The socio-economic root causes need to be addressed to prevent that. Where possible, economic activities need to be developed that bring sustainable benefits from the restored mangroves, thereby strengthening the business case for restoration. Land ownership and use rights need to be established, and there must be both a desire for recovery and a possibility for management. Successful projects empower communities, engage local government and ensure that local actions are strengthened by policies and planning.

Wetlands International 2016

Sustainable management of ecosystems

Ecosystems can serve many purposes, but different uses of ecosystems may be conflicting. To avoid such conflict, sustainable management of ecosystems strives to balance human needs with the long-term sustainability of ecosystems (Smith, Berry, & Harrison, 2016).

First, the case needs to be made for the sustainable management of ecosystems by generating knowledge on ecosystem services, their relation to human well-being and their economic value, as well as understanding of the drivers of change, such as land use change or over-exploitation. This allows defining ecosystem management strategies that maximize the delivery of ecosystem services. The aim is to improve ecosystem functioning and resilience by addressing the drivers of ecosystem change and ensuring equitable access to ecosystem services (UNEP, 2009). To this end, it is necessary to:

- determine which services have priority for the local communityy;
- develop effective intervention strategies; and
- ensure equitable access and use of ecosystem services by all stakeholders.

Once management measures are in place, the impact of intervention strategies must be monitored and evaluated so as to take steps for improvement if needed (UNEP, 2009). Ensuring the optimal delivery of ecosystem services involves:

- development and review of indicators of ecosystem service delivery; and
- review of the delivery of ecosystem services against established baselines.

Strategies for DRR often also combine the three approaches listed above (conservation, restoration and sustainable management) and overlap with ecological engineering. Regardless of the BGI approach, its design and implementation follows a process whose key steps are illustrated in **Figure 3.5**.

FIGURE 3.5

Seven key steps in designing and implementing green and blue infrastructure (BGI). Based on: EU, 2013; PEDRR, 2016; Andersson et al., 2019; European Union (EU), 2019; Ghofrani et al., 2017; Natural Hazards – Nature-based Solutions, 2017; Victoria State Government, 2017; Acclimatise Group Ltd and the InterAmerican Development Bank.

1 Define problem, project scope and objectives

Identify the direct area of interest and the main hazard(s) and risk(s).

- Identify stakeholders and beneficiaries; hold meetings to undertand their needs.
- Define problem scope and determine the project's physical intervention area.
- Define measurable project objectives.

2 Financing strategy

- Assess financial requirements for project implementation, recognizing different disbursement, performance, and risk timelines of NbS.
- Identify financing sources available to implement NbS.

3 Conduct ecosystem, hazard and risk assessment

- Assess the ecosystem, its services and risk reduction potential, and the main hazard types.
- Collect data for the risk assessment on hazard, exposure and vulnerability.

4 Develop NbS risk management strategies

- Identify possible NbS for DRR strategies.
- Consult and build on national/regional development plans and strategies, and policy documents relating to green infrastructure to identify synergies.
- Gather local level/ community maps with current ecosystem cover.
- Design risk management strategies with the community.
- Adjust and finalize funding strategy based on project costs for risk reduction strategies.
- Discuss risk reduction strategies and the role of ecosystems with stakeholders to understand preferences and select/ prioritize options.

5 Estimate costs, benefits and effectiveness

- Quantify the effect of measures on project objectives. A cost-benefit analysis supports assessing construction and maintenance costs of a measure against the range of (co-)benefits to select the most effective and most appropriate option.

6 Implement

- Implement project in consultation with stakeholders. Use adaptive management, closely tied to monitoring.

7 Monitor and evaluate

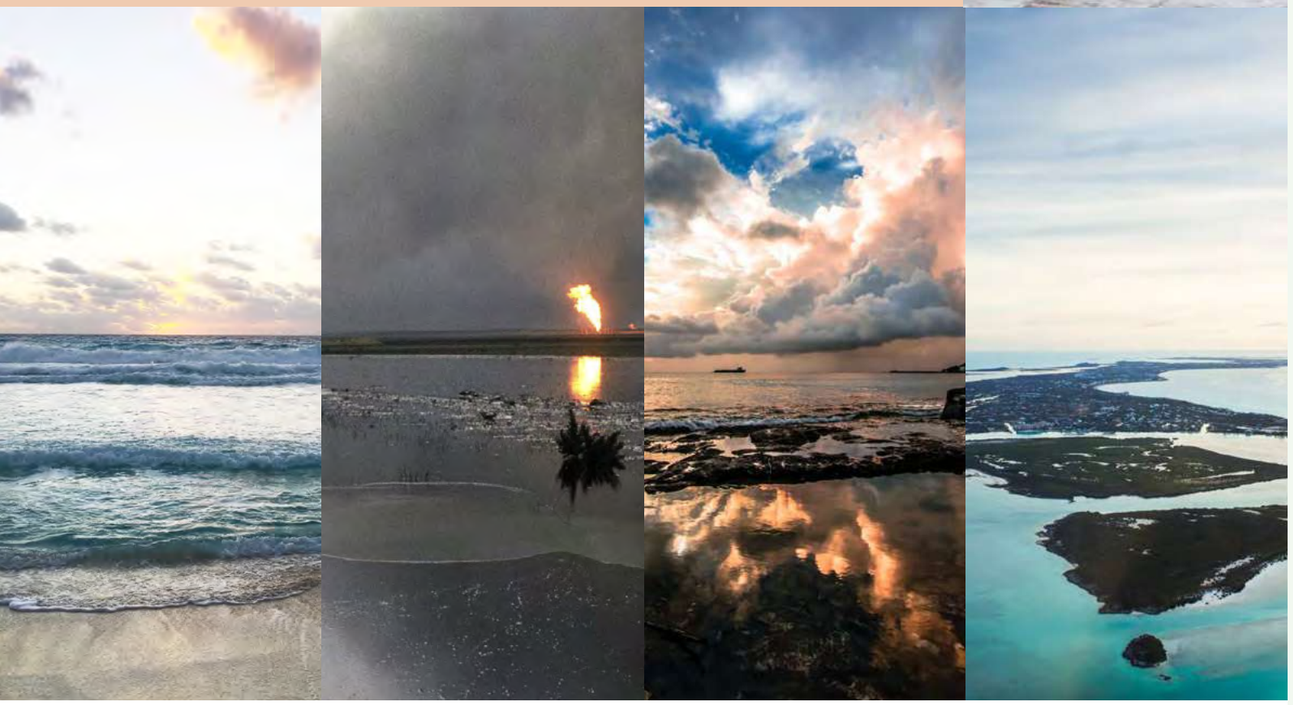
- Monitor the development of the ecosystem in the area of the implementation to assess the intervention's impact on the area and the ecosystem's effectiveness in reducing risk. Adjust implementation based on evaluation of effectiveness.

Case study 3.10 below highlights some of these concepts in practice.

Further guidance on principles and implementation of NbS and Eco-DRR:

- The Blue Guide to Coastal Resilience: https://www.natureprotects.org/
- U.S. National Oceanic and Atmospheric Administration (NOAA) for more detailed information and guidance on design and existing technical guidelines
- The U.S. Army Corps of Engineers (USACE) https://ewn.el.erdc.dren.mil/index.html
- Ecoshape https://www.ecoshape.org/en/
- ADPC (2020) Nature-based Solutions for site-specific landslides. https://www.adpc.net/Igo/category/ID1643/doc/2020-pULw5B-ADPC-Nature_based_Soltutions_for_Landslide_Risk_Management_ADPC.pdf
- IFRC NbS Knowledge Platform https://preparecenter.org/site/nbs/
- Guidebook for monitoring and evalution: https://www.adaptationcommunity.net/download/ME-Guidebook_EbA.pdf
- Handbook on assessing the impact of NbS https://op.europa.eu/en/publication-detail/-/publication/d7d496b5-ad4e-11eb-9767-01aa75ed71a1





CASE STUDY 3.10

Resilient Islands: Advancing climate adaptation through nature-based solutions in the Caribbean region – International Federation of Red Cross and Red Crescent Societies (IFRC)

Caribbean islands are increasingly affected by climate change impacts, with storms, floods, wind damage and sea level rise all predicted to worsen, threatening hospitals, power plants, freshwater sources, roads, houses and schools. Island communities must work together to prepare for disasters caused by natural hazards and minimize the impacts they will endure. Recognizing the role of key ecosystems, like coral reefs and mangroves, in helping to reduce these risks while enhancing sustainable economic development, The Nature Conservancy (TNC) and the Grenada Red Cross started a partnership in 2012 with the project 'At the Water's Edge'. Vulnerability and capacity assessments with an environmental focus were carried out with the community, along with some awareness activities regarding protection of the environment at household level and community disaster preparedness. Based on the assessment, a joint plan was created with selected nature-based solutions, such as mangrove planting and artificial reef building.

Then in 2017, the TNC and the IFRC jointly launched the resilient islands project – 'Integrating ecosystem and community-based approaches to enhance climate change adaptation in the Caribbean' – with the financial and technical support of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. The four-year initiative in the Dominican Republic, Grenada and Jamaica is supported by national Red Cross societies in each country. A resilient island decision-support tool was developed to help identify risk and areas where NbS could help mitigate such risks and integrate community and ecosystem-based adaptation into local, national and regional decision-making processes to reduce community vulnerability and boost adaptive capacity. Other activities were also undertaken for this purpose:

- Developing DRR & NbS resources for a planning process at community level;
- Awareness building at community level by identifying EbA ambassadors;
- Hosting trainings and public education activities, working together with community and local leaders to advance NbS within their communities or organizations;
- Applying community lead tools, particularly the "enhanced vulnerability and capacity assessment" (Red Cross methodology) to reduce risk and increase resilience at community level;
- Applying a community adaptation to nature check list to promote decision-making around disaster risk and climate action;
- Conducting environmental assessments to demonstrate the importance of natural resources and their ability to enhance food security, promote economic development and provide physical protection against flooding and other climate-related risks;
- Encouraging coalition building to connect stakeholders with knowledge platforms and explore financial opportunities to scale-up projects and integrate EbA into national and regional policy.

For more information https://coastalresilience.org/project/resilient-islands/

Action plan template for incorporating Eco-DRR into national DRR strategies

The Words into Action on Developing National Disaster Risk Reduction Strategies (UNDRR, 2019) provides an action plan template to help countries plan their DRR priorities. **Table 3.8** provides an example of what outcomes, indicators, and activities could be used to include NbS for DRR in such a national action plan under **Priority for action 3 (investing in DRR for resilience**). The outcomes and indicators are to be decided at the national level as to what is most relevant. More explanation on the Eco-DRR template can be found in **Annex 1.**

TABLE 3.8

Filled in UNDRR template (2019) to exemplify how to include the environment in an action plan for achieving Priority for action 3.

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Ecosystems and their services are enhanced for resilience and disaster risk reduction *Contributes to SDG target 14.2 and indicator 14.2.1* *Contributes to SDG targets 15.1 and 15.2 and indicators 15.1.1, 15.1.2 and 15.2.1*			
RESULT/IMPACT INDICATOR	Increased investments ($) in green/blue infrastructure (BGI)			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
Ecosystem-based disaster risk reduction (Eco-DRR) is implemented	• Investments ($) in Eco-DRR at national and local level Green and blue infrastructure is routinely embedded in projects	• Projects and programmes for Eco-DRR • Management and implementation plans for green and blue infrastructure	• Embed and mainstream Eco-DRR in national plans and programmes • Secure funding for Eco-DRR projects • Develop implementation and management plan for Eco-DRR/green and blue infrastructure.	• UNEP opportunity mapping • National and local plans, programmes and projects • IGOs and NGOs operating in country • UNFCCC national plans of action and nationally determined contributions • UNCCD national action programmes • CBD Biodiversity action plans

Recommendations for incorporating NbS in Sendai Framework in Priority 3:

- Budget for ecosystems to support investments in NbS, including for protecting, restoring and sustainably managing ecosystems with DRR functions
- Plan NbS interventions locally and at a landscape scale
- Develop national and local capacities for NbS

(PEDRR, 2016)

USEFUL RESOURCES AND TOOLS

- IIED, IUCN, UNEP-WCMC and GIZ EbA Tools Navigator: features information on more than 230 EbA tools, methodologies and guidance documents; from planning, assessments and implementation to monitoring and mainstreaming https://www.iied.org/tools-for-ecosystem-based-adaptation-new-navigator-now-available
- Browder, G., Ozmet, S., Rehberger Bescos, I., Gartner, T., Lange, G.-M. (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. World Bank and World Resources Institute, Washington D.C.: guides on how to integrate natural systems into infrastructure programmes https://www.wri.org/publication/integrating-green-gray
- EcoShape's Building with Nature Platform https://www.ecoshape.org/en/ and Building with Nature design guidelines https://www.ecoshape.org/en/concepts/ contain knowledge on 'building with nature' and guide users in choosing and implementing the best building with nature solution for their challenge.
- Deltares (2019). Building With Nature Guideline (BwN): provides steps for generating building with nature designs https://publicwiki.deltares.nl/display/BTG/Steps+and+phases
- The IUCN Resilience through Investing in Ecosystems project: documents linkages between biodiversity and disasters and establishes capacity development knowledge products https://www.iucn.org/theme/ecosystem-management/our-work/environment-and-disasters/relief-kit-project
- The Blue Guide to Coastal Resilience provides practical guidance on setting NbS in coastal areas: https://www.natureprotects.org/
- U.S. Army Corps of Engineers (2019). Engineering with Nature: provides guidance on alignment of natural and engineering processes for water resources infrastructure https://ewn.el.erdc.dren.mil/
- Gray, E., Ozment, S., Altamirano, JC., Feltran-Barbieri, R. and Morales, G. (2019). Green-Gray Assessment: How to assess the Costs and Benefits of Green Infrastructure for Water Supply Systems Working Paper. World Resources Institute: provides a method to value the costs and benefits of integrating green or natural infrastructure into water supply systems www.wri.org/publication/green-gray-assessment
- The Mersey Forest Green Infrastructure Valuation toolkit: provides an open-source toolkit to value GI https://www.merseyforest.org.uk/services/gi-val/

3.1.4 Priority for action 4: Enhancing disaster preparedness for effective response and to 'build back better' in recovery, rehabilitation and reconstruction

Properly dealing with a disaster involves several stages, all of which can feature ecosystem-based considerations as illustrated in **Figure 3.6** and **Table 3.9**. For an effective response, disaster preparedness needs to be enhanced prior to the disaster and recovery; rehabilitation and reconstruction are required after a disaster.

FIGURE 3.6

DRR spiral – modified from Tony Lloyd-Jones (editor), Max Lock Centre, University of Westminster (2009). Redrawing by: S. Plog

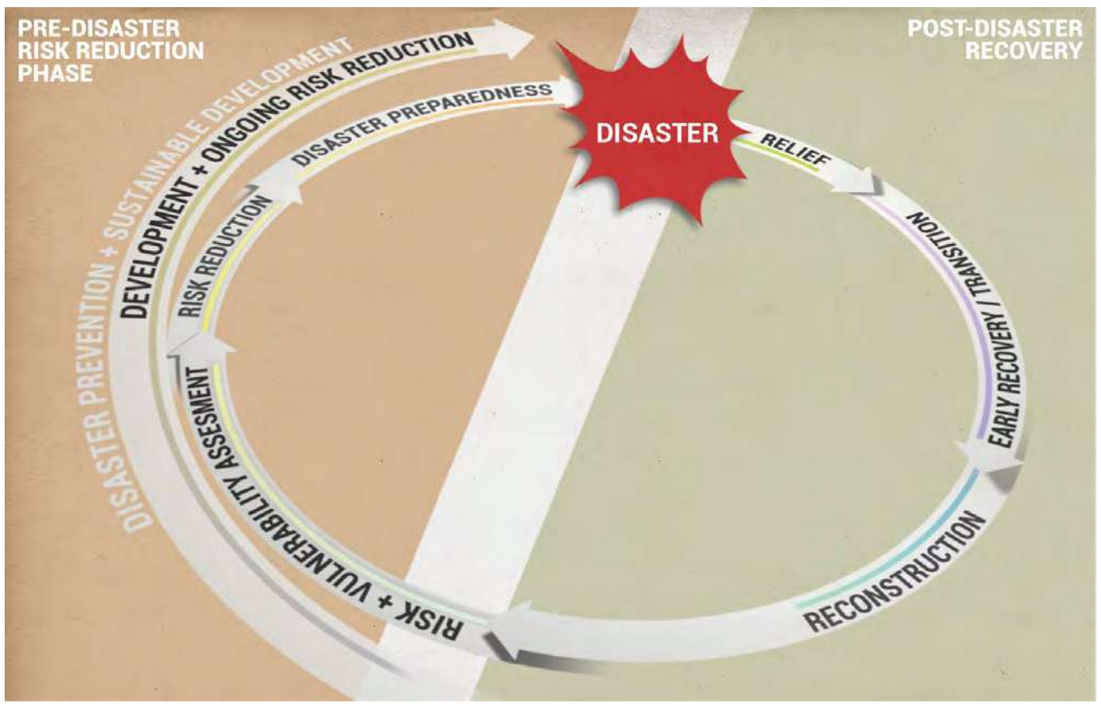


TABLE 3.9

NbS for different phases of DRR. Modified from UNEP & CUAS (Cologne University of Applied Sciences), 2015

Phase		Time frame after hazard event	Objectives	Main actions	Ecosystem services privileged	Ecosystem-management component
Response		Hours to days after	Save lives	Search & rescue, emergency skills	Provisioning services	Avoiding dumping of hazardous materials in environmentally sensitive areas or habitats; possible use of provisioning services from ecosystems (food, wood, shelter, etc.)
Rehabilitation / Recovery		Days to months after	Secure livelihoods	Temporary shelters, provision of basic services, e.g. water, food	Provisioning, regulatory services	Rapid environmental assessments, sourcing of sustainable materials for recovery, waste management
Reconstruction		Months to years after	Reconstruct livelihoods	Reconstruction/ provision of housing and infrastructure, job creation	Provisioning, regulatory, supporting and cultural services	Environmentally sensitive reconstruction, sustainable materials sourcing, improved waste management, ecosystem restoration, green infrastructure and improved ecosystem management for DRR
Prevention	**a) Risk and vulnerability assessments**	Continuously updated	Analyses and assess risk	Hazard and exposure mapping, vulnerability assessments, risk	Regulatory and provisioning services	Integrating ecosystems in risk assessments (see Priority for action 1)
	b) Development planning and risk reduction	Continuous process, on regular intervals	Hazard, vulnerability and exposure reduction	Risk-sensitive land use planning, based on assessments	Provisioning, regulatory, supporting and cultural services	Ecosystem and land management plans, ecosystem protection and restoration included in planning and zoning (see Priority for action 3)
	c) Preparedness	Continuously updated	Increase readiness for future hazard events	Creation and maintenance of early warning systems, evacuation plans	Regulatory and provisioning services	Including ecosystems in environmental emergency preparedness programmes

CASE STUDY 3.11

Bio-indicators in Bolivia

Local communities in Omasuyo province in Bolivia traditionally use local bio-indicators as a kind of local agro-meteorological service to predict extreme weather events. Observing blossoms or stem colours, for instance, has produced reliable guidance on harvest and rainfall over centuries for mitigating the impact of extreme climate events on crops.

FAO (2011), Loma et al. (2017).



Preparedness mainly deals with increasing readiness through early warning and evacuation plans. Nature has traditionally been used as an early warning (see for instance **case study 3.11**). It can also offer shelter (e.g. hills for safety during floods). It is important to ensure ecosystems feature in emergency preparedness programmes. Preparedness for a greener response is key to doing 'no harm' and the inclusion of environmental considerations in preparedness strengthens capacity to anticipate negative long-term impacts. This involves working on greener procurement, mapping environmental hazards, training staff on environmental sustainability standards developed by Sphere, an international humanitarian group, understanding compliance with environmental regulations, and developing coordination mechanisms with environmental organizations. Additionally, it requires developing environmental contingency plans and having rapid environmental assessment plans for the early recovery phase. Screening disaster response, recovery and reconstruction plans against resilience criteria and sustainability safeguards can be a useful tool (PEDRR, 2016).

Post disaster: While the initial focus will be on quick relief for saving lives, it will be important to avoid dumping material in environmentally sensitive areas. Emergency response can indeed have many different impacts on the environment and ecosystems (International Federation of Red Cross and Red Crescent Societies, 2018); there can be a great deal of over-exploitation (e.g. of timber) and habitat destruction (e.g. clear-felling forests for shelters) during rescue and relief (Miththapala, 2008).

While conducting post-disaster needs assessments and/or rapid assessments to assess the level and magnitude of disaster damage and losses, it is important to ascertain the damage and losses to the environment sector and establish relief and recovery needs that guide the restoration of the environment and natural resources damaged due to a disaster. This also enables environmentally friendly reconstruction in all sectors, while informing recovery plans that support the restoration of the environment and natural resources (PDNA Post-disaster needs assessment, guideline B). Environmental impacts of specific disasters have been documented and should be used to frame response and recovery plans, starting with critical services (UNEP 2008).

During rehabilitation, recovery and reconstruction, basic environmental concerns must be integrated into each stage, also known as 'green recovery' (Mainka and McNeely, 2011), while planning with the goal of "reducing the underlying risk factors" in mind (Sudmeier-Rieux et al., 2013).

It is thus important to consider several aspects in the response phase (see **Box 3.3** below) and to run environmental screening and impact assessments of planned activities to identify environmental risks and provide recommendations for subsequent action. This should be a collaborative process with affected communities, external partners and environmental actors wherever possible in order to enhance project quality and improve the accountability of humanitarian programming (EHA Connect, 2020).

Disaster recovery also provides an opportunity to take stock of how NbS can help a community to "bounce forwards" and bring about more long-term positive changes contributing to enhanced resilience rather than re-creating what was there before (Mabon, 2019). These changes support recovering both people's livelihoods and ecosystems while decreasing vulnerability to future disasters. 'Building back better' is a recognized strategy using the opportunity to begin reconstructing sustainable livelihoods based on healthy ecosystems (UNDP, 2011; Mainka and McNeely, 2011).

Taking the example of coastal forests and the devastating effects of a tsunami, the long-term recovery phase provides the opportunity to regrow healthy forests and coastal ecosystems to provide enhanced community benefits while being more resilient to future disasters. This includes replanting or assisted regeneration with low-maintenance, low-risk and long-lived species; preparing and maintaining baseline inventories of ecosystem services and green infrastructure; and supporting local authorities with implementing long-term management and development programmes (Mabon, 2019).

'Building back better'" is especially relevant for ecosystems in the long term, and the term 'building back greener" has been gaining traction. Also, under the humanitarian guiding principle of 'do no harm', disaster recovery and environmental stewardship complement one another (see **case study 3.12**).

BOX 3.3

Aspects to consider in the response phase

Avoid over-exploitation of natural products.

- Ensure that fuelwood and timber are obtained according to plans set during the preparedness phase.
- Ensure that natural resource extraction for shelter and food is carried out according to existing legislation.

Avoid unplanned habitat change.

- Put up shelters only in areas that have been identified for the purpose.
- Avoid clearing natural habitats if they have not been identified for clearance in the prevention phase.

Minimize solid waste pollution.

- Dispose of solid waste at locations identified in the previous phase.
- Start a process of separating degradable from non-degradable waste and recyclable and reusable waste.
- Ensure that incineration is not used as a method of waste disposal, as this contributes to global warming and air pollution.
- Actively train persons at shelters to dispose of waste responsibly.

Minimize water pollution.

- Build toilets only in locations identified in the preparedness phase.
- Manage waste water only in the manner identified in the previous phase.

Miththapala, 2008; WWF and American National Red Cross, 2010













CASE STUDY 3.12

Green response by IFRC

While saving lives is and must remain the top priority of any emergency operation, addressing environmental issues and reducing the climatic impact of disaster response have become concerns of increasing importance in the humanitarian aid sector. The Red Cross and Red Crescent Movement recognizes the responsibility to minimize potential adverse impacts of humanitarian operations on the surrounding environment and ecosystems. Their work on mainstreaming the environment is known as 'green response'.

Green response is a way in which the Red Cross and Red Crescent Movement approaches its work, emphasizing stronger accountability towards affected populations by actively promoting alternative, more environmentally beneficial solutions in addressing needs. In short, it is about extending the fundamental humanitarian principle of 'do no harm' to the environment and ecosystems, which the people are reliant on, recognizing that sustainability is generated through environmentally sound actions. Some examples of its work:

- Developing and implementing environmental policies and strategies to ensure environmental protection is mainstreamed in the work.
- Improving procurement and sending of life-saving goods around the world, including working with suppliers to remove unnecessary plastic packaging from relief items and monitoring fleet emissions. (https://media.ifrc.org/ifrc/wp-content/uploads/sites/5/2018/08/CaseStudy_Greening-IFRC-Supply-chains.pdf)
- Piloting and adapting environmental assessment tools as a way to identify and mitigate negative impacts on the local environment caused by planned interventions. (https://ehaconnect.org/?s=NEAT)
- Deploying environmental specialists to carry out environmental assessments and advice on interventions to be introduced to mitigate and reduce adverse environmental impacts as a result of response activities. (https://media.ifrc.org/ifrc/wp-content/uploads/sites/5/2018/08/CaseStudy_Environmental-Field-Advisor-IFRC-Bangladesh-Population-Movement-Operation.pdf
- Piloting different sanitation techniques to improve the management of sewage in emergencies.
- Working on influencing policy and practice that enhances the environmental sustainability of humanitarian action internally within the movement and among external actors (Sphere thematic sheet – Reducing environmental impact in humanitarian response: https://spherestandards.org/thematic-sheet-environment/)

Integration of environmental aspects in design, implementation, monitoring, evaluation and reporting, in line with the concept of 'build back better', is important for enhancing preparedness for effective and more sustainable response and recovery actions. Guidance on planning and implementation of ecosystem rehabilitation is available, and the following steps are generally considered key (**Box 3.4**):

BOX 3.4
Steps for ecosystem rehabilitation

Step 1

Carry out a post-disaster assessment of ecosystem conditions and human well-being after a disaster.

- This can be in the form of a post-disaster needs assessment, rapid environmental assessment or environmental needs assessment.
- Comparing these data with the baseline data allows for clear analysis and can serve to track implementation of environmental recovery interventions.

Step 2

Follow existing legislation, establish policies on building codes if necessary and ensure that there is no over-exploitation of natural resources and species.

- For example, is timber and sand extraction sustainable and legal?

Step 3

Ensure that proper, ecosystem-friendly design standards are followed.

- Use designs that employ environmentally friendly materials and climate proofing.
- Draw up ecosystem-friendly designs with community input and ensure gender concerns are integrated.

Step 4

Minimize habitat change, conducting land use planning and zoning.

- Ensure that sensitive areas/ ecologically and economically valuable are not cleared for resettlements.
- Ensure that coastal/mountain morphology is not changed by built infrastructure.

Step 5

Prevent the spread of invasive alien species.

- Rehabilitate damaged ecosystems with native species when suitable.

Step 6

Ensure that water is not polluted.

- Protect resources from further contamination, such as fecal waste.
- Dispose organic and inorganic debris properly so that water bodies are not polluted.
- Ensure that new construction has good sanitation facilities and sewage systems and that drainage systems in place correspond to that approved by relevant local authorities.

Step 7

Ensure that measures are taken to mitigate the impact of, and to adapt to, climate change.

- Identify most vulnerable communities through vulnerability and risk assessments.
- Adopt energy conservation measures. For example, is there through-flow ventilation in hot climates? Are energy-saving bulbs and alternate energy sources being used where possible?
- Adopt water conservation measures (e.g. provide for rainwater harvesting in drought prone areas).
- Use environmentally friendly materials as much as possible.

Step 8

Ensure that ecosystems and natural habitats are conserved, restored and created.

- Make efforts to replant and landscape during structural changes.
- Carry out ecosystem restoration with reference to existing national laws and resource maps. This may require the establishment of protected areas.
- Consult all relevant government departments and include them together with the local community in restoration efforts.
- Adopt a landscape approach to restoration, fostering a spatial and biological heterogeneity.
- Match ecosystem restoration with local needs and prioritise the services that ecosystems provide.
- Restoration should use native, multiple-use and locally beneficial species.
- Ensure that replanting is carried out in suitable areas, using species native to the area.

(Miththapala, 2008; UNDP, 2011; Sudmeier-Rieux et al., 2013; Mainka and McNeely, 2015; Oglethorpe et al., 2016)

Action plan template for incorporating Eco-DRR into national DRR strategies

The Words into Action on Developing National Disaster Risk Reduction Strategies (UNDRR, 2019) provides an action plan template to help countries plan their DRR priorities. **Table 3.10** provides an example of what outcomes, indicators, and activities could be used to include NbS for DRR in such a national action plan under **Priority for action 4 (preparedness and 'build back better**'). The outcomes and indicators are to be decided at the national level as to what is most relevant. More explanation on the Eco-DRR template can be found in **Annex 1**.

TABLE 3.10

Filled in UNDRR template (2019) to exemplify how to include the environment in the action plan for achieving Priority for action 4.

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Ecosystems and their services are included in preparedness and response, recovery, rehabilitation and reconstruction *Contributes to SDG target 14.2 and indicator 14.2.1* *Contributes to SDG targets 15.1 and 15.2 and indicators 15.1.1, 15.1.2 and 15.2.1*			
RESULT/IMPACT INDICATOR	Improved ecosystems or at least no net harm to ecosystems			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
Ecosystems are not harmed in the response and are enhanced while building back better	• Presence of environmental contingency plans • Area of restored ecosystems	• Rapid environmental assessments • Environmental contingency plans • Environmental PDNA	• Post-disaster environmental assessments are undertaken. • Environmental contingency plans are made • Green humanitarian response • Secure funding for environment during build back better	• Sphere handbook • Green recovery and response toolkit

Recommendations for incorporating NbS in Sendai Framework in Priority 4:

- Include ecosystems and their services in preparedness planning and follow agreed preparedness measures/guidelines when imlementing response, recovery and reconstruction.
- Consider the environmental impacts of disasters and incorporate ecosystem rehabilitation/restoration/ protection measures as part of post-disaster needs assessment and recovery and reconstruction plans.
- Ensure disaster response, recovery and reconstruction activities do not have adverse environmental impacts and do not exacerbate vulnerability to future disasters.
- Undertake rapid environmental assessments to complement post-disaster needs assessments in order to identify the scope for environmental recovery and reconstruction.
- Leverage country-level experiences on sustainable recovery and reconstruction to share lessons learned and promote best practices.

(PEDRR, 2016)

USEFUL RESOURCES AND TOOLS

- InaSAFE: provides a free software to produces realistic natural hazard impact scenarios for better planning, preparedness and response activities. http://inasafe.org
- WWF: Building back safer and greener – A guide to sound environmental practices for disaster recovery in Nepal: outlines good practices to avoid adverse environmental impacts after disasters.. http://envirodm.org/cms/wp-content/uploads/2017/07/Building_back_safer_and_greener_WWF-2016.pdf
- World Wildlife Fund & American National Red Cross (2010). Green Recovery and Reconstruction Toolkit: provides a toolkit and training programme to increase awareness and knowledge of environmentally responsible disaster response approaches. http://envirodm.org/green-recovery
- The Environment and Disaster Management Help Desk: is an online platform providing roundthe-clock access to a team of advisors, skilled in supporting green rebuilding efforts. https://envirodm.org/helpdesk
- Environmental screenings tool NEAT+: is an open-source tool that assesses a snapshot of the current sensitivity of the local environment. https://www.eecentre.org/resources/neat/
- Integrated Strategic Environmental Assessments in Post-Crisis Countries: A guidance note for integrating DRR and CCA in sustainable reconstruction and development planning. https://postconflict.unep.ch/publications/Eco-DRR/ISEA_Guidance_Note_EN_interactive.pdf
- Sphere: Reducing environmental impact in humanitarian response: provides guidance on how to include environmental considerations in humanitarian response work. https://spherestandards.org/wp-content/uploads/Sphere-thematic-sheet-environment-EN.pdf
- EHA Connect: provides a repository of tools and guidelines for crisis response and recovery. https://ehaconnect.org/
- Guidelines for Rapid Environmental Assessment in Disasters: a tool to identify, define and prioritize potential environmental impacts in disaster situations. https://reliefweb.int/report/world/guidelines-rapid-environmental-impact-assessment-disasters-version-5-2018
- FEAT 2.0 provides guidance for field use to support rapid environmental impact assessments. https://www.unocha.org/sites/dms/Documents/FEAT_pocket_final.pdf
- Environmental Emergency Centre provides learning modules as well as tools and resources on environmental emergency preparedness and response https://www.eecentre.org/
- MOOC – Sustainable Development in Humanitarian Action provides an overview of principles and practices of sustainable development. https://www.futurelearn.com/courses/sustainable-development-humanitarian-action
- MOOC – Ecosystem management contributions preand post-disaster. https://www.youtube.com/watch?v=wvrr9RLhsgc&list=PLH___LL2LODuduh-dhLSFKOhyJZtRnlc_&index=6&t=0s

3.2 Sendai Framework Monitor and ecosystems

Strong accountability is one of the cornerstones of the Sendai Framework. A set of 38 indicators, recommended by an Open-ended Intergovernmental Expert Working Group (OIEWG), and endorsed by the UN General Assembly, tracks the progress in implementing the seven global targets of the Sendai Framework. The Sendai Framework Monitor functions as a progress tracker.

3.2.1 Targets C and D

Two of the seven Sendai Framework targets explicitly mention "green" infrastructure. These include Target C (reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030) and Target D (substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030). These targets are aligned with the SDGs 1 and 11, respectively. In particular, the OIEWG recommends including green infrastructure under indicators C-5 (direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters) and D-4 (number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters).

Although the Sendai Framework only refers to green infrastructure, the term should be understood to include the types of 'blue' infrastructure already discussed in this guide. Within the Sendai Framework Monitor, for example, categories related to green infrastructure include coastal defences; mangroves; parks and green space; urban tree canopy; regional storm water reservoirs; rain gardens; rainwater harvesting; ground reinforcement for landslide prevention, and underground water infiltration trenches and storage systems. BGI will therefore be used here when referring to the Framework's "green" infrastructure.

The UNDRR Technical Guidance for Monitoring and Reporting on Progress in Achieving the Global Targets of the Sendai Framework further elaborates on green infrastructure (BGI) as part of critical infrastructure and outlines its key elements.

Reporting disaster impact(s) on BGI as well as monitoring the progress in reducing it (them) in the Sendai Framework Monitor involves three steps: 1. Inventories of BGI; 2. Regular monitoring of BGI; and 3. Assessments of disaster impacts on BGI.

1. Inventories of BGI

After identifying BGI, a baseline assessment needs to be conducted (Sebesvari et al., 2019). Such assessment, comprising information about the distribution, diversity and value of ecosystems and their services, can provide an essential basis for planning and management of the environment as well as for disaster risk management (see Priority for action 2) (Ricaurte et al., 2019). Furthermore, determining pre-disaster environmental status and condition of BGI serves as point of reference to compare post-disaster conditions and assess disaster impacts on BGI (UN ECLAC, 2014).

Inventories of BGI can be produced based on, for example, available publications, earth observation data or field data on ecosystems, ecosystem services, natural capital, strategic environmental impact assessments and economic assessments of ecosystem goods and services (UN ECLAC, 2014; Sebesvari et al., 2019; also see chapter 3.1.1). Colombia has recently established a baseline of the functional and spatial composition of its wetlands. Its approach to creating an inventory of national wetland using satellite imagery and expert knowledge is an exemplary case study (**see case study 3.13**).

CASE STUDY 3.13

The Colombian case of ecosystem inventories

Floods in 2010 and 2011 set off alarms about a lack of information on the services provided by Colombian wetlands in terms of flood regulation. As a result, the country invested in getting a better understanding of its wetlands and creating a national wetland classification system. With the help of wetland experts, the following parameters were identified for the classification of the functional and spatial composition of national wetlands:

- *Climate and geomorphology*: territories with similar climate and geomorphological processes influence the structure and dynamics of wetlands similarly.
- *Hydrology*: the availability and sources of water (stable water levels vs flood pulses) will affect wetlands.
- *Chemical quality of water and sediments*: the impact of water quality and sediments on the occurrence and productivity of wetland plants.
- *Biological criteria*: plants reflect the impacts of environmental conditions over years; the predominant vegetation physiognomy (dominant growth forms, height and appearance of the vegetation) is assessed for each wetland type.

The parameters were overlaid and spatially analysed to identify the wetland diversity and understand the functioning and spatial composition of Colombian wetlands. The results of this wetland mapping and classification exercise provided the basis for new guidelines defining opportunities and constraints for wetland classification in the country (Ricaurte et al 2019). From the 86 identified macrohabitats, table XX illustrates some examples of the applied classification.

System	Macroregion	Subsystem	Order	Suborder	Class	Subclass	Macrohabitat
Marine-Coastal	Atlantic sea and coast	Wetlands with Fluctuating water level	Wetlands subjected to polymodal predictable tidal flood pulses of low amplitude (<1m)	Saltwater wetlands in current deltaic plains			Beaches and dunes
	Atlantic and Pacific islands	Wetlands with stable water level	Permanent shallow marine wetlands				Coral reefs
Inland	Andean mountain range	Wetlands with Fluctuating water level	Wetland with unpredictable polymodal flood pulses				Riparian wetlands along small streams and low order rivers
	Amazonian and Orinoco piedmonts and alluvial plains	Wetlands with a rather stable water level			Interfluvial swamps	Swamps covered with trees and shrubs	Palm swamps (e.g. Mauritia flexuosa)
Human-Made							Marine and freshwater aquaculture
							Salt farms

The Regional Municipality of York in Ontario, Canada, is an example of where having such ecosystem inventories serves management decisions. Since assessing the value of regional green infrastructure, the municipality has become aware of the role of BGI and has been managing it as an asset. The guide for municipal asset management can be accessed at: https://www.ontario.ca/page/building-together-guide-municipal-asset-management-plans#section-3

Similarly, London supports decision-making related to social and environmental investments through providing an overview of the existing network of parks, green spaces, gardens, woodlands, rivers and wetlands. See: https://maps.london.gov.uk/green-infrastructure/

As part of the European programme CLEVER Cities, baseline information of green cover is also available for Hamburg, Germany, and Milan, Italy. (http://www.urbandataplatform.hamburg/daten-finden/11696686/daten-finden/ and http://dati.comune.milano.it/dataset/ds89_infogeo_parchi_giardini_localizzazione_).

2. Monitoring BGI

In addition to determining a baseline for BGI, it is important to monitor it over time as its status and condition may change. This could include recurring valuations of BGI, considering that the value attributed may change under altering circumstances.

The monitoring of BGI includes many aspects, as BGI not only contributes to the moderation of extreme events, but also provides numerous other ecosystem services that reduce vulnerabilities and/or enhance capacities.

To assess the role of an ecosystem as BGI as well as its co-benefits, environmental aspects that would benefit from being monitored are:

- Land use and land use change,
- the distribution of the ecosystem,
- the ecosystem functioning,
- ecosystem health,
- ecological connectivity,
- biodiversity,
- protected areas,
- land degradation
- freshwater quality and quantity.

Satellite imagery and remote sensing can support the monitoring exercise, delivering ecologically relevant and long-term dataset for analysing changes in ecosystem area, structure and function at temporal and spatial scales (Murray et al., 2018).

Furthermore, monitoring schemes and products exist at global level:

- The IUCN Red List of Ecosystems Categories and Criteria is a global standard to evaluate the status of ecosystems, applicable at local, national, regional and global levels. It measures the status by assessing losses in area, degradation or other major changes, such as land conversion.



The IUCN Red List of Ecosystems website https://iucnrle.org/;
Guidelines for the application of IUCN Red List of Ecosystems Categories and Criteria https://portals.iucn.org/library/sites/library/files/documents/2016-010.pdf
Published assessments https://iucnrle.org/resources/published-assessments/

- The Ramsar Convention on Wetlands requires its member states to regularly monitor their wetlands. The monitoring and assessment of wetlands is generally based on performance indicators that are annually reviewed. Each Convention on Wetland contracting party defines its performance indicators. Some general examples of performance indicators for the species and habitat components of ecological character features are (Ramsar Convention Secretariat, 2010):

  i) Performance indicators for species:

  a) Quantity:

  The size of a population, for example:
  - the total number of individuals present
  - the total number of breeding adults
  - the population at a specified point in an annual cycle
  - the extent or distribution of a population

  b) Quality:
  - survival rates
  - productivity
  - age structure

  ii) Performance indicators for habitats:

  a) Quantity:
  - size of area occupied by the habitat
  - distribution of the habitat

  b) Quality:
  - physical structure
  - individual or groups of species indicative of condition
  - individual or groups of species indicative of change

  The full framework for designing a wetland monitoring programme is available at Ramsar Wise Use Handbook [18 (4th edition)] Managing Wetlands. https://www.ramsar.org/sites/default/files/documents/pdf/lib/hbk4-18.pdf

- Most frequently used Earth observation indicators for assessing the health of ecosystems used as BGI are listed in Table 3.11 below.

TABLE 3.11

Frequently used Earth observation indicators for monitoring ecosystems health

Ecosystem	Indicator	Rationale	Data needed	Resources
Forest	Land surface area covered by forest	Changes in forest surface area affect its service provision	National forest land cover data	https://earthexplorer.usgs.gov/
Wetland	Wetland fragmentation	Wetland fragmentation reduces species richness and the speed of recovery, both of which affect the provision of ecosystem services	National wetlands land cover data	https://www.umass.edu/landeco/research/fragstats/fragstats.html https://www2.cifor.org/global-wetlands/
Dune	Dune boundary change	Disruption and high erosion rates decrease the ability to provide ecosystem services	National dune land cover data	https://www.usgs.gov/centers/whcmsc/science/digital-shoreline-analysis-system-dsas?qt-science_center_objects=0#qt-science_center_objects
Mangrove forest	Land surface area covered by mangrove forest	Changes in mangroves surface area affect its service provision	National mangrove forest land cover data	https://earthexplorer.usgs.gov/ https://gma-panda.opendata.arcgis.com/
Coral reef	Coral bleaching rate	Increased bleaching rates affect the services provided by the reef	Satellite imagery	https://coralreefwatch.noaa.gov/satellite/methodology/methodology.php

Melbourne, Australia, presents an excellent example of monitoring of green infrastructure within a city. Melbourne monitors and shares data on its urban forest in terms of diversity and life expectancy (see http://melbourneurbanforestvisual.com.au/).

3. Assessing disaster impacts on blue-green infrastructure

In the case of a disaster impacting BGI, it is important to use the opportunity provided by the Sendai Framework Monitor to report on the damaged or destroyed BGI and the resulting economic loss.

If baseline data is available on the value of BGI, the loss of that BGI can be measured by multiplying the BGI value with the affected area. The extent of the affected area can be measured by comparing pre-disaster photographs to the situation post-disaster. In the case of wetlands, for instance, an intersection of storm surge, wetland polygons and pre-/post-disaster aerial photos can serve to map the wetland area affected by the disaster, as illustrated in **Figure 3.7** (Hauser et al., 2015).

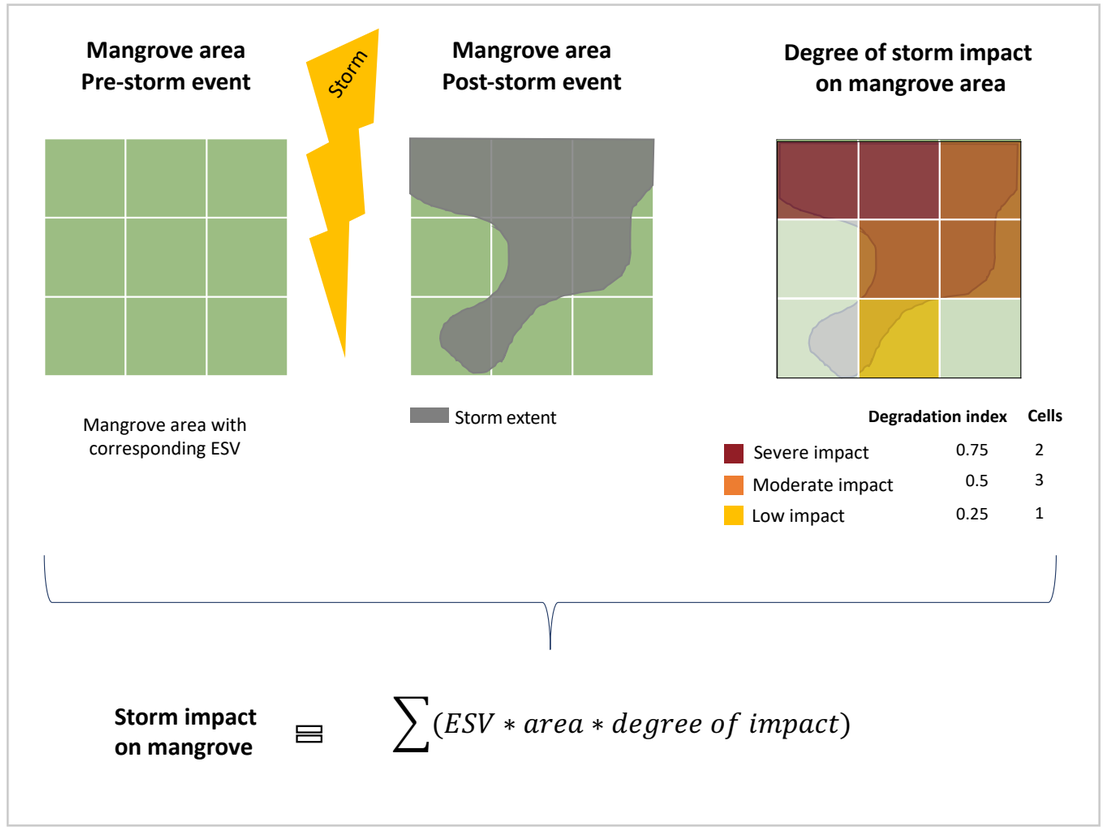
BGI can be reported on in Sendai in the following indicators:

C5 Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters.

D4 - Number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters

FIGURE 3.7

Schematic illustration of disaster impact assessment, taking the example of a mangrove forest. ESV stands for ecosystem service value.



The degree of storm impact could be assessed assigning the following values to reflect degradation categories: low=0.25, moderate=0.50, severe=0.75. The impact of a mangrove forest area with a "moderate degradation" score would thus be estimated by multiplying the affected mangrove area by 0.50. This value would then be multiplied by the ESV.

They used satellite imagery to assess the degree of damage, assigning a tier degradation index to each wetland polygon depending on the hurricane impact. Areas with greater disaster impacts were assigned higher scores to indicate greater degradation. Figure 3.7 schematically illustrates how disaster impacts could be assessed, using the example of a mangrove forest with a known ecosystem service value (ESV) hit by a storm. The degree of storm impact could be assessed assigning the following values to reflect degradation categories: low=0.25, moderate=0.50, severe=0.75. The impact of a mangrove forest area with a "moderate degradation" score would thus be estimated by multiplying the affected mangrove area by 0.50. This value would then be multiplied by the ESV. **Table 3.12** provides a list of remote sensing products that can serve to assess the area of important ecosystems affected by disasters.

TABLE 3.12

Indicators and respective remote sensing products for assessing disaster impacts on ecosystems with BGI function

Ecosystem	Indicator	Remote sensing product
Forest	Biomass	Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI)
Wetland	Fragmentation	FRAGSTATS 4.4
Dune	Height	GIS DSAS 3.2 extensions
Mangrove	Biomass	NDVI and EVI
Coral reef	Bleaching	National Environmental Satellite, Data and Information Service (NESDRIS)

Should no information be available on the value of the BGI prior to a disaster, it is important to estimate the affected area, nonetheless. Aerial images allow counting the number of destroyed or damaged BGI (D-4). Additionally, although it is generally difficult to quantify ecosystems in monetary terms, knowing the affected area can support estimating the direct economic cost linked to damaged or destroyed BGI (C-5), by using:

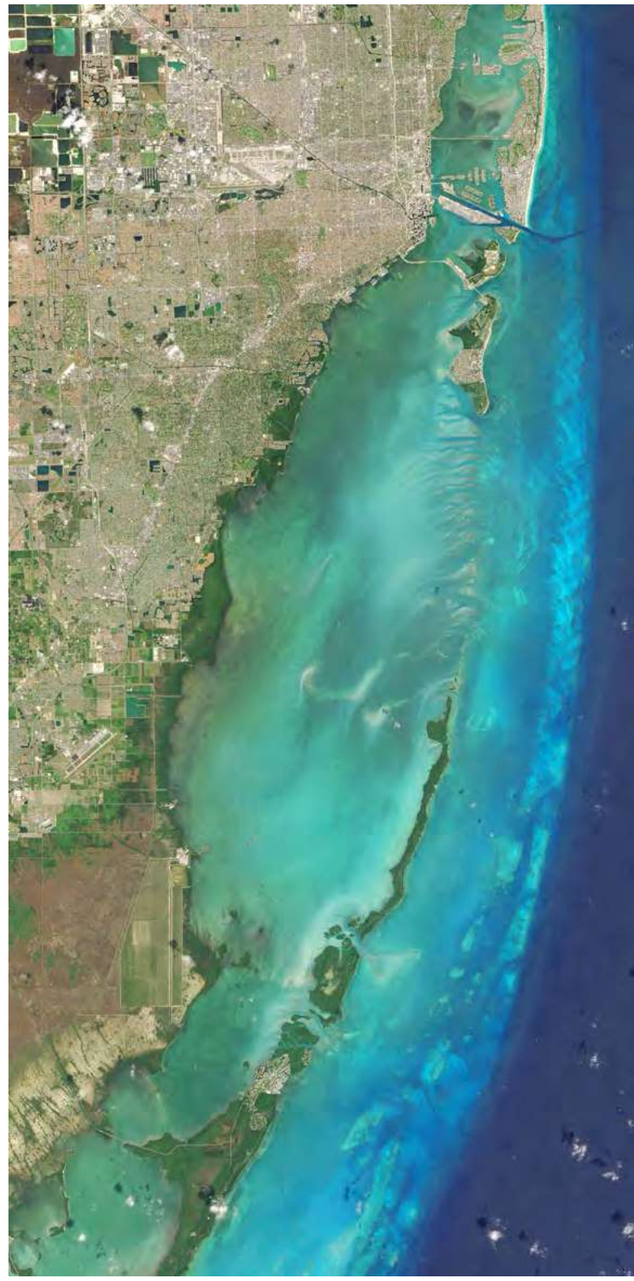
- Benefit transfer or value transfer methods, i.e. assessing disaster impacts to BGI by taking ecosystem value estimates calculated for other sites and applying them to the disaster affected BGI. Comprehensive ecosystem service assessments, databases and meta-analyses, such as that by Costanza et al. (2006), or Bordt and Saner (2019), Brander et al. (2013) and de Groot et al. (2012) can provide a baseline to appraise environmental damage (UN ECLAC, 2014). Country- and ecosystem-specific economic valuations are also available in some cases (e.g., the total economic value of U.S. coral reefs reported by the National Oceanographic and Atmospheric Administration (NOAA) Coral Reef Conservation Program (CRCP) in 2013). It is however important to understand and consider the local situation and avoid inappropriate transfer of values from very different ecological, biological or socio-economic contexts (Ready et al., 2004).
- The Economics of Ecosystems and Biodiversity's (TEEB) valuation database can help to estimate monetary values of ecosystem services prior to a disaster impact (van der Ploeg and de Groot, 2010).
- Replacement costs are an economic valuation approach that can be applied post-disaster impact.
- Loss of income-generation sources as a result of damage to wetlands, forests or marshes in local communities, for instance, can serve to provide an economic value, although this presents an underestimation of the loss, as all other services provided by the ecosystems are not recognized.

USEFUL RESOURCES

- Costanza et al. (2006). The Value of New Jersey's Ecosystem Services and Natural Capital: provides the economic value of New Jersey's natural capital https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1014&context=iss_pub
- TEEB´s Estimation of Monetary Values of Ecosystem Services: presents the monetary values of ecosystem services https://www.es-partnership.org/wp-content/uploads/2016/06/TEEB-D0-App-C.pdf ; specifically for wetlands https://www.ramsar.org/sites/default/files/documents/library/teeb_waterwetlands_report_2013.pdf and TEEB database: a searchable database of 1,310 estimates of monetary values of ecosystem services. https://www.es-partnership.org/wp-content/uploads/2016/06/ESVD-TEEB-database.xls
- Bordt, M. and M. Saner (2019) Which ecosystems provide which services? A meta-analysis of nine selected ecosystem services assessments. One Ecosystem 4: e31420.
- de Groot et al. (2012) Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services 1(1): 50-61

To progress on the reporting of BGI infrastructure in the Sendai Framework Monitor, under targets C5 and D4, authorities, practitioners and stakeholders should:

- encourage determining baselines of identified BGI
- regularly monitor the status and condition of the BGI
- evaluate disaster impacts on BGI and report on them via the Sendai Framework Monitor





3.2.2 Target E

Target E of the Sendai Framework aims to "substantially increase the number of countries with national and local disaster risk reduction strategies by 2020". This, according to the Sendai Framework, includes: "To adopt and implement national and local DRR strategies and plans, across different timescales, with targets, indicators and timeframes, aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of economic, social, health and environmental resilience."

As can be seen from preceding sections in this guide, NbS can be included in Target E, both at national and local levels. Given the importance of the environment in the potential to reduce disaster risk, the inclusion of targets/goals, objectives and activities directly related to the environment can be an asset to a DRR strategy. Furthermore, national and local DRR strategies can provide an enabling framework towards implementation of NbS (Lo, 2016). Authorities should thus be encouraged to embed NbS in policy-making, planning, programming, budgeting and implementation. NbS require governance architectures that support integrated planning and implementation of NbS (Raymond et al., 2017).

The Words into Action on Developing National Disaster Risk Reduction Strategies (2019) proposes a 10-step approach to developing a national DRR strategy (Figure 3.8). As has been outlined previously, in particular, on the application of NbS to the four priorities of the Sendai Framework, NbS forms strong linkage with several of these 10 key elements, thus offering governments better opportunities of alignment of the national strategy with the Sendai Framework.

10 STEPS TO GUIDE AND SUPPORT THE DEVELOPMENT OF A NATIONAL DRR STRATEGY.

PHASE I

BUILDING UNDERSTANDING AND EVIDENCE

1. ASSESS EXISTING SYSTEMS AND COUNTRY CONTEXT

2. DEFINE OBJECTIVES AND VISION

3. IDENTIFY APPROPRIATE INSTITUTIONS AND MECHANISM

4. EVALUATE FINANCIAL RESOURCES, ENGAGE WITH FINANCE MINISTRY

5. DESIGN A WORK PLAN

PHASE II

DESIGNING THE STRATEGY AND ACTION PLAN

6. COMMUNICATE AND REACH OUT

7. CONSOLIDATE EVIDENCE INTO A DRAFT STRATEGY

PHASE III

PREPARING FOR IMPLEMENTATION

8. SECURE AND ACTIVATE FUNDING SOURCES

9. MOBILIZE PARTNERSHIPS ON COUNTRY-LEVEL

10. SET UP MONITORING, EVALUATION AND REPORTING

10 steps are recommended to guide and support the development of a national DRR strategy. They are not meant to be prescriptive or rigid. The sequencing and content should be adjusted to meet the country's DRR context, needs, priorities and capacities.

In using the 'three phases' for developing national DRR strategies (UNDRR, 2019), outlined in the Words into Action, it is particularly opportune to include NbS in the first phase – 'building understanding and evidence'.Doing this then helps in the design of the strategy and action plan (Phase 2) and in preparing implementation (Phase 3). The three steps are closely linked to the Sendai Framework priorities for action.

Phase 1

The following **Table 3.12** illustrates NbS-related activities that ensure the inclusion of environment in developing a national DRR strategy at Phase 1.

TABLE 3.13

NbS-related activities that ensure the inclusion of environment in developing a national DRR strategy at Phase 1

STEP	Activities	Opportunity for Eco-DRR
1 Assess existing system and country context 	1.1. Understand or define the existing DRR system and governance mechanism in each sector and across sectors.	Understand if and to what extent NbS are considered in existing DRR system.
	1.2. Build strong understanding and evidence of the disaster risk context.	Include ecosystems in risk assessments (see chapter 3.1.1).
	1.3. Define and agree on a standard terminology on disaster risk reduction to be used by all.	Use the Eco-DRR definition by PEDRR www.pedrr.org
2 Define objectives and mission 	2.1. Draft a proposed set of high-level objectives for the DRR strategy in the context of national social, economic, political and environmental priorities and development goals based on the outputs of the previous step.	Explore the potential of Eco-DRR within the context of national social, economic, political and environmental priorities and development goals.
	2.2. The proposal should then be discussed by a governing mechanism for the national strategy development, to be comprised of senior representatives of line ministries and other sectors (see Step 3), and the high-level objectives of the national DRR strategy endorsed.	Ensure that the ministry of environment is part of the governing mechanisms.
3 Identify appropriate institutions and mechanisms 	3.1. Identify / select the most appropriate institutional leadership structure to drive the development of the national DRR strategy (high level, governing mechanism and working groups).	Ensure that the Eco-DRR perspective is represented by the leadership.
	3.2. Set up a multi-sectoral and multi-stakeholder national DRR coordination mechanism – or update/use the existing national platform for DRR – to ensure a truly participatory, whole-of-society and inclusive approach to the DRR strategy that will bring coherence among all required areas of expertise, knowledge and agendas to design the content of a comprehensive DRR strategy.	Ensure that the ministry of environment is part of the coordination mechanism.
	3.3. Define the form of coordination between the DRR mechanism, or national platform, and other key mechanisms coordinating climate change adaptation and SDG implementation and reporting.	Recognize the role of environment in bridging DRR, CCA and SDG implementation.

4	Evaluate financial resources, engage with finance ministry 	4.1. Identify national / domestic and international sources of funding. The ministry of finance can also provide information on both national and international sources and decision-making processes.	Consider international public finance and development aid as sources of funding for NbS (e.g., the Global Environmental Facility or the Green Climate Fund).
		4.2. Evaluate current decision-making processes for investments in DRR and resource mobilization capacity at national level and from national to local level.	Evaluate whether and to what extent decisions take environment and co-benefits into consideration.
		4.3. Ensure DRR is taken into account in any planned national development finance assessment. Ensure risk assessment of all development projects financed by the finance ministry/budget office.	Recognize the role of environment as bridge between DRR and development.
		4.4. Conduct a survey of existing budgets dedicated to various categories of risk reduction; resilient new development, reducing existing risk and disaster management (preparedness, response, relief and recovery).	Include NbS in the survey to identify budgets allocated to it in the various categories of risk reduction; resilient new development, reducing existing risk and disaster management (preparedness, response, relief and recovery).
		4.5. Get an overview of the current status of national reserves and public risk transfer mechanisms in catastrophic events, including how past financial losses in disasters have been managed. Explore the contingent liabilities that were assumed by governments in previous disasters. Explore availability and opportunities to access national / international funds for DRR, including climate change adaptation funds, as well as recovery financing mechanisms.	Explore availability of international public finance to access funds for Eco-DRR (e.g. the Global Environmental Facility or the Green Climate Fund).
		4.6. Prepare a report of findings from the financial resources evaluation and submit to the governing mechanism for consideration.	-
5	Design a work plan 	5.1. Propose content for each core area identified as critical for the national strategy (as per the working groups identified under Step 3), with clear objectives, set of activities and expected outcomes identified for each of them. This should basically be a compilation of the reports submitted by the different working groups on their respective priority areas.	If possible, consider the inclusion of ecosystems as core area.
		5.2. Establish a timeframe to undertake and deliver each activity.	-
		5.3. Allocate roles and responsibilities across all actors planned to engage in the development of the strategy, endorsed by the respective actors through the national platform for DRR consultation and discussion.	-
6	Communicate and reach out 	Communicate through an appropriate combination of media tools, such as newsletters, TV and radio outlets, online broadcasts, social media and websites of key stakeholders involved in developing the strategy.	Develop stakeholder engagement processes to actively engage academics, practitioners, policymakers, NGOs and local residents in the design and assessment of NbS, while improving literacy on NbS to motivate involvement in its implementation.

Phase 2

Building an understanding and evidence of DRR strategies that include the environment then serves to design the strategy and action plan. This phase consists of putting together all the evidence and reports gathered to come up with a strategy document. After developing a narrative and confirming overall objectives and shared visions of the strategy (see UNDRR, 2019, for more details), an action plan must be developed that provides a clear roadmap for implementation, with a clear definition of:

- the allocation of roles and responsibilities among stakeholders;
- the modalities of interaction across sectors and stakeholders;
- partnership-building opportunities;
- the allocation of resources and required resource mobilization efforts to ensure a smooth and effective implementation of the strategy.

The templates for such action plans presented above under the four Sendai Framework priorities (see **tables 3.5** on page 94, **3.6** on page 108, **3.8** on page 126, and **3.10** on page 136) can support this phase.

see table 3.5

see table 3.6

see table 3.8

see table 3.10

Phase 3

After defining the roadmap, it is essential to prepare for the implementation of the action plan. Guidance on activating funding, mobilizing partnerships and setting up a monitoring, evaluation and reporting mechanism is provided in UNDRR (2019).

3.2.3 Custom targets and indicators

The Sendai Framework Monitor allows countries to create their own targets customized to their strategies. To report on their custom targets, countries can either input their own indicators or choose from a predefined list.

Own indicators

Developing custom targets and indicators according to countries' needs allows reporting on both losses of BGI as well as progress made on BGI solutions (Sebesvari et al., 2019). For instance, having identified wetlands as an important element of DRR strategy, wetland restoration and protection could be chosen as a custom target defining respective custom indicators. This aligns the monitoring process of targets C-5, D-4 and E.

UNISDR published *a Guide to Custom Targets and Indicators* in 2018.

Pre-defined indicators

Member states can additionally report on a list of pre-defined indicators. Some of these predefined custom indicators originate from the Resilient Cities Campaign and are ecosystem related.







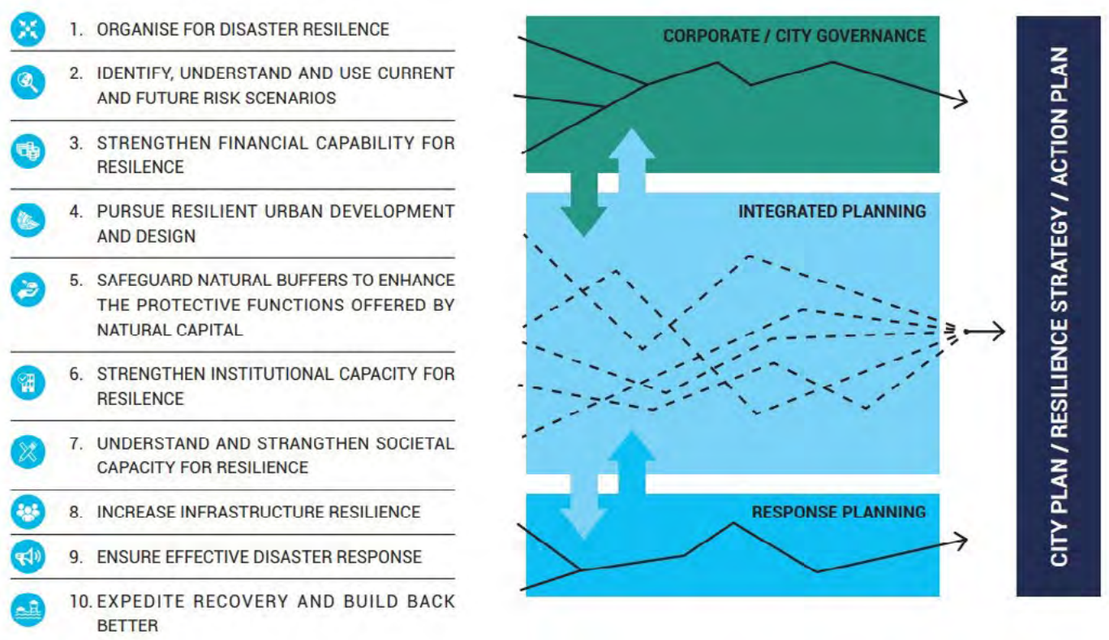


Resilient Cities Campaign

The UNDRR's 'Ten Essentials for Making Cities Resilient' provide an operational scheme for the Sendai Framework at local level and map directly against the Sendai priorities for action (**Figure 3.9**).

FIGURE 3.9

The 'Ten Essentials' for making cities resilient. Source: UNISDR, 2017.



Essential 5 – "Safeguard natural buffers to enhance ecosystems' protective functions" – recognizes the critical services provided by ecosystems in terms of DRR and the need for healthy ecosystems to ensure the provision of services.

To achieve Essential 5, the following steps are encouraged:

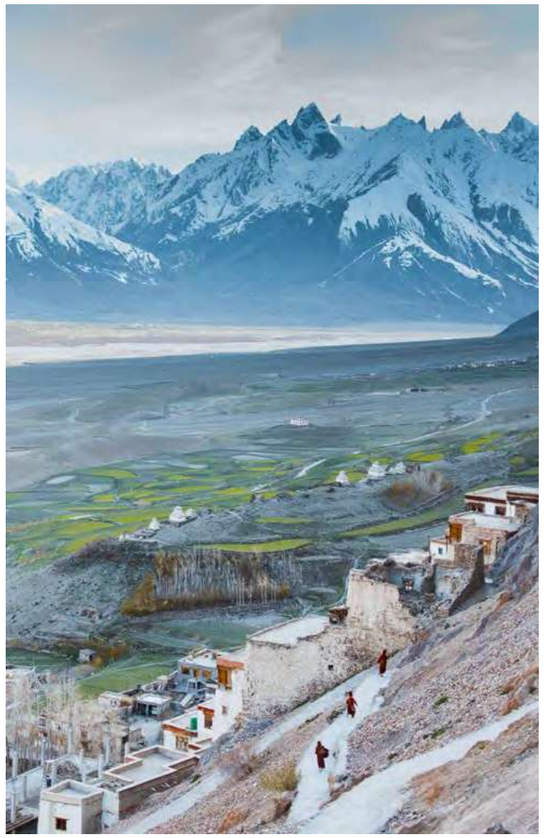
1. Raise awareness of the impact of environmental change and ecosystem degradation on disaster risk:
   - Recognize value and benefits from ecosystem services for disaster risk prevention; protect and /or enhance them as part of risk reduction strategies for cities.

2. Promote better management of critical ecosystems to strengthen resilience to disaster:
   - Integrate ecosystem services for more urban resilience into urban land use management, urban design and into relevant investment projects;
   - Consider also natural buffers in the rural hinterland of the city and wider region and cooperate with municipalities there to establish a regional approach to land use planning to protect the buffers.

3. Strengthen existing ecosystem management based on risk scenarios assessments:
   - Anticipate changes from climate trends, urbanization and planning to enable ecosystem services to withstand these.

The Disaster Resilience Scorecard for Cities thus is a great tool to help cities in particular to monitor NbS and some of its elements could be modified for national level use.

Eight indicators from the Resilient Cities scorecard relevant to ecosystems have been identified (**Table 3.14**). The indicator "Green and blue infrastructure is routinely embedded in plans" would be an easy and useful indicator to monitor not only DRR strategies themselves but also sectoral plans and programmes.



To include NbS in DRR strategies authorities, practitioners and stakeholders should:

- create custom targets that include ecosystems and NbS
- find appropriate indicators to monitor success
- create national and local programmes for implementing NbS

TABLE 3.14

Indicators from the Resilient Cities relevant to ecosystems

Indicator	Methodology – self-rated scale from 0-5	Difficulty of measuring indicator	Needed data / other indicators
1. Application of land use zoning	0 = zoning is <50% implemented and enforced and 5 is 100% implemented and enforced.	Easy	Map of land use; assessment of zoning enforcement; satellite images.
2. Awareness of the role that ecosystem services may play in the country's/ city's disaster resilience	0 is no monitoring and 5 is critical ecosystem services identified and monitored annually on a defined set of key health/performance indicators.	Easy	DRM assessment; monitoring plans of government; identification of BGI for DRR; monitoring ecosystem health.
3. Ecosystem health	0 is potentially fatal damage to some or many key ecosystems and 5 is improved health and performance across the board for critical ecosystem services.	Difficult	Biodiversity indicators (species richness, abundance and distribution of species); states condition indicators (ecosystem connectivity, soil organic carbon, habitat conservation status).
4. Impact of land use and other policies on ecosystem services	0 is land use policies (or lack thereof) may lead or have led to complete destruction of critical ecosystem services and 5 is land use policies are strongly supportive of critical ecosystem services and are fully enforced.	Easy/medium	Environmental impact assessments; strategic environmental assessment.
5. Green and blue infrastructure is routinely embedded into city/ national projects	0 is no usage or awareness of blue and green infrastructure issues and 5 is the city has maximized opportunities to include green and blue infrastructure and has processes and codes to ensure this will continue with future development.	Easy/medium	Awareness of BGI as an option for DRR, database of BGI, building codes for BGI, funding dedicated to BGI, share of city projects that consider BGI among available options.
6. Identification of critical environmental assets	0 is the city has no plans to consider ecosystems beyond its own borders and 5 is the city regularly undertakes transboundary assessments of ecosystem assets and works with border neighbours to manage these.	Easy/medium	Map of critical environmental assets; inventory of critical environmental assets used by the city; cooperation across administrative boundaries; payment for ecosystem services.
7. Transboundary cooperation	0 country/city sees no value in establishing transboundary agreements and has no plans to do so and 5 is all transboundary agreements and collaborations are in place with relevant organizations and implemented where required, according to findings of risk assessment.	Medium	Existing cooperation with neighbouring countries/cities; transboundary authorities; joint agreements of cooperation; international projects across boundaries; platform of knowledge sharing.
8. Adequacy of protective infrastructure (including natural buffers)	0 is no protection and 5 is protective infrastructure fully in place designed to deal with most severe scenario, with minimal economic or humanitarian impact.	Difficult	Existence of risk assessment and cost-benefit analysis; BGI regular monitoring; BGI decision based on modeling.

04

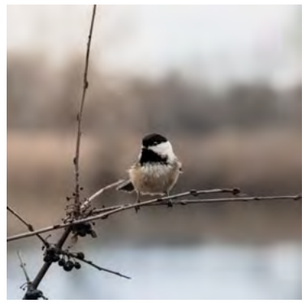
MAINSTREAMING AND UPSCALING



©Shutterstock/Enrique Ramos

The focus of this chapter is on mainstreaming and upscaling NbS for disaster risk reduction and climate change adaptation. However, mainstreaming NbS as a whole will create multiple synergies. Mainstreaming nature-based solutions is the process of routinely assessing the implications for ecosystems of any planned action, including legislation, policies or programmes, in all areas and at all levels to ultimately incorporate NbS in planning. Upscaling is about widening action from local and small-scale projects into large-scale projects and systemic undertakings.

First, we will look at how NbS are taken into account in international policy agreements and how mainstreaming NbS at the national level helps foster the policy coherence needed to achieve sustainable development as outlined by the United Nations Agenda 2030 and Sustainable Development Goals (SDGs) (section 4.1). We will also look at how to increase uptake and engagement in the public and private sector, showing examples of how this could be achieved at the national, sub-national and local level (section 4.2). Finally, we will discuss financing for NbS, which is an important part of upscaling (section 4.3).








4.1 Policy coherence





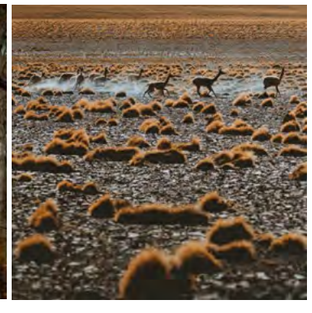




4.2 Uptake and engagement







4.3 Financing NbS




4.1 Policy coherence

Many policy mechanisms have been implemented in silos – in isolation, with little connection or coordination between them. As stated in the UNDRR's *Global Assessment Report (GAR) 2019*, "Global Challenges are more and more integrated, and responses are more and more fragmented" (UNDRR 2019).

Coordinating actions taken to deliver different frameworks or policies can help to avoid duplication, maximize gains and manage compromises (GNDR, 2019). In this context, coherence in implementing global agendas and other international policies becomes increasingly important. Different commitments and priorities at different administrative levels and between respective actors involved in policy planning, implementation and reporting pose a challenge to the alignment of policies and actions. As a consequence, mainstreaming processes are largely still in their infancy, although crosscutting approaches have a strong potential to achieve common goals (Sandholz et al., 2020).

Various initiatives aim at establishing coherence; for example, coherence across global agendas related to disaster risk management (GIZ, 2018). The European Union's approach on policy coherence for development seeks to build synergies between different EU policies to increase development cooperation effectiveness (European Commission, 2019). Another example is transboundary legal coherence, like in the case of marine protected areas or the Arctic (Platjouw, 2019).

SDG 17, target 14, requires governments to "enhance policy coherence for sustainable development", which can be defined as an "approach and policy tool to integrate the economic, social, environmental, and governance dimensions of sustainable development at all stages of domestic and international policy-making" (OECD, 2020a). It highlights the importance of coherence across sectors, including the environment (horizontal coherence) and across spatial and administrative scales, from international agendas to national policies and from national to local scales (vertical coherence).

The Sendai Framework adopts coherence across international agendas as its guiding principle and outlines several measures to ensure coherent implementation across all its priorities for action. One of the key elements of alignment of a national DRR strategy with the Sendai Framework is "policy coherence relevant to disaster risk reduction, such as sustainable development, poverty eradication, and climate change, notably with the SDGs, the Paris Agreement (on climate change)".

However, even though coherence is increasingly advocated, the reality in many countries is still different. Different commitments and priorities at different administrative levels and between the respective actors involved pose a challenge to the alignment of policies and actions. Incomplete knowledge of the gains and losses of current – often incoherent – practices and the potentialities of a coherent approach is another factor hindering change.



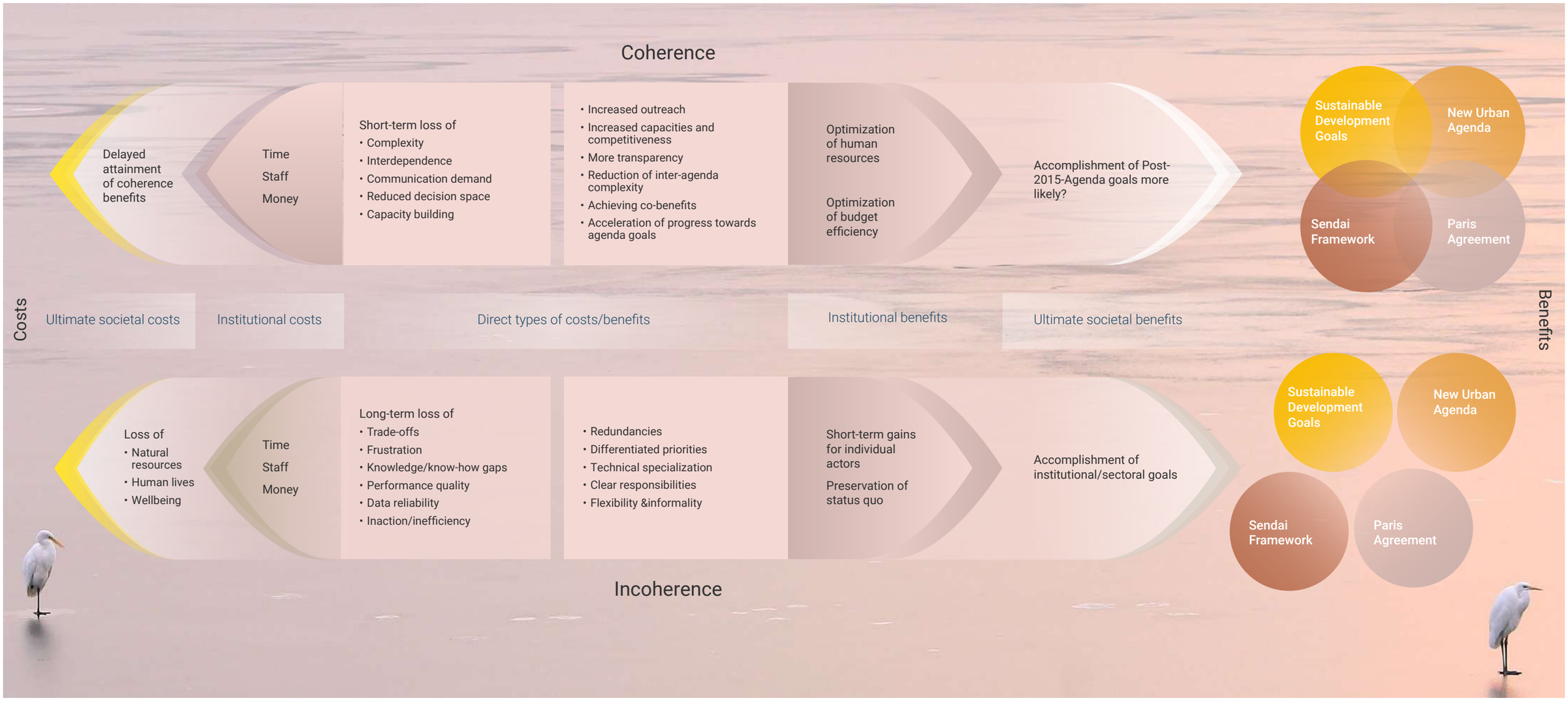
The cost of incoherence

Policy incoherence can seriously undermine sustainable development (CIDOB, 2019). Costs of incoherence relate to negative impacts of ineffective policy design and implementation, where progress on one sector or agenda can hinder progress on others (OECD, 2018; UNEP, 2015), resulting in a lack of stakeholder coordination and a competition for limited resources or even their misallocation (Carter et al., 2018; Curran et al., 2015).

However, it is important to understand that both policy coherence and incoherence can come with costs and benefits (see **Figure 4.1**). Nevertheless, their implications differ fundamentally. "Despite initial benefits of incoherence in many policy processes, the long-term costs of incoherence are far higher, making the case for coherence-building but also highlighting the difficulties of taking the first steps in this direction" (Sandholz et al., 2020).

FIGURE 4.1

Typology of the costs and benefits of (in)coherence. Sandholz et al. (2020)



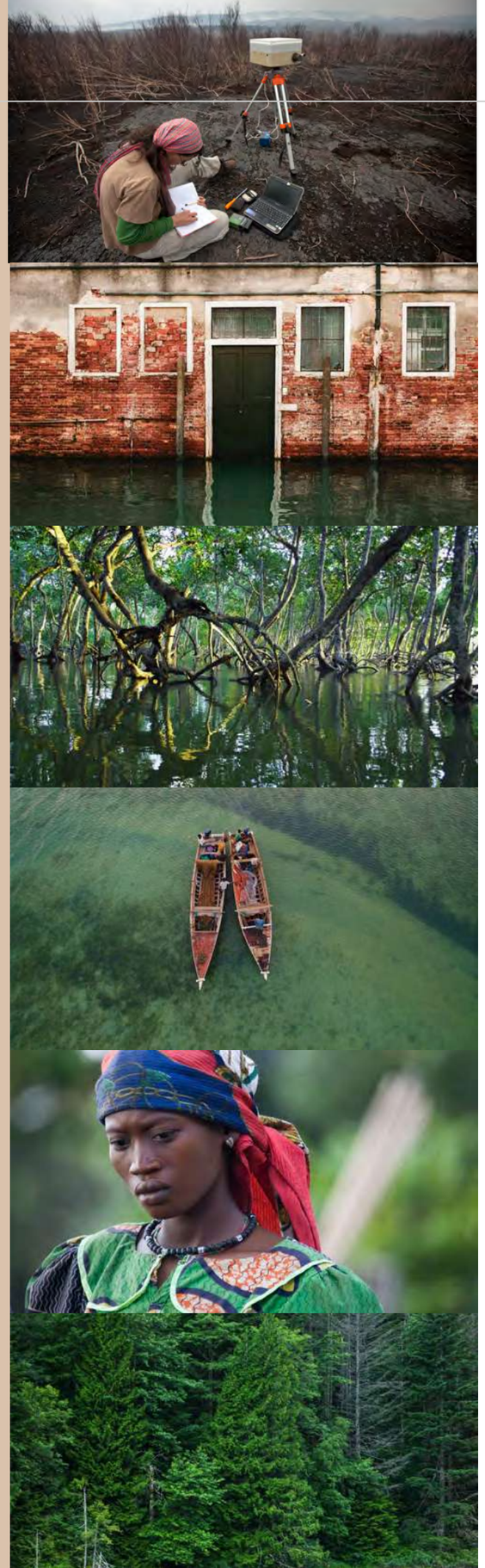
In a study carried out by Sandholz et al. (2020), case studies on disaster risk reduction in the post-2015 agendas in Mexico and the Philippines revealed that the costs of coherence identified by stakeholders mostly arise from the need to divert staff, money and time in order to develop structures for joint collaboration, planning, and for communication when aligning tools, policies and/or programmes. However, these costs were mostly perceived as being initial investments linked to re-organization purposes. On the other hand, time, staff and financial costs related to incoherence are generally linked to duplication of work, inefficiency and contradictory interventions, such as redundancies in data collection. Costs of incoherence are therefore not bound to a point in time. Conversely, positive effects of coherence are very likely to accrue over time.

Ultimately, incoherence is likely to result in a loss of natural resources. Take the example of Mexico, where different tools guiding spatial planning exist in parallel. Tools for zoning and ecological spatial planning, which categorize territories based on ecosystem variables, exist alongside 'atlases of risk' [18], which divide them according to natural and human-made risk factors. The outcomes of these land-planning tools are often contradictory. Land unit stimulus programmes for deforesting – to start new cropping systems, for example – can exist in parallel with programmes supporting forest conservation, potentially with even the same beneficiaries.

In the context of NbS, lack of policy coherence can lead to inaction when, for example, one actor sees 'adaptation' as the responsibility of another. It can also result in conflicts in the case of non-aligned agendas or trade-offs. For example, protection forests can reduce landslide risks at the cost of agricultural productivity due to compromised groundwater recharge – the process by which surface water moves downward through the soil to aquifers – and therefore reduced water availability (Seddon et al., 2020).

Both, coherence and incoherence are triggered by underlying drivers. They are very context specific and should be considered carefully together with the costs of establishing coherence because they may represent a significant disincentive for full commitment to coherence.

18 http://www.atlasnacionalderiesgos.gob.mx/



Drivers of incoherence

Incoherence does not emerge randomly or accidentally; rather, distinct drivers of incoherence, including in the build-up of NbS, are at play which need to be understood.

Siloed approaches in sectors, or at administrative levels, can lead to lack of exchange, cooperation and collaboration between actors. They hinder the development of integrated policies and lead to incoherence. Existing sectoral regulatory frameworks and policies can conflict with environmental management needs and hinder NbS uptake (Dale et al., 2019; Seddon et al., 2020); for instance, in the case of post-disaster recovery policies (Sutton et al., 2015). At the same time, coherence in policies does not automatically result in coherence in implementation. Realities on the ground can diverge significantly from the conditions assumed in plans and policies, therefore the link between planning and implementation has to be carefully watched, in particular through efficient monitoring.

Vertical bureaucracy with hierarchical political structures comes with the risk of diffusing incoherence from the national level through the system. As priorities, plans and policies are translated down the hierarchy to lower administrative levels, the importance of high-level commitment to coherence and integrated planning at national level, as well as the consideration of diverse local conditions, is even more crucial (Sandholz et al., 2020).

Frequent turnover of staff and politicians can result in workflow disruptions and lack of institutional knowledge and long-term planning. Establishing networks and trust between actors is key for coherence and needs to be part of any strategy, including capacity development and awareness. Differences in available capacities and knowledge, such as technical know-how or assessment capacities, and the existence of knowledge silos, hinder the achievement of coherence and the uptake of new approaches, like the shift from grey to more nature-based approaches in DRR and CCA. Path dependency, whereby decision-makers implement solutions familiar to them without even considering new approaches or novel actor coalitions can be a key barrier to coherence (Davies et al., 2019; Sandholz et al., 2020) and for mainstreaming NbS into decision-making processes. Establishing coherence needs to address all the underlying drivers that thwart cross-sectoral and cross-scale collaboration.

Potential entry points for coherence building drawn from studies in Mexico and the Philippines (Sandholz et al. 2020) are:

1. **Building on past experiences and ongoing efforts**, such as existing integrated policy frameworks or co-benefits already identified, to help reduce initial costs of coherence building.

2. **Simplifying policy structures**, governance/work structures and processes: too complex or too many (sectoral) plans and budgets complicate coherence building. Harmonizing budgets and streamlining planning could reduce competition for resources and collaboration.

3. **Changing institutional habits** to overcome established roles and routines. Strong political will is required to divert from individual actors' business-as-usual approaches.

4. **Capitalizing on the low-hanging fruits** for change towards more coherence. This requires an assessment of suitable entry points as they may differ between countries and regions.

4.1.1 International policies

There exist many international policy agreements which already integrate nature-based solutions for CCA and DRR; for example, ecosystem-based disaster risk reduction (Eco-DRR) and ecosystem-based adaptation (EbA) to variable degrees (see **Box 4.1**). These have been summarized in Sudmeier-Rieux et al. (2019) and Renaud et al. (2016).

BOX 4.1
International policy agreements and conventions which have provisions for NbS

- Sendai Framework for Disaster Risk Reduction
- Sustainable Development Goals (SDG)
- United Nations Framework Convention on Climate Change (UNFCCC)
- Convention on Biological Diversity (CBD)
- The Ramsar Conventions on Wetlands (Ramsar)
- United Nations Convention to Combat Desertification (UNCCD)
- New Urban Agenda (UN Habitat)

Black = specifically mentions ecosystem-based approaches/Brown = implied

Initiatives for coherence

Many of the international agreements that include NbS aim for synergies and integration within their approach. The Rio conventions (UNFCCC, CBD, UNCCD), for example, are intrinsically linked. These three conventions were direct outcomes of the Earth Summit held in Rio de Janeiro in 1992 (Agenda 21), with the aim to ensure a sustainable planet for future generations. The Joint Liaison Group (between secretariats) was set up to boost cooperation among the three conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern. It now also incorporates the Ramsar Convention on Wetlands, which aims to protect wetlands. We can now find references to the other conventions in each convention text and each promotes and respects both agendas. For example, the CBD produced a document to promote synergies between its national biodiversity strategies (NBSAPs) and the national adaptation plan (NAP) process of the UNFCCC (CBD, 2014).

The links between the Sendai Framework and SDG targets were also made apparent from the beginning: 25 SDG targets were specifically identified as related to disaster risk reduction (UNISDR, 2015).

UN Habitat's New Urban Agenda also contributes to the Sendai Framework. It calls for "strengthening the resilience of cities and human settlements, including through the development of quality infrastructure and spatial planning, by adopting and implementing integrated, age- and gender-responsive policies and plans and ecosystem-based approaches in line with the Sendai Framework for Disaster Risk Reduction 2015-2030" (UN Habitat, 2017).

Achieving the Sustainable Development Goals

The 2030 Agenda aims at achieving an equitable, peaceful and prosperous world and provides a global blueprint for people and the planet, now and in the future. Many international agreements aim to align with the 2030 Agenda, such as those adopted in the same year (2015): the Sendai Framework and the Paris Agreement of the UNFCCC (**Figure 4.2**).

Indeed, all the Sendai Framework targets relate to the SDGs (see **Annex 3**) and are critical for the achievement of the SDGs[19], in particular those related to reduction of disaster impact (SDGs 1 & 11) and disaster risk management (SDGs 11 & 13).

Furthermore, many of the national targets in the nationally determined contributions (NDCs) of the Paris Agreement reflect the global SDGs (see **Annex 3**; UNFCCC, 2017a). The NDC is the main instrument of the Paris Agreement: Parties establish self-reported targets for greenhouse gas reductions and adaptation targets to which they have committed.

Subsequent to the adoption of the SDGs, other environmental agreements also investigated how their targets matched up with the SDGs and could help achieve the 2030 Agenda. Given that a major pillar of the SDGs is combating environmental degradation, sustainable ecosystem management (i.e., nature-based solutions) is explicitly addressed under goals 1, 2, 4, 8, 9, 11, 14 and 15. DRR/CCA and resilience are mentioned in goals 1, 2, 4, 9, 11, 13, 14 and 15 (see **Annex 3**).

The above examples provide strong arguments to convince countries to mainstream and upscale NbS in their sustainable development agendas (see **case studies 4.1 and 4.2**).

see Annex 3

19 https://www.unisdr.org/files/50438_implementingthesendaiframeworktoach.pdf

CASE STUDY 4.1

Building with nature in Northern Java

The building with nature project in Northern Java, Indonesia, (see **case studies 2.7** and **3.8**), addresses SDG 6 on clean water and sanitation, 9 on industry, innovation and infrastructure, 11 on sustainable cities and communities, 12 on responsible consumption and production, 13 on climate action, 14 on life below water and 15 on life on land.

Source: https://www.ecoshape.org/en/projects/building-with-nature-indonesia/

CASE STUDY 4.2

Chile's climate action strategy

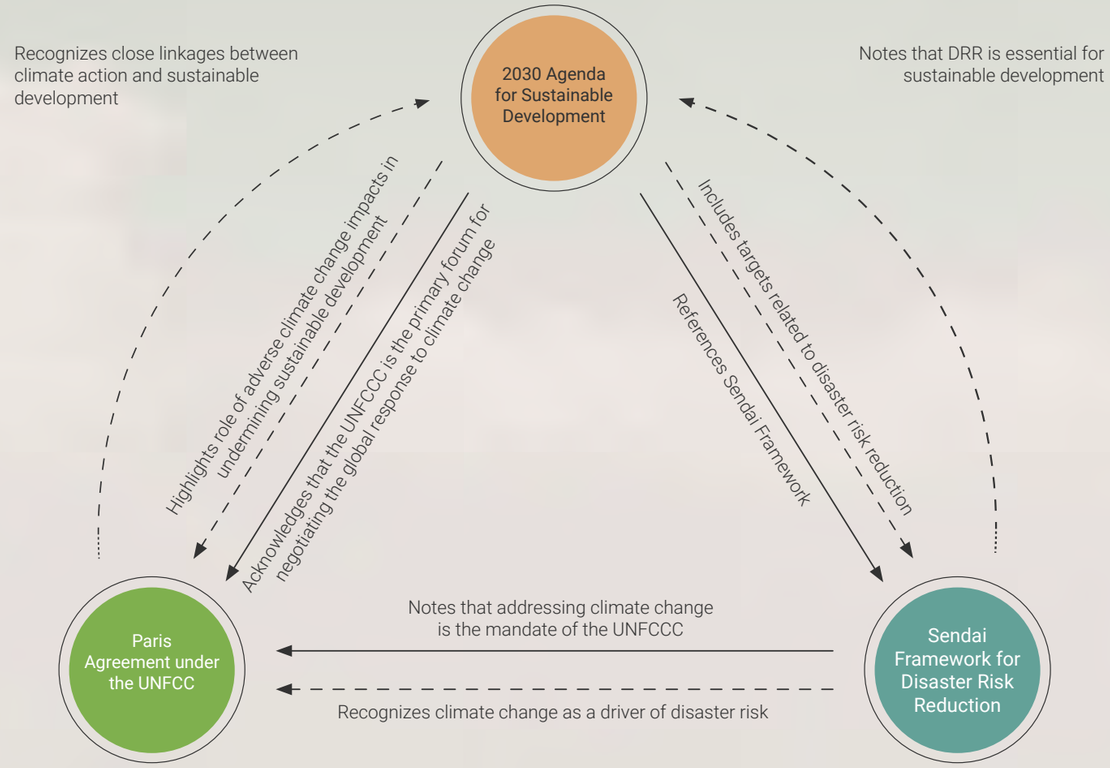
In its nationally determined contribution update of 2020[1], Chile highlighted as a climate action that "(by) 2030, (its) national policy for disaster risk reduction 2019-2030 will be fully implemented, and its content will be harmonized with the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the 2030 Agenda for Sustainable Development". This climate action is linked to an adaptation strategy that aims to strengthen the country's "capacity to adapt to climate-related risks and the capacity to manage the adverse effects of socio-natural disasters". Explicit links are made to SDG 11 on sustainable cities and communities and 13 on climate action. Nature-based solutions are emphasized as important to achieve the global goal on adaptation. The aim[2] is to enhance adaptive capacity and resilience and to reduce vulnerability, with a view to contributing to sustainable development.

Sources:
[1] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Chile%20First/Chile%27s_NDC_2020_english.pdf

[2] https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/new-elements-and-dimensions-of-adaptation-under-the-paris-agreement-article-7

FIGURE 4.2

Connections in the texts of the global agendas.



Source:
http://napglobalnetwork.org/themes/ndc-nap-linkages/



Climate change adaptation and disaster risk reduction

CCA and DRR, while separate at the policy level, are inexorably linked when it comes to implementation (see Doswald and Estrella, 2015).

A UNFCCC report identified two common themes that could be seen as an opportunity for integration between the CCA and DRR agendas: **resilience** and **ecosystems** (UNFCCC, 2017; United Nations Climate Change Secretariat, 2017)(see case **study 4.3**). As seen in Chapter 2, Eco-DRR and EbA are very similar approaches, and using NbS can achieve multiple goals at the same time, co-benefiting multiple sectors.

Moreover, integrating EbA as well as Eco-DRR into a DRR strategy helps advancing the NAP and NDCs process in countries. As mandated by the UNFCCC's Conference of the Parties (COP) 17 in 2011, NAPs represent the primary national strategy document for adaptation. NAPs are an iterative planning process that should be driven by the best available science. They therefore provide a key starting point for NbS integration. NDCs, which represent individual countries' commitments under the Paris Agreement and in most cases cover adaptation as well as mitigation, are normally aligned with or are supported and informed by the respective NAPs (where these exist). Given that 109 of the 186 intended NDCs submitted to the UNFCCC, as noted in Chapter 2, included ecosystem considerations in their visions for adaptation, with 23 countries explicitly referring to EbA, there is a foundation upon which further EbA integration efforts can build.[20]

20 UNEP, EbA Briefing Note 6. Integrating EbA into national planning , http://wedocs.unep.org/bitstream/handle/20.500.11822/28179/Eba6.pdf?sequence=1&isAllowed=y

CASE STUDY 4.3

Coherence between DRR and CCA using an ecosystem-based approach

A UN Environment Programme (UNEP) project in Tanzania is using a combination of grey and green infrastructure to combat coastal erosion, including both concrete seawalls and mangrove forests. The project has restored mangrove and coral habitats, both of which act as natural barriers and buffers against wave surges. The projects have rehabilitated around 1,000 hectares (ha) of mangrove habitat in Rufiji District (benefitting 31,500 people by providing flood defences and a habitat for fish species), another 1,260 ha across two sites in Zanzibar, and up to 3,000 m^2 of coral reefs (1,000 m^2 more than the target). The restoration was carried out using locally available, climate-resilient species. No-take zones were established with the goal to reduce deforestation by 40% in the restored sites. A network of 87 community groups was established in the project areas to manage the mangrove sites.

Source : http://wedocs.unep.org/bitstream/handle/20.500.11822/28427/EbA_Tanzania.pdf?sequence=1&isAllowed=y https://www.unenvironment.org/news-and-stories/story/rising-sea-levels-how-stop-city-sinking
Photo by UN Environment Programme / Hannah McNeish





A UNFCCC report (2017) on integration of DRR and CCA strategies concludes that the NAPs are probably the best place for integration because at any higher level "a fully integrated approach may be undesirable, as high levels of integration may undermine the ability of the various international policymaking processes to develop and pursue self-determined outcomes".

4.1.2 National policy

Coherence can be achieved by changing national planning processes and procedures (GNDR, 2019). For example, the Government of Luxembourg has an inter-departmental commission on sustainable development which coordinates the overall planning, implementation and monitoring of the National Plan for Sustainable Development to achieve the SDGs. The Dutch Action Plan for Policy Coherence for Development sets out goals linked to the SDGs, actions and indicators (EC, 2019). "Good legislation is critical to reducing disaster and climate risks. Law can set the stage for early warning, financing, community empowerment and accountability – or it can obscure and obstruct the necessary steps" (IFRC[21]).

As mentioned in Chapter 3, national laws are important mechanisms for ensuring not only DRR but also the inclusion of NbS in DRR policy. Moreover, they ensure an enabling environment for the mainstreaming and upscaling of NbS (see section 4.2).





BOX 4.2
The checklist on law and disaster risk reduction

This checklist by IFRC provides a prioritized list of 10 key questions that lawmakers, implementing officials, and those supporting them, need to consider in order to ensure that their laws provide the best support for DRR. It covers not only dedicated disaster risk management laws but also other sectoral laws and regulations that are critical for building safety and resilience, as well as the environment, land and natural resource management.

Source: https://www.ifrc.org/PageFiles/115542/The-checklist-on-law-and-drr.pdf

IFRC has created a simple check list on 'law and DRR' to help countries review their national legislation in relation to DRR (**Box 4.2**). The Capacity for Disaster Reduction Initiative (CADRI) (see Chapter 3) has a similar but more in-depth tool covering different capacity dimensions to help countries assess their capacity needs on DRR[22].

Also, the process of formulating and implementing NAPs can effectively support the implementation of enhanced adaptation action and the development of integrated approaches to adaptation, sustainable development and DRR (UNDRR, 2019). NAPs include the use of ecosystem and risk reduction perspectives in a landscape or systems approach, the consideration of economic, ecosystem and social costs and benefits, and the possibility to link different approaches under the NAP umbrella. EbA is explicitly listed as one of several approaches in the NAP technical guidelines for conducting vulnerability and risk assessments (UNDRR, 2019).

21 https://media.ifrc.org/ifrc/what-we-do/disaster-law/
22 https://www.cadri.net/

National DRR and CCA strategies

In reality the integration of DRR and CCA into legal frameworks remains the exception rather than the rule. Often, the responsibility for CCA lies within ministries of environment, without explicitly requiring them to coordinate with disaster risk management (DRM) institutions and vice versa. The number of countries that have integrated their DRR and CCA strategies has recently grown (UNDRR, 2019). Two examples are India, whose National Disaster Management Plan also includes to a certain extent climate change risk management under each hazard (National Disaster Management Authority, 2019), and Chile (see **case study 4.2**). A number of Small Island Developing States (SIDS) have also adopted integrated plans, particularly in the Pacific, including among others the Joint National Action Plan for DRM and CCA of the Cook Islands, the Marshall Islands, Niue and Tonga. The Kiribati Joint Implementation Plan (KJIP) is being updated to complement the National Disaster Risk Management Plan and the National Framework for Climate Change and Climate Change Adaptation, thereby adopting a new model of integrating CCA and DRR with development planning and resource management legislation (UNDRR, 2019). Other states have CCA strategies that integrate DRM, such as the Comoros' National Action Plan for Adaptation to Climate Change and Variability (OECD/World Bank, 2016).

In the Philippines, mainstreamed and aligned DRR and CCA goals are well reflected in policy plans across different levels. Climate change and the disaster risk reduction and management acts were introduced in 2009 and 2010, respectively, initiating DRM and CCA mainstreaming across policy planning and implementation. The process culminated in the establishment of a sophisticated and complex multi-level, cross-sectoral policy framework with oversight institutions, such as the Climate Change Commission (CCC). CCA and DRR plans and goals are translated across administrative levels and integrated in local plans (OECD, 2020; Sandholz et al., 2020).

Mainstreaming can only be achieved once NbS are recognized as a valid approach to address DRR and/or CCA concerns at the national and local levels (see case **studies 4.4 and 4.5**). There is an increasing number of guidelines that have been developed in the last few years for the implementation of NbS-type approaches, such as the qualification criteria, quality standards and indicators for EbA (FEBA, 2017), NbS for flood protection (World Bank, 2017), or more recently, the CBD voluntary guidelines for the implementation of ecosystem-based approaches for CCA or DRR (CBD, 2019). IUCN has also recently released a global standard for NbS, which explicitly aim to increase demand for NbS globally (see Chapter 2). This, combined with increased training and capacity-development activities, will allow NbS to be mainstreamed into decision-making processes related to CCA and DRR, further facilitated by the fact that the role of ecosystem-based approaches is recognized in international agreements.

Upscaling, on the other hand, will only be possible on a case-by-case basis. NbS have to be developed taking into consideration site-specific natural and cultural contexts (IUCN NbS Principle 3, Cohen-Shacham et al., 2016) (see Chapter 2, **Table 2.2**) and have to be deployed at the landscape scale and/or integrate landscape-scale processes in their design (IUCN NbS Principle 6, Cohen-Shacham et al., 2016). The consequence of adhering to these principles implies that all natural, social, economic and cultural processes need to be considered before attempting to upscale existing approaches.

see Table 2.2

CASE STUDY 4.4

Mainstreaming adaptation in water management for flood protection in Isola Vicentina, Italy

To reduce Isola Vicentina's flood risk a municipal water management plan that integrated climate change adaptation into its water management policies was elaborated. Such plans are coordination tools between municipalities and land reclamation authorities: in the case Isola Vicentina, the idea was to elaborate a local flood adaptation plan that combines prevention, protection and preparedness goals and strategies, considering future climate change impacts on flood patterns. Among the around 50 protection measures identified were NbS measures, such as new retention areas and a 10-hectare pilot area to simulate how the preservation of woodlands can improve the resilience of the municipal territory to flooding and landslides.

Stakeholder participation by means of public workshops was a key factor for collecting feedback on proposed measures, deciding on locally suited flood risk reduction measures and raising flood risk awareness.

Source:
The European Climate Adaptation Platform Climate-ADAPT. https://climate-adapt.eea.europa.eu/metadata/case-studies/mainstreaming-adaptation-in-water-management-for-flood-protection-in-isola-vicentina

CASE STUDY 4.5

Nature-based measures against rockfalls in Switzerland

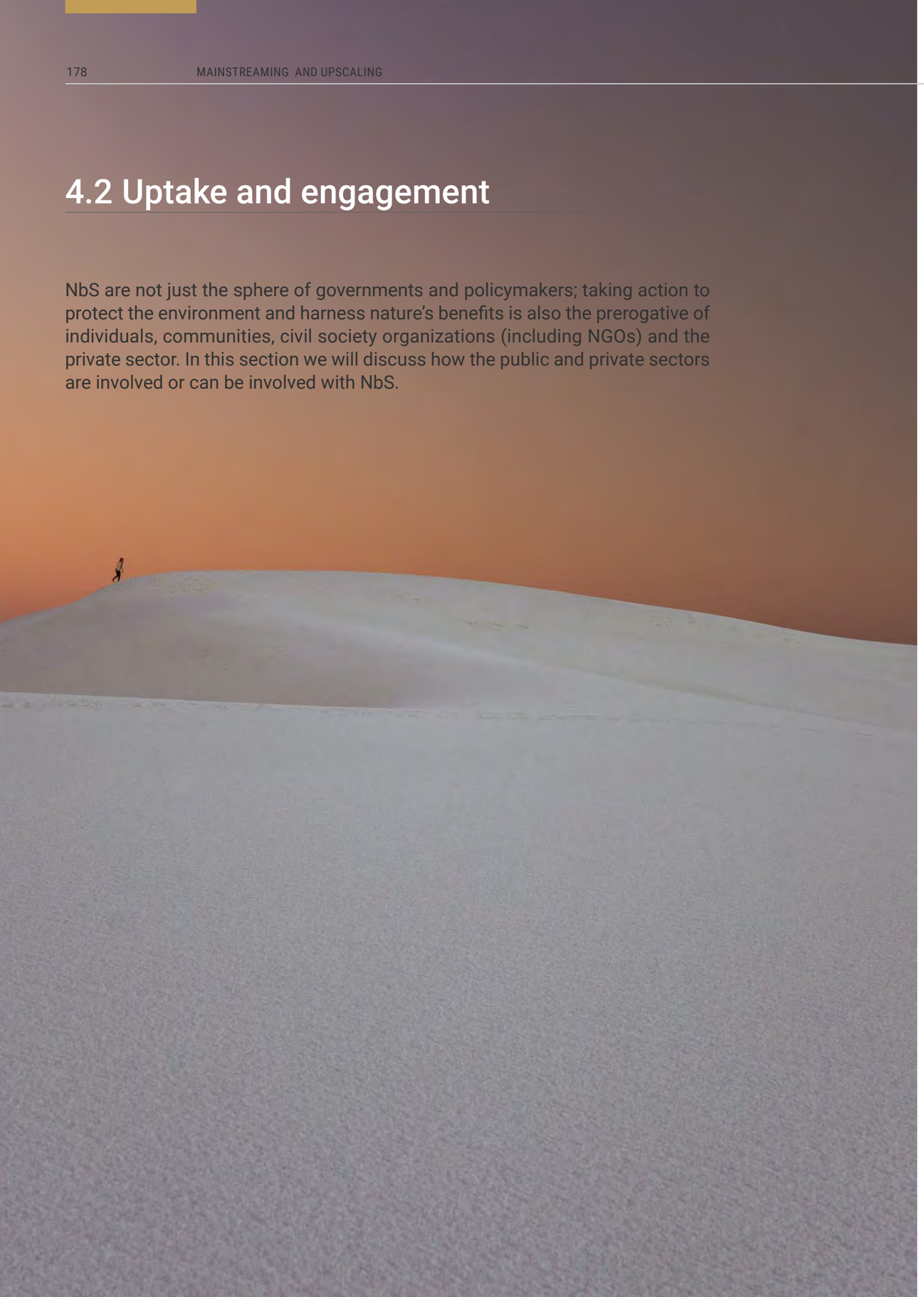
Fuorn Pass road, near Zernez in the Engadin region in Switzerland, is an approximately 800-metre-long stretch of road prone to rockfalls, which are likely to be exacerbated by climate change. To determine the potential of nature-based protection services, like forests, the 'protect bio' method was applied by the Federal Office for the Environment (FOEN). The method was developed to determine the effect of the forest and other biological protection measures and to take them into account accurately in hazard protection projects. One aim was to evaluate the degree to which forest protects against natural hazards and whether there was a need for implementing engineered protective measures, like barriers or nets. One finding was that technical and more expensive measures (such as nets) are only needed in stretches of the road where the forest is thin.

Given their efficacy, Switzerland has adopted protection forests in law and in practice, with subsidies and guidelines for cantons (administrative units of the country) to manage protection forests.

Sources:
1. The European Climate Adaptation Platform Climate-ADAPT. https://climate-adapt.eea.europa.eu/metadata/case-studies/nature-based-measures-against-rockfalls-over-forests-in-the-engadin-region-switzerland
2. www.bafu.admin.ch/uv-1817-f

4.2 Uptake and engagement

NbS are not just the sphere of governments and policymakers; taking action to protect the environment and harness nature's benefits is also the prerogative of individuals, communities, civil society organizations (including NGOs) and the private sector. In this section we will discuss how the public and private sectors are involved or can be involved with NbS.



4.2.1 Civil society

NGOs and civil society play a large role in promoting and implementing NbS. Behavioral change at the individual and institutional level is required for change to occur. At the global level, the Partnership for Environment and Disaster Risk Reduction (PEDRR) is a partnership of over 27 organizations dedicated to providing knowledge, training, advocacy and practice on Eco-DRR. Friends of Ecosystem-based Adaptation, or FEBA, is a sister group to PEDRR on EbA. More than 60 government ministries and sub-agencies, UN bodies and conventions, NGOs, research centers and other institutions make up FEBA.

The Global Network of Civil Society Organisations for Disaster Reduction (GNDR) is the largest international network of organizations committed to working together to improve the lives of people affected by disasters worldwide. They asked approximately 100,000 local stakeholders about the role of ecosystems in protecting communities against hazards, and the need to consider, restore and manage these ecosystems in their resilience-building activities. Communities were asked if they considered including ecosystems while implementing development plans.

As can be seen in the **Figure 4.3**, almost 56% of the respondents stated that the ecosystems protect them from hazards. However almost 61% of the respondents stated that ecosystem-based approaches are either not considered or considered only to a limited extent in the process of building communities' resilience. In addition, almost 50% of the communities surveyed identified a clear link between ecosystem degradation and development works, further reinforcing the evidence that considerations about ecosystem conservation are not integrated into development plans and actions.

This data shows that there is awareness on the role of ecosystems in DRR, although respondents recommended that more effort should focus on education and awareness-raising activities, especially at community level. Moreover, respondents noted that ecosystems are underutilized and more needs to be done to mainstream ecosystem-based approaches into DRR policy and practice, both at community level and national level. There is therefore an opportunity to scale-up NbS at the community level.

FIGURE 4.3

GNDR's Views from the Frontline 2019 data on ecosystems and risk, www.vfl.world



Community involvement

On the frontlines of disasters, preparedness and disaster risk reduction activities are undertaken by individuals, women, men, children and communities. Flood and drought zones often overlap with areas of high poverty and low access to essential services such as water and sanitation. Thus, climate change and disasters disproportionately impact the poorest, deepening existing inequities. With temperatures rising globally, together with water scarcity and water and air pollution, children will feel the deadliest impact of water-borne diseases and dangerous respiratory conditions. Currently, over half a billion children are living in areas with extremely high levels of flood occurrence, and nearly 160 million live in areas of high or extremely high drought severity (UNICEF, 2015).

The needs of all should be taken into account in DRR, especially those that are often marginalized. Many civil societies and intergovernmental organizations (IGOs) aim to fill this gap. As part of the effort to involve those on the frontlines, they catalogue work and ideas for communities to reduce their risk and reap the benefits by applying nature-based solutions.

Community-based projects on NbS for DRR or CCA can be developed and led by NGOs and IGOs but many of them are initiated by local grassroot organizations (see **case study 4.6**). As described in case studies of chapters 2 and 3, local communities have an important role in management and maintenance of NbS. Specifically, water-related NbS need to include stakeholders living and working in the river basins or deltas, such as civil society and community-based organizations. Their engagement and 'buy in' (or 'sense of ownership') is critical for viability and sustainability of NbS.

Community-based projects need to demonstrate their benefits to the community, as well as promote inclusive decision-making and engagement as they may otherwise not work nor promote sustainability (Richerzhagen et al., 2019; UNEP, 2016).

CASE STUDY 4.6

The Green Belt Movement

The Green Belt Movement (GBM) is a broad-based grassroots organization in Kenya, whose main focus is poverty reduction and environmental conservation through tree planting. The organization grew out of an idea by Nobel Peace Prize winner Professor Wangari Maathai in 1976, when she was serving on the National Council of Women, to introduce community-based tree planting.

Since 1977, GBM communities have planted over 51 million trees in Kenya, in watersheds in the highlands of Mt. Kenya, the Aberdare Range and the Mau Complex, three of the country's five major mountain ecosystems, as well as on private lands. GBM also plants trees on public lands, together with institutions such as faith-based groups and schools and has a partnership with the Kenya Army to help access remote areas for tree planting on army lands.

Source: Green Belt Movement;
http://www.greenbeltmovement.org/











There may be social costs and benefits to such projects. As indicated in Chapter 2, land ownership and opportunity costs to landowners can be an important barrier or source of contention. Richerzhagen et al. (2019) reviewed the social costs and benefits of two NbS projects in Colombia. They found that perceived benefits outweighed the costs and that the greatest benefit was invariably increased knowledge and capacity as well as improved livelihoods. Social costs relate to unsatisfied expectations, social tension and unequal distribution, which therefore need to be managed in any project.

Improved livelihoods occur through provision of extra food, such as fish and fruits, and other provisions like timber and fresh water. Also, trees provide shelter, shade, etc. It has been observed from projects undertaken that when these benefits are observed by community members, there is incentive to further plant and maintain trees or to replicate the work (UNEP, 2016; see **case study 4.7**). Survival rates of planted trees depend on the local context, the ecological backdrop/ knowledge, and safeguarding from grazing animals.

It is also important in community-based projects to secure the support of local authorities and have stakeholder input and participation at all levels (see **case study 4.8**).

Inclusiveness is essential in DRR and in Eco-DRR. Ensuring inclusiveness by, for example, taking into account the views and circumstances of all gender and ages, minorities and disabilities, as well as planning for their needs, ensures that "no one is left behind" when disaster strikes. Furthermore, when dealing with the restoration and management of natural resources for DRR, involving all members of the community can help reduce conflict and ensure sustainability in the long term.

CASE STUDY 4.7

Local community implementing EbA interventions in Cambodia

Under a forest restoration project led by UNEP in Cambodia's Kulen mountain area, local community members are paid a salary to look after a tree nursery. The forest restoration was carried out using multi-use native tree species that provide food, erosion control, timber, medicine and fruit. The project planted trees alongside 2,200 hectares of rice paddies to reduce erosion and enhance soil productivity. The project sites are extremely vulnerable to climate change due to increasingly erratic rainfall, where dry seasons are getting drier and wet seasons are wetter, causing devastating floods and droughts.

Thy is one of 10 community members elected by the community to look after the tree nursery. She is paid around US$7.50 a month to do so, but some days she spends four hours weeding, watering and tending to the seedlings. The community has started sharing seedlings with another village in the area that has seen the community protected area's success at reforestation and set up its own tree nursery to grow seedlings of rare species to restore other cleared areas. In the local school, children are learning about climate change and the importance of maintaining the forest cover. Thy has already taught one daughter how to produce seedlings. "I tell her she needs to care for trees and they will care for her, like by providing materials to build a house, and I tell her that when you protect the trees and the forest, they bring you rain and make the weather cooler," she said.

"I am committed to this work because I want the next generation to have trees, and some species have already disappeared," she said. Thuch Ron, who heads the village of Chuop Tasok's community protected area, is very pleased about the training that he and his team received to produce seedlings and is inspiring other villages and generations to restore their areas. "I am proud to have set up this nursery in Cambodia, at the top of the mountain. And I'm proud to have brought the rain back," he said.

Source:

https://www.unenvironment.org/news-and-stories/story/im-proud-have-brought-rain-back-reforestation-revives-cambodian-mountains

https://www.unenvironment.org/news-and-stories/story/seeding-future-school-children-cambodia-pave-way-climate-adaptation

https://www.unenvironment.org/news-and-stories/story/rice-riches-adapting-climate-change-cambodias-coasts

http://wedocs.unep.org/bitstream/handle/20.500.11822/28423/EBA_Cambodia.pdf?sequence=1&isAllowed=y



Women are seen weeding saplings at a tree nursery on Kulen Mountain in Cambodia.

CASE STUDY 4.8

The Feri-Feri hill story

Communities living along the Feri Feri hill, in the Niger region of Tillaberi, pioneered an ecosystem-based approach to try and reduce the risk of floods. The Feri-Feri hill, once a lush green area, had been heavily degraded by unsustainable development works and the impact of climate change. No trees means no way to stop the speed at which rainfall water runs down into the main town in the foothills; a green hill means not only a better environment, but also reduced impact of flooding.

The community, through discussions and consultation with local authorities, local leaders, the elderly and technical experts, designed an environmental restoration plan, which would serve also as a DRR plan. Environmental restoration activities were coupled with income-generating activities, mainly linked to the production of straw to be used for cattle feeding.

All activities are coordinated by the ADPE Bonferey group, a group led by community members and local authorities. Securing support from local authorities was crucial, as the government was instrumental in ensuring that the land acquisition process ran smoothly. In addition, all activities run by the group are in line with the local development plan. Communities' determination and engagement (achieved by ensuring their buy-in on the activities) shows a common understanding of the importance of these activities in the long term, but also a recognition of the short-term benefits of the environmental restoration activities.

Source: https://cbdrm.org/recipes/protection-restoration-feri-feri-hill/



Women and nature-based solutions

Women can be stewards and agents of change with respect to NbS (Sudmeier-Rieux et al., 2019), as seen in the case study 4.6 on the Green Belt Movement. In some countries, women are directly involved in natural resource management and can therefore have an immediate impact on the environment they live in However, it is important not to increase the burden on women, who may already share a disproportionate part of the work (Richerzhagen et al., 2019), but find solutions that are tenable in the long term. Having women as part of the decision-making process, ensuring the material benefits are for them and have them involved in every stage of DRR provides win-win situations by reducing vulnerability and sustaining livelihoods (see case **studies 4.9 and 4.10**).

UNEP developed a checklist for Eco-DRR and gender to help make gender-responsive Eco-DRR projects and/or policies that consider the nexus between ecosystem management and DRR (see Sudmeier et al., 2019). This checklist serves as a guide for projects and not as just a checkbox system to label a project as gender sensitive.

CASE STUDY 4.9

Women and Eco-DRR in Sudan

A 2012-2015 project funded by the European Commission, which was led by UNEP and Practical Action Sudan and partnered by local communities and government, won the 2017 Land for Life Award – granted by the UNCCD every two years. The award was for improving food security and disaster resilience and reducing community tensions through sustainable management of dryland areas of North Darfur. Women were involved in every stage, from planning to training and implementation.

Natural resource management and rehabilitation of the landscape through community forests and planting were important components that were managed by women to support community forestry and household agroforestry, while re-greening the landscape.

Source: UNEP 2016a; photo ©UNEP 2015

CASE STUDY 4.10

Women in Viet Nam are crucial in mangrove plantations and as teachers of DRR

Between 2011 and 2015, thousands of women planted hundreds of thousands of mangrove saplings in 100 selected communes along the coast of northern Viet Nam with the support from the Viet Nam Red Cross, the Japanese Red Cross and the International Federation of Red Cross and Red Crescent Societies (IFRC). The aim was to reduce the impact of typhoons and storm surges. Because many women were skilled in rice planting, they could more easily plant mangroves.

In addition, over 15,000 teachers, 90% of whom were women, from 200 selected primary schools, reaching potentially half a million children and their families, received instruction on disaster preparedness, protecting their lives, properties and facilities before, during and after a disaster event.

Source: https://www.unwomen.org/-/media/headquarters/media/publications/en/iddr2012vietnambookhumaninterestst orieseng.pdf?la=en&vs=945



Youth, children and nature-based solutions

Children are one of the most vulnerable groups to the impacts of climate change, yet they are rarely consulted. Children furthermore rarely participate in decision-making processes or in the design and content of climate policies that directly affect their lives (UNICEF, 2019). However, children are not just a vulnerable group; environmentally aware children are potentially the greatest agents of change for the long-term protection and stewardship of the Earth. Acknowledging the importance of children's agency and establishing a series of activities and forums for ensuring their participation is helpful. Additionally, children often have a better understanding of the science of climate change processes than adults in the community due to their school lessons, and they can draw out the implications for local livelihoods (Mitchell & Bourchard, 2014; Reid et al., 2006).

The Paris Agreement represents an important step forward, acknowledging that children's rights should be considered in the context of action to address climate change. Children need to not only be given access to the knowledge to better understand climate change impacts and solutions, but also the right to meaningful participation, influence and voice enabling and empowering them to affect change.[23] The September 2019 climate strikes "Child-led Advocacy", also known as the Global Week for Future, were a series of international strikes and protests to demand action to address climate change. They took place across 4,500 locations in 150 countries, inspired by then 16-year-old Swedish climate activist Greta Thunberg. The Sendai Framework also acknowledges the importance of engaging with all people, including children, highlighting that, "Children and youth are agents of change and should be given the space and modalities to contribute to disaster risk reduction." To help children and youth understand DRR, a child-friendly publication[24] was developed in consultation with children by the Children in a Changing Climate coalition (ChildFund Alliance, Plan International, Save the Children, UNICEF and World Vision).



Within the scope of DRR, youth groups take part in regional and global platforms. For example, the United Nations Major Group for Children and Youth's (UNMGCY) Disaster Risk Reduction Working Group is a dynamic, international network of young people and organizations bringing about change in the world. Furthermore, UNDRR has developed a 'Words into Action' guideline on engaging children and youth in DRR [25] which contains a section on environment. This section gives some ideas of how youth and children can get involved in DRR. Youth can be involved in many different Eco-DRR activities, as seen in the case study from Sri Lanka (**case study 4.11**).

23 Conventions of the Right of the Child (1989). Articles 12-15

24 https://www.preventionweb.net/educational/view/46959

25 https://www.undrr.org/publication/words-action-guidelines-engaging-children-and-youth-disaster-risk-reduction-and







CASE STUDY 4.11

Youth and Eco-DRR in Sri Lanka

A project led by ChildFund, an international child development organization, and funded by ChildFund Korea, with technical support from IUCN, seeks to improve the resilience of children and youth to disaster risks by involving them in implementing nature-based approaches at the community level.

In 26 villages, youth groups were approached or formed to take part in disaster risk reduction activities along with adults. Children and youths between the ages of 13 and 29 participated.

Activities included a participatory risk assessment in the village after which, an overall action plan for risk reduction was drawn up and appropriate actions selected to implement it. Other activities include capacity-building efforts and the development of emergency response plans.

The field interventions ranged from establishing bio-fences (lines of trees including bushes planted to demarcate the village or forest boundaries) to keep animals out and avoid human-animal conflict to renovating ponds to reduce flood and drought risks.

Source: IUCN Sri Lanka

The right of every child to quality education is becoming widely recognized as a universal right and an important predictor of economic growth, human development and poverty reduction (UN, 2015). While considerable progress on education access and participation has been observed over the past decade[26], leading to an increase in children attending schools, many children are still unable to realize this right due to the impact of natural and other disasters on the education system. Nearly 40 million children a year have their education interrupted by the impact of natural hazards such as earthquakes, typhoons and disease outbreaks[27]. In the Asia-Pacific region alone, Save the Children estimated that, considering the unprecedented climate trends and predictions, around 200 million children per year will have their lives severely disrupted by disasters in the coming decades[28]. Beyond the physical and psychological impact on children, school disruption has a lasting effect on children's education (Hallegate et al., 2016)[29], disproportionately impacting girls as climate-related disasters increase gender-based violence (GBV), trafficking and child marriage (IUCN, 2020).

Children have a unique understanding and knowledge of their environments, their lives, their needs and their aspirations, with research showing that care and concern for nature in adulthood grow out of childhood experiences (Chawla, 2007). Eco-DRR in schools, with active participation of children, will generate the double benefit of maintaining the connection between nature and children, while empowering children and increasing the safety of their schools. This could help increase the chance of their learning continuing when disasters strike. It is envisioned that children in schools protected by Eco-DRR initiatives will have the skills to contribute to greener and more inclusive societies. Increased knowledge will enable children and youth to be agents of change by taking a leading role in community-based adaptation activities and becoming climate change educators within their communities.

Many Eco-DRR and other NbS activities can be carried out with children, such as tree planting, slope stabilization by re-vegetation, developing and maintaining tree nurseries, rainwater harvesting, roof-top gardens, school-level local food growing practices. Children can also be involved in environmental mitigation activities, such as solid waste management, including segregation at source, re-use and re-cycling, and efficient uses of electric light in schools and homes to instill good environmental standards (see **case study 4.12**). It is essential that children participate from design to implementation and in the monitoring of adaptation activities.

CASE STUDY 4.12

Children and CCA in Vanuatu

In Vanuatu, a project funded by USAID Pacific American Climate Fund (PACAM) and led by CARE International and Save the Children aimed to sensitize children to climate change adaptation. The overall goal of the 2016-2017 project was to increase the resilience of communities, especially children, young people, boys and girls, to shocks, stresses and future uncertainty resulting from climate change. Environmental mitigation activities undertaken in schools and communities included:

- Piloting climate-resilient agricultural demonstration plots in schools and communities (replanting hybrid plant cuttings);
- Using solar dryers to preserve food ahead of the cyclone season;
- Re-using water and cooking scraps to increase the nutrient levels of their soils.

Source**:** USAID, CARE and Save the Children, November 2017.

26 SDG progress report, goal 4

27 Their world report 2018: Safe Schools: The Hidden Crisis A Framework for Action to Deliver Safe, Non-violent, Inclusive and Effective Learning Environments

28 Education Disrupted, Save the Children, 2015

29 Hallegatte et al (2016) Shock Waves: managing the impacts of climate change on poverty (https://openknowledge.worldbank.org/handle/10986/22787) at p.80 and 97 for likelihood of completing schooling when its disrupted, even for short periods

4.2.2 Private sector

The private sector plays a critical role in advancing DRR and CCA by investing in the support of ecosystems and biodiversity (IUCN, 2012; UNDRR, 2015; CBD, 2019; Prabhakar et al., 2019; Sudmeier-Rieux et al., 2019). In helping to scale-up action on NbS, the private sector will also be important (WBCSD, 2019b).

From a business perspective, there are two main reasons why engagement in adaptation and risk reduction, in general, is attractive: 1) managing risks or 2) capitalizing on business opportunities (AC, 2019; IISD, 2019).

Risks to businesses

Risks can be direct or indirect. Direct climate-related risks affect core business operations through physical impact. For instance, extreme weather events can damage physical assets or affect supply chains and employees and thereby cause business disruption. Sectors that are particularly at risk are those that are directly dependent on natural assets, such as agriculture, infrastructure operators and tourism.

Indirect climate-related risks result from changes in market conditions (i.e. regulations, technology and market dynamics) and changes within a supply chain, for instance, through challenges to production and increased competition for some resources. Another indirect risk is the reputational risk from not responding adequately to the threat of climate change because reputation on climate action is increasingly valued by customers. In general, indirect climate risks are becoming a serious challenge for private actors of all sectors (Mc Kinsey, 2015; Hegger et al., 2017; Cochu et al., 2019).

Opportunities to businesses

In addition to avoiding damage and losses, adaptation and risk reduction efforts offer a wealth of opportunities to the private sector. Aside from decreasing indirect risk and building a company's corporate reputation, the main opportunities come from capitalizing on new emerging markets by offering new products and services, improving operations and competitiveness (AC, 2019). For example, the demand for green resilient urban development has provided many innovative and profitable urban hybrid NbS business ventures (see for example UNDRR 2013, 2015).

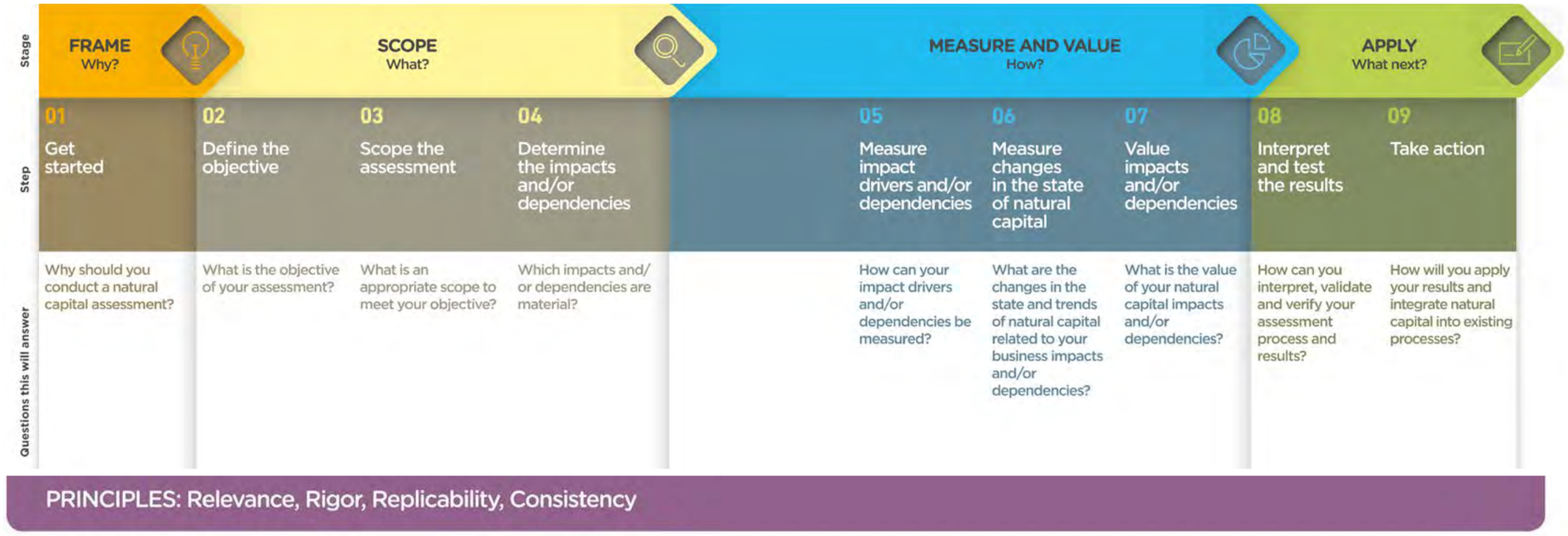
NbS can also be an attractive means for the private sector to reduce disaster risk, address business opportunities and boost their reputations through investing in ecosystems and biodiversity, or so-called natural capital – the stock of renewable and non-renewable natural resources providing a service to businesses and communities (see **box 4.3**).

All businesses are to some extent dependent on nature and the impact of nature. The increasing pressure the world is putting on natural resources means there are more risks and opportunities for all elements of business management, including supply chains, resources, land use, reputation, etc. Understanding businesses' dependencies and impact enables business leaders to make more informed decisions about managing these risks and the potential benefits of investing in natural capital and NbS.

The Natural Capital Protocol[30], produced by the Natural Capital Coalition, a global leader in mainstreaming natural capital approaches in the private sector, has developed a decision-making framework to identify, measure and evaluate direct and indirect impacts and dependencies on natural capital (**Figure 4.4**).

FIGURE 4.4

Natural Capital Protocol Framework by Natural Capital Coalition (sourced from We Value Nature)



30 https://naturalcapitalcoalition.org/natural-capital-protocol/

BOX 4.3
Reasons to engage in natural capital and nature-based solutions

- Understand relationships with nature in a structured way
- Challenge your business model
- Mitigate risks
- Increased competitive advantage
- Create opportunities
- Inform decisions that are really important to your business
- Access to finance
- Recruitment and retention of staff

Source: Natural capital protocol; sourced from We Value Nature.

Once the relationship between a business and natural capital is understood, decisions can be made. The main risks to businesses due to their relationship with nature are operational risks from biodiversity loss, reputation and societal risks, legal risks (e.g., environmental liability) and financial risks. Mitigating these risks and turning them into opportunities can create competitive advantages (see **case study 4.13**).



CASE STUDY 4.13
EDP and fire management in Portugal

EDP – ENERGIAS DE PORTUGAL, S.A.P. is the largest generator, distributor and supplier of electricity in Portugal. A large part of its infrastructure is found in the wilds and uses nature's services; an example is its hydroelectric dam in the Sabor Valley. The reservoir for this dam falls within two of the European Union's 'Natura 2000' protected areas and there were large legal risks to the project. Compensation measures had to be applied to protect biodiversity as an integral part of its management. The area also extended across the land of over 2,000 owners.

EDP developed a biodiversity conservation plan that recognized the environmental and socioeconomic benefits of preserving natural capital. It included a fire hazard reduction plan with four strategic pillars: infrastructure improvement/creation; forest fuel management; fire surveillance, and; dissemination, interaction and collaboration with local and national authorities. This integrated fire management is a nature-based solution (see Chapter 2) for reducing fire hazard.

This nature-based solution was cheaper than conventional alternatives, with the additional benefit of creating local jobs and fostering rural development. Furthermore, the approach was extremely effective, decreasing the number of hectares burnt in forest fires in the Sabor Valley from an average of 210 a year to just 14 after the plan was implemented in 2013, and with an 86% reduction in the area of high-value habitats – those that are important for biodiversity – that were burned and with a 78% decrease in the number of fires. As a result, EDP was commended by the State Authority for Fire Management for excellence in practice.

Source: **EDP's natural capital story** by **We Value Nature** sourced from We Value Nature and licensed under Creative Commons Attribution 4.0.

Until now, the private sector has been engaged in NbS in many ways, from implementation and financing to contributing with research and awareness-raising programmes to the success of ecosystem conservation and restoration. A typology that categorizes the role of the private sector in NbS is introduced here (see **Table 4.1**).

TABLE 4.1

Typology of the roles of the private sector in NbS engagement (own typology, drawing on (OECD, 2016b; OECD, 2016a; Schaer and Kuruppu, 2018)

Typology - The role of the private sector in nature-based solutions
Implementation - The private sector takes part in the implementation of ecosystem restoration and conservation activities and thus supports both its own risk reduction and adaptation and that of others. It can be an organizer, participant or non-financial resource provider in such activities (direct engagement).
Finance – The private sector is supporting NbS by providing financial resources for the implementation of activities related to ecosystem management, conservation and restoration (indirect engagement).
Knowledge & Information – The private sector is supporting NbS by engaging in education and awareness raising, conducting research or providing expertise (direct or indirect engagement).

Resources for the private sector

- We value nature campaign https://wevaluenature.eu/
- World Business Council for Sustainable Development https://www.wbcsd.org/
- The Natural Capital Coalition https://naturalcapitalcoalition.org/
- TNC (2019): Strategies for operationalizing nature-based solutions in the private sector. https://www.preventionweb.net/publications/view/66907
- European Investment Bank (2019): Investing in Nature: financing conservation and nature-based solutions. https://www.eib.org/attachments/pj/ncff-invest-nature-report-en.pdf

Enabling environment for private sector engagement in NbS for DRR/CCA

In making decisions regarding NbS, businesses are influenced by and depend on the general socio-economic and political context in which the decisions are taken.

As governments commit to achieving the SDGs and the Paris Agreement, the need to finance climate-resilient solutions also creates a demand for investment and delivery by the private sector. Without a market for NbS, the private sector will not be fully engaged. This demand depends, sometimes to a large degree, on national and local policies, legislation, codes and regulations. Pro-green policies, tax policies and financing schemes and instruments for funding green investments are important regulatory and incentivizing mechanisms. In some cases, however, donor support may be needed for a country to start developing greener measures.

In order to increase the amount of private sector action and finance, several strategies have been outlined that address challenges to successfully implementing NbS by creating an enabling environment (GCF, 2019). To engage the private sector, underlying enabling conditions need to be addressed. The following non-exhaustive list includes some key points:

- **Regulatory & legislative**: Policies and regulations that enable and incentivise private sector engagement in adaptation and risk reduction through NbS, including improved land use planning (Naumann et al., 2011; Morgado and Lasfargues, 2017; WBCSD, 2017; AC, 2019; Fayolle et al., 2019; GIZ, 2019b).

- **Capacity & awareness:** The integration of NbS into business training curricula and corporate sustainability programmes as potential enabling factors for anchoring NbS in the private sector (ATCP, 2010; Fayolle et al., 2019; IDB, 2019); supporting individual businesses in resilience building (Cameron et al., 2018); educating businesses on the potential of addressing risks and opportunities through NbS (PwC and DFID, 2013).

- **Structural & contextual:** Engaging the private sector in adaptation planning processes, such as national adaptation plans (NAPs) (Crawford and Church, 2019; IISD, 2019); reduce the complexity of organizational structures related to ecosystem management (Naumann et al., 2011).

- **Financial:** Designing financial products, such as insurance or environmental and social impact bonds as well as access to public funding (AXA Group and WWF France, 2019; Mak, 2019).

The following provides a number of examples of useful products that have been successfully implemented in practice.



REGULATORY & LEGISLATIVE:

Regulations can require that environmental considerations be taken into account in development. For example, environmental impact assessments and reasonable alternatives to proposed measures are required by European Union law[31].

Taxation of non-green alternatives or reduced taxation of green alternatives is a way for incentivizing the private and public sectors to invest in nature-based solutions. Incentives can play a very important role. In Switzerland, for instance, investing in nature-based solutions is incentivized through subsidies (see **case study 4.18, section 4.3**).

see case study 4.18

CAPACITY & AWARENESS INSTRUMENTS:

Corporate social responsibility (CSR) programmes within companies are an important way for the private sector to engage with the environmental sector on sustainable development. But CSR programmes also make good business sense.

CSR covers a wide range of aspects that should be taken into account when managing a company. CSR programmes are dependent on compliance with rules and the stakeholder interests, which means that sometimes CSR actions go above and beyond compliance. For example, the telecommunications company Ericsson undertook a project as part of its CSR to rehabilitate and monitor up to 10,000 mangrove seedlings by 2020 in Malaysia. This project won the United Nations climate change award at UN Climate Conference in Marrakech[32].

Biodiversity offsets are a kind of CSR activity, where a company will invest in the conservation/restoration of an area to compensate for any unavoidable biodiversity loss resulting from its activities. The goal is no net loss of biodiversity and ideally companies should strive for net gains. This is one mechanism by which land degradation in a country can be reduced and measured. In fact, the Land Degradation Neutrality (LDN) agreement under the United Nations Convention to Combat Desertification requires offsets by public and private actors to achieve LDN.

A company's sustainability goals can be another major reason to invest in NbS. These could relate to cost-saving choices; for example, investing in a constructed wetland instead of a waste-water treatment plant, or responding to sustainability needs, whether for production purposes or for disaster risk reduction reasons. Social, environmental and governance criteria have emerged to help investors (Sloan et al., 2019).

Partnerships between companies and public entities can create win-win situations for sustainability when good environmental functioning is essential for a companies' production. If a company relies on water delivery from a catchment area for its production, it is important that the catchment is sustainably managed. For example, Volkswagen partnered with the Comisión Nacional de Áreas Naturales Protegidas (CONANP, or National Commission of Natural Protected Areas), Mexico's national park service, to restore the upland watershed in IztaccíhuatI-Popocatépetl National Park to ensure better water flow (USAID, 2018).

31 https://ec.europa.eu/environment/eia/index_en.htm
32 https://www.ericsson.com/en/news/2016/9/ericsson-mangrove-boosting-project-in-malaysia-wins-prestigious-un-award

STRUCTURAL & CONTEXTUAL

Public-private partnerships (PPPs) have also been used and are a way to create bridges with the private sector for climate resilience and green infrastructure projects (USAID, 2018). PPPs have often been used by cities to achieve their green objectives (Merk et al., 2012).

PPPs are long-term contracts between government and private stakeholders wherein the private stakeholder provides services traditionally delivered by the public sector. There are two main types of PPP arrangements: concessions or private finance initiatives (PFI). Concessions mean that the users of the service/infrastructure pay the company, which is interested in making a return. For example, a PPP focused on improved water management through green infrastructure would generate income to the concessionaire through property owners' water fees (USAID, 2018).

A PFI means that the government pays a corporation to make a service/infrastructure available, with agreements often tied to performance standards (Merk et al., 2012). For example, if a city wants to reduce its water consumption, this could mean that the supply company receives less money from water usage. So, the government pays extra to cover that loss in income because it is more environmentally friendly, enabling the company to meet standards without losing revenue.

FINANCIAL PRODUCTS AND SERVICES

As stated earlier, there needs to be demand for a market to develop and prosper and generate revenue. There are a few financial and insurance products and services that relate directly to NbS for DRR/CCA. There are more when it comes to general green products, such as carbon trading (see UNEP, 2007).

Insurance

There already exist types of insurance which can be leveraged for NbS. One of these is *environmental liability insurance*. Because environmental legislation is evolving due to government commitments to the SDGs and other global environmental targets, companies see their potential exposure to environmental liability increasing. As a result, they are increasingly seeking to include this coverage when they work internationally.

Climate-risk insurance can cover individuals, businesses or even countries for damage caused by extreme events. Weather insurance can be especially useful in reducing farmers' exposure. However, uptake by farmers does not always follow (Carter et al., 2014; Awojobi, 2018).

Innovative insurance schemes linked to natural ecosystems are currently being explored and created (see **case study 4.14**).

Insurance can also help make investment more attractive and enable more nature-based solutions by removing some of the risk. For example, in the Netherlands, the construction of a nature-based dyke next to a World Heritage Site was supported by Swiss Re with a 'Construction All Risks' (CAR) policy – which protected the project and operators from accidents and damage, ensuring project completion.[33]

33 https://www.swissre.com/our-business/public-sector-solutions/our-solutions/nature-based-solutions/world-heritage-site-nature-based-solution-leads-way-reducing-risk-rising-sea-levels.html

CASE STUDY 4.14

Insurance for coral reef protection

Healthy coral reefs are essential to the tourism industry of the Mexican state of Quintana Roo. They also provide coastal protection against storms and reduce beach erosion.

The Nature Conservancy (TNC), the Quintana Roo state government, the National Commission of Natural Protected Areas, insurer Swiss Re and other partners devised the concept of insuring the reef against hurricane damage.

The concept became reality when in 2019 the state government purchased an insurance policy from Mexico-based insurer Afirme Seguros Grupo Financiero SA de CV. The policy will be triggered if wind speeds above 100 knots are registered within the area covered. Up to US$ 3.8 million will be paid out to repair hurricane damage, split of 50 percent for reefs and 50 percent for beaches.

A payout was triggered by Hurricane Delta when it hit Quintana Roo in October 2020. This enabled the stabilisation of uprooted coral colonies, and the collection and replanting of broken coral fragments, many of which will now grow as new coral colonies –in the days immediately following.

Sources: TNC, 2019a; https://www.businessinsurance.com/article/20190607/NEWS06/912328933/Parametric-insurance-policy-to-cover-Mexico-coral-reef

https://www.swissre.com/our-business/public-sector-solutions/thought-leadership/we-insure-all-that-we-love-why-dont-we-protect-mother-nature.html

Resources:
Swiss Re Biodiversity and Ecosystems Index
The index can inform decision-making for governments' efforts to improve ecosystem restoration and preservation, for corporates and investors protecting against environmental shocks, or for the provision of insurance services that support the Sustainable Development Goals.
https://www.swissre.com/institute/research/topics-and-risk-dialogues/climate-and-natural-catastrophe-risk/expertise-publication-biodiversity-and-ecosystems-services.html

Banking

Banks make a business out of responding to the "financial needs of large corporations, governments and other public entities that use corporate and investment green products, including project finance, partial credit guarantees, trading operations (carbon finance), bonds, and others" (World Bank, 2011). These products may be used to fund NbS projects.

Commercial offset programmes

These take into account the public appetite for reducing their emissions and environmental footprint on the globe. For example, some companies, including airlines and credit card companies, or even web search engines (e.g. Ecosia), offer emission offsets, such as tree planting, either through a small financial contribution from the public to add to the cost of purchase or from usage of the company product. Some retail banks also offer credit cards that give donations to NGOs (UNEP, 2007).

BARRIERS/CHALLENGES

The involvement of the private sector in NbS for DRR and CCA at the global level is far below its potential and the specific roles that the private sector can play are not yet fully explored (CBD, 2019; GIZ, 2019a). Currently, private sector approaches to NbS often fall within the remit of CSR rather than in executive, engineering and operational teams. To increase the uptake and incorporation of NbS into business strategies, several implementation barriers will need to be overcome (Graham et al., 2019; WBCSD, 2019a). Such barriers are especially related to a lack of targeted private sector strategies, including to create trust in such measures and communicate the various benefits of NbS (Graham et al., 2019; Wamsler et al., 2020). A clear business case, including different ways to seize these opportunities, is lacking and information is often kept too general (ATCP, 2010; GCF, 2019).

The absence of the enabling conditions outlined above is a major barrier to private sector uptake of NbS.

Other barriers may include:

- Harmful subsidies which negate the push towards greener alternatives or harm the environment in some way.
- Liquidity: natural infrastructure is an illiquid asset (i.e. it cannot easily be sold without a substantial loss in value). This may reduce the attractiveness and affordability of such investments for institutional investors because they may mean a lower return on capital due to prudential regulations relating to such assets (Aldergates Group & CUSP, 2017).
- Small scale of investment needed for NbS can be challenging for investors used to large investments.
- Expertise in setting up NbS projects and implementing ecological engineering within the private sector may be limited.
- Despite good supporting evidence for NbS there are still some gaps, and coordinated data collection, measurement and monitoring are lacking in many countries.
- Data on NbS investment outcomes and tools for interpreting these are still in their infancy and require more time to become generally understood (Aldergates Group & CUSP, 2017).
- How to measure NbS and the lack of key performance indicators for NbS.

Further research and work should be dedicated to understanding the political and social components that can incentivize or disincentivize private sector action and their implication and relevance for the different sectors (Crawford and Church, 2019; Slobodian and Badoz, 2019; TNC, 2019). In particular, it is necessary to identify suitable incentives for smaller and medium-sized businesses (Mavrodieva and Shaw, 2019).

4.2.3 Outreach

Outreach involves bringing information and services to individuals. Communicating on NbS, their role with respect to different societal challenges, how these are relevant to people and how people can engage are important aspects of mainstreaming and up-scaling. Awareness raising is the first stage of outreach. It is followed by education and training and the making available of services to aid uptake and implementation. These are often provided by NGOs, civil society organizations, academia and government.

Awareness raising

Language plays an important role when addressing different stakeholders. Translating scientific concepts and jargon into understandable messages is one point, but also including language that a sector can relate to needs to be considered. For instance, engineers and bankers view the world through different paradigms and this needs to be taken into account when communicating on NbS. Using art-based methods to communicate the concept of ecosystem services and NbS maybe be more effective in some cases (see **case study 4.15 and 4.16**). Videos, theatre, etc., can be effective ways to increase awareness on issues related to NbS.

It is also important to consider the different reasons different stakeholders might have for being interested in NbS when raising awareness. The cultural value of ecosystems, along with their DRR and CCA capacities, might mean more to some people, while economic benefits may be more pertinent to others.

Getting people involved in either thinking about NbS or participating in a project provides hands-on-learning and promotes awareness of the issues.



CASE STUDY 4.15

Using arts-based research methods to engage the private sector in mangrove conservation and restoration in Sri Lanka

An illustration of a fictitious coastal setting was used in discussing and communicating the various co-benefits and business opportunities of mangrove ecosystems with different private sector actors in Sri Lanka (Figure 4.5). The use of the illustration in combination with conducting expert interviews was especially useful to help different stakeholders within the coastal environment understand interrelationships with mangrove ecosystems and their various benefits, including for DRR.

In this case, the combination of art and science can be considered as an alternative method that can be used to communicate ecosystem co-benefits in a non-scientific way. It does so by providing a more holistic overview and reducing the complexity of multiple ecosystem services, helping to assess trade-offs between the supply of and the demand for different ecosystem services by different stakeholders (Scheffer et al., 2015; Harrison et al., 2018).

FIGURE 4.5

Visual illustration of the various co-benefits of mangrove ecosystems to the private sector in the coastal environment (Irushi Tennekoon & Lukas Edbauer, 2019)



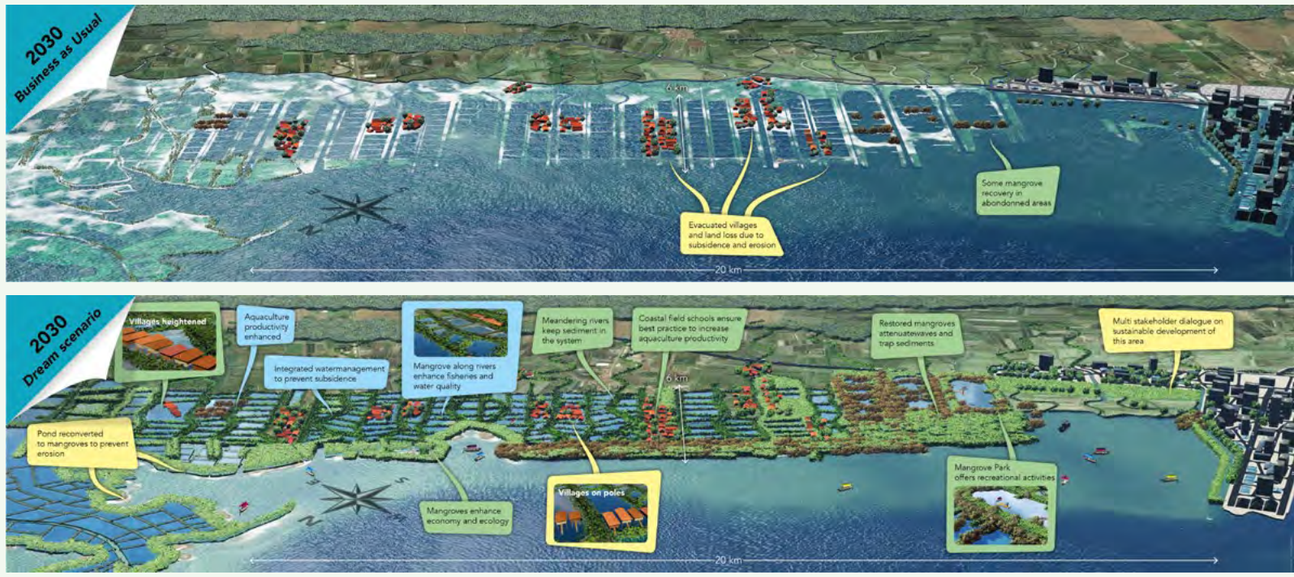
Source: Edbauer, L. 2021. Private Sector Engagement in Nature-based Solutions, exemplified by Mangrove Conservation and Restoration in Sri Lanka. Discussion Paper. German Development Institute (DIE), Bonn

CASE STUDY 4.16

Using pictorial scenarios to communicate vision to stakeholders

In conjunction with the illustration, different story cards were used to explore the possible incentives and roles of the private sector in NbS. Multiple discussions with different businesses showed that the reasons and incentives for an engagement in NbS varied greatly. As a result of the discussions, one of the private sector actors that was interviewed for this study started a collaboration with the organization SLYCAN Trust for community-based mangrove restoration. In December 2019, both actors, a local university and other stakeholders planted a total of 1,500 mangroves in Kalpitiya, Sri Lanka, in collaboration with the Coast Conservation Department (SLYCAN Trust, 2020).

To construct a vision for the future of Denmak, Central Java, Indonesia (see **case studies 2.4 and 3.8**), pictorial designs of the current coastal situation and two scenarios for 2030 were developed (business as usual and a dream scenario) to help communicate with stakeholders and empower their decision-making and ownership of the project. Furthermore, coastal field schools where run to provide communities in Demak with a long-term perspective for sustainable economic development. To avoid mangroves being cut down again, the project gave villagers instruction in best practices for aquaculture. They were also involved in mangrove restoration. Villagers were empowered to join policy dialogues to express their needs, successfully securing additional government support for these measures.



Source: Business as usual and dream scenarios for building with nature in Indonesia, designed by Frédérik Ruys, Vizualism.

Sources: https://www.wetlands.org/casestudy/building-with-nature-indonesia/
https://www.ecoshape.org/en/projects/building-with-nature-indonesia/

www.indonesia.buildingwithnature.nl

Education and training

Research shows that teaching DRR has positive effects on the community and is effective for preventing disasters or reducing its effects (Torani et al., 2019). There are also many benefits to teaching DRR to school children as they are not only more prepared but also incite the whole community through what they have learned (Torani et al., 2019). Teaching Eco-DRR will help people understand the linkages between the environment and disasters and how to manage and respect the environment to improve people's well-being.

Many projects undertaken on Eco-DRR or EbA include capacity-building workshops and training programmes. These can vary from lecture style to participative and practice driven. Hands-on training is especially useful (see **Figure 4.6**).

BOX 4.4
Adopting a rights-based approach

The right for children to a healthy environment is framed by the Human Rights Council in article A/HRC/43/30. Implementation of Eco-DRR to protect schools and children should be done with their participation. The UN Convention on the Rights of the Child states that measures should be put in place to encourage and facilitate their participation in accordance with their age and maturity. Participation should promote the best interest of the child and enhance the personal development of each child. All children have equal rights to participation without discrimination.

FIGURE 4.6

On the left: Coastal field school (CFS) in Indonesia through the building with nature programme. CFS's are used to introduce sustainable aquaculture practice to provide communities with a long-term perspective for sustainable development and food security and to avoid the restored mangrove belt being cut again in the future. **On the right: National Eco-DRR and EbA workshop in Columbia**. The workshop was delivered by UNEP to develop a national working group on Eco-DRR and an action plan for greater uptake of Eco-DRR and EbA approaches to reducing disaster risks in national policies.


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Scaling up Eco-DRR in schools

Children have the right to have access to environmental education and the right to education must include: "...the development of respect for the natural environment."[34] (**Box 4.4**) There needs to be environmental education materials and climate change tools readily availability to be integrated into the school curriculum, including the development and dissemination of key messages around climate change and environmental protection. This should be done by integrating EbA and Eco-DRR into existing school-based global agreements, such as the Comprehensive School Safety Framework (CSS). Promoted by the Global Alliance for Disaster Risk Reduction & Resilience in the Education Sector (GADRRRES), over 100 countries have signed the Comprehensive School Safety Declaration. The CSS uses a child-centred, all-hazards risk assessment and context analysis for action in three overlapping pillars: safe learning facilities, school disaster management and risk reduction and education.

Aside from including environment and DRR within the curriculum, together with any necessary preparedness drills, school-wide initiatives relating to DRR, CCA and NbS can help foster many skills and competences in children and youth, as well as reduce their vulnerability. The Clean, Green and Safe School initiative undertaken by Save the Children in Bangladesh is one such programme delivering on numerous points (see **case study 4.17**).

Schools will only really be clean, green and safe if environmental considerations are taken into account in the retrofitting or expansion of existing school buildings, construction and management of new schools and the surrounding environment and adopt climate-smart and nature-based designs.

CASE STUDY 4.17
Child-centered climate change adaptation project in Bangladesh: The Clean, Green and Safe Approach

In an effort to create a clean, green and safe environment for students, teachers and school staff, Save the Children Bangladesh introduced the 'oxygen bank' – an innovative approach for a school-based adaptation to climate change. The oxygen bank is a one-square-foot wooden box, which is setup in a visible place on a school campus.

Students willingly save a small amount from their food money to place in the bank. At the end of the month, the box is opened in the presence of an assigned schoolteacher called the 'green ambassador'. The total money is used to create a cleaner, greener and safer school through nature-based solutions. The bank idea has tremendous impact. It helps to develop adaptive sensitivity while at the same time developing a "saving mentality" among the children. It also helps the children to be prepared to cope with future climatic challenges and thus also to develop their leadership. They are exercising some adaptive methods at their school level to make their institutions green, clean and safe from climatic risks by using their savings from the oxygen bank.

Source: Clean, Green and Safe Approach. Save the Children Bangladesh. https://bangladesh.savethechildren.net/sites/bangladesh.savethechildren.net/files/library/Clean%2C%20Green%20%26%20Safe%20Approach%20%28compressed%20higher%20quality%29.pdf

34 Conventions of the Right of the Child (1989). Articles 29 (e)



Scaling-up Eco-DRR in universities

A master's elective course on Eco-DRR was developed by PEDRR and the Centers for Natural Resources and Development (CNRD) network of higher education institutions and launched in 2013. Compiled by researchers and practitioners from more than 15 countries and institutions worldwide, the module contains 50 hours of teaching material, divided into approximately 30 sessions (corresponding to 3-5 credits). The master's course was updated in 2019 to contain a module on gender and Eco-DRR. It is also available in Spanish and French. The course is free of charge and available to any university or national training institution interested. By 2020, over 100 universities around the world have been taught to deliver the course and are either teaching this course or have integrated some of the modules into their other courses (see www.pedrr.org).

Scaling-up Eco-DRR for professional development

Various training programmes on Eco-DRR and EbA exist or are being developed:

- https://pedrr.org/education-training-courses/
- https://www.adaptationcommunity.net/trainings/
- https://www.preventionweb.net/calendar/training/

Massive open online courses (MOOC) and webinars can also be ways to increase knowledge on topics related to NbS (**Box 4.5**).

BOX 4.5
Massive online courses on ecosystems, disaster risk reduction and climate change adaptation by PEDRR

- **MOOC: Disasters and Ecosystems Resilience in a Changing Climate**. First launched in 2015 with more than 12,000 participants, the massive open online course (MOOC) 'Disasters and Ecosystems: Resilience in a Changing Climate' was relaunched in 2017 with revised material and interviews. Although the course is no longer active, the course videos and accompanying book can be viewed online at https://pedrr.org/education-training-courses/
- **MOOC on Nature-based Solutions for Disaster and Climate Resilience**. This is a follow-up free online course to the one above. It gives insights into how nature can help in protecting people from disasters and solving the climate crisis. It is more practical than the first MOOC and goes into what young people and teachers, policy makers, practitioners, businesses and engineers can do to get involved in our race against the climate emergency. It was released early 2021. Check out www.pedrr.org/mooc for further information.

4.3 Financing nature-based solutions

The OECD estimates that US$ 6.9 trillion a year is required up to 2030 to meet climate and development objectives in transport, water and sanitation, telecommunications and energy supply alone (OECD, 2017). Thus, finance is a key question on the path to creating a climate-resilient future (OECD/the World Bank/UN Environment, 2018) and one that is important for upscaling nature-based solutions.

The question of how to finance NbS is not only about finding resources. It is also about re-allocating budgets initially reserved for grey infrastructure, about redirecting 'perverse subsidies' (leading to degradation of ecosystems) towards NbS and about finding sustainable financial mechanisms that lend themselves to something that is difficult to value on the one hand and is an illiquid asset on the other.

Fiscal and economic instruments

As mentioned in section 4.2 in relation to the private sector and NbS, an enabling finance environment, including conditions and opportunities, is key. Laws and policies ensure that the framework is laid for NbS (see **case study 4.18**). Incentives, subsidies or tax rebates are often instrumental for local authorities and private companies to upscale NbS.

Photo: Protection forests, Davos, Switzerland © UNEP



CASE STUDY 4.18

Incentives for nature-based solutions

The Swiss federal government has provisions for incentivizing NbS. In practice, the federal government makes an agreement with a canton to undertake NbS in line with federal laws. Examples include flood protection and water resource management (including through river renaturation), avalanche and landside protection through, for example, forest services, and biodiversity management.

Due to the governance system of Switzerland, work is actually undertaken at the municipal level through an agreement with the canton. Municipalities are in charge of both realizing the work and paying for it. As per federal law and the agreement made between the federal government and the canton, municipalities receive the subsidy through their canton. In addition, the canton can add to the subsidy.

The subsidization of NbS varies according to the different programmes of work (water, forest, etc.). For NbS relating to river renaturation, federal contributions vary from 35% to a maximum of 80% of costs incurred. The cantonal subsidy can vary between 10% and 35%, leaving the municipality to contribute between 5% and 20%.

Source: www.bafu.admin.ch/uv-1817-f

Being able to provide such fiscal instruments requires national budgetary flexibility. National fiscal and economic instruments could include environmental taxes and budget reform. Taxing non-environmentally friendly products could allow the proceeds to go towards more environmentally friendly activities as well as incentivize green alternatives. Many countries have moved towards an environmental tax reform, with taxes on polluting or natural resource-extractive practices. A green tax and budget reform go a step further by redirecting both taxes and subsidies to more environmentally friendly activities without increasing taxes overall (World Bank, 2011).

Finally, encouraging sustainability disclosures through reporting can help to enhance investments. In some parts of the world, like in the European Union, nonfinancial reporting is a requirement for some large companies. Such disclosures can help stakeholders make investment decisions. Indeed, the Global Sustainable Investment Alliance found that global assets managed according to sustainable-investment strategies more than doubled from US$13.3 trillion in 2012 to US$30.7 trillion in 2018 (Global Sustainable Investment Alliance, 2012, 2018).

Financial instruments

Financial instruments are either debt based or equity based. Green bonds and resilience bonds are recent debt-based developments that respond to demand for more sustainable investments. Green bonds are an instrument aimed at raising funds from investors to support the transition to low-carbon and climate-resilient growth. Since 2008, the World Bank has issued 158 green bonds in 21 currencies for a total of over US$13 billion in funding. As of 2019, US$17 billion funds have been committed, nearly 17% of which are for agriculture, land use, forests and ecological resources (World Bank, 2019).

Specifically targeted at resilience building, resilience impact bonds and resilience bonds can be very effective and could be leveraged for Eco-DRR projects. In 2019, the European Bank for Reconstruction and Development (ERDB) raised US$700 million for the first climate resilience bond. In a disaster context, catastrophe bonds (CAT bonds) and other risk-linked securities, such as catastrophe equity puts (Cat-E Puts), can help secure funds, along with reserves, contingency funds, contingent debt facilities and risk-transfer products.

Equity financing, where companies sell shares to acquire funds, is another instrument, which is usually governed by rules at the national level. A recent survey by The Nature Conservancy indicated that 43% of respondents had invested in private green equity, which includes forestry, natural defences and mangrove resilience (TNC, 2019a). Finally, the availability of blended finance, where part of the finance comes from a non-recoverable grant, can be very helpful for private sector start-ups (European Investment Bank, 2019).

Many multilateral development banks disperse such green and resilience bonds and other financial services. Blended finance is another avenue where projects are undertaken with finance from both government and multilateral development banks. The European Investment Bank and the European Commission, for example, have created a natural capital financing facility (NCFF), which is a blended finance mechanism[35] dedicated to boosting investment in biodiversity and nature-based solutions for climate adaptation within the European Union (see **case study 4.19**).

CASE STUDY 4.19

Green infrastructure for urban resilience in Athens

A natural capital financing facility (NCFF) loan of five million euros to the Municipality of Athens will integrate green-blue infrastructure into the restoration of public squares, parks and streets and contribute to the restoration of Athens second landmark hill after the Acropolis, Lycabettus hill. The objective of this operation is to support the implementation of the Athens Resilience 2030 Strategy and thus contribute to reducing urban heat islands, increase natural water infiltration and improve overall attractiveness of the project areas through nature-based solutions. The loan is attached to a EUR 50 million loan for resilient urban renewal and development to the Municipality of Athens. The NCFF loan is complemented by a 500,000 Euro technical assistance (TA) grant for redesigning selected urban spaces. The NCFF technical assistance is linked to another package that supports Athens in integrating climate mitigation and earthquake resilience measures in public and listed buildings, provided by the European Investment Advisory Hub (EIAH).

Source: https://www.eib.org/en/products/blending/ncff/project-examples/index.htm#

35 https://www.eib.org/en/products/blending/ncff/index.htm

Global Funds

There are several sources of funds from donor aid that can be accessed for nature-based solutions for disaster risk reduction and climate change adaptation. First of all, within the context of disaster risk reduction, a post-disaster needs assessment (PDNA) may be an avenue for finding funds for environmental restoration and to 'build back better' through NbS (see case **study 4.20**). After a PDNA is undertaken, an international partners' meeting is usually convened, and pledges/commitments are made.

The main dedicated global funds for EbA and Eco-DRR projects that can be accessed are the Global Environment Facility (GEF)[36], the Green Climate Fund (GCF)[37] and the Global Facility for Disaster Reduction and Recovery (GFDRR /World Bank)[38].

There are also dedicated funds set up specifically to drive environment and climate action – such as the European Commission's LIFE Programme[39].

CASE STUDY 4.20

Kerala's post-disaster needs assessment (PDNA)

Kerala's PDNA report after the floods in 2018 incorporated Eco-DRR/EbA by suggesting building back better to a green and resilient state, including:

1) Integrated water resource management;
2) An eco-sensitive and risk-informed approach to land use;
3) An inclusive and people centered;
4) Knowledge, innovation and technology.

Source: Kerala PDNA 2018.



36 https://www.thegef.org/
37 https://www.greenclimate.fund/
38 https://www.gfdrr.org/en
39 https://ec.europa.eu/easme/en/life

Payment for ecosystem services

Payment for ecosystem services (PES) is an incentive-based mechanism to support sound ecosystem management. The basic idea is that ecosystems provide a variety of services which support human well-being. To protect and efficiently use these services, landowners and farmers receive payments to manage their land properly and avoid public costs related to unsustainable land use, such as water contamination and soil degradation. PES can therefore be described as a financial transaction between providers and beneficiaries of ecosystem services.

Latin America has undertaken quite a few PES schemes since the 1990s with many successful results (Grima et al., 2015). Currently, Colombia aims to direct at least 1% of annual revenues towards PES schemes in water source areas (IDB, 2019). However, PES schemes are not always that effective because sometimes risk (e.g. deforestation) gets transferred elsewhere and some impact evaluations have found no difference or only small positive environmental outcomes (Börner et al., 2017).

Carbon markets

As an incentive to reduce greenhouse gas emissions, carbon credits were devised as a market-oriented mechanism. This kind of 'emission trading' was devised under the UNFCCC Kyoto Protocol, which sets out in Article 17 a way for countries that have emission units to spare – emissions permitted to them but not used – to sell this excess capacity to countries that are over their targets.

Defining carbon as a commodity created carbon markets. There are two types of carbon markets: cap and trade schemes and baseline-and-credit mechanisms[40]. Carbon offsets (see section 4.2.2) are also part of this market. Investing in forests, for example, can be part of a carbon trading scheme (see **case study 4.21**).

CASE STUDY 4.21

Café Selva Norte – Climate-smart coffee agroforestry systems in Peru

A project undertaken in Peru by local businesses aims at mitigating land degradation and climate change and, more broadly, ensuring sustainable development of the coffee value chain by transforming deforested and degraded land through agroforestry. Financial returns are generated through sales of coffee and timber, a processing plant and through carbon trading (from the newly planted forests). The project is financed through the URAPI Sustainable Land Use Vehicle, managed by ECOTIERRA, which received a capital injection from the Land Degradation Neutrality (LDN) Fund (see section 4.2.2). URAPI, which extends long-term financing to projects that meet strict environmental and social standards, provides debt to farmers' cooperatives whereas equity is directly invested in the processing plant. The cooperatives also own shares from the processing plant from the start. URAPI aims to gradually transfer all of the processing plant's ownership rights to the cooperatives and have the carbon credits paid for.

Source: WWF (2020) Bankable Nature Solutions. Blueprints for Bankable Nature Solutions from across the globe to adapt to and mitigate climate change and to help our living planet thrive.

https://wwf.panda.org/our_work/water/?364413/Blueprints-for-bankable-nature-solutions-to-help-tackle-nature-and-climate-crises







40 https://carbonmarketwatch.org/wp/wp-content/uploads/2019/06/CMW-CARBON-MARKETS-101-THE-ULTIMATE-GUIDE-TO-MARKET-BASED-CLIMATE-MECHANISMS-WEB-FINAL-SINGLE.pdf

From grants to loans and investments

Implementing NbS on a large scale requires different financing mechanisms and the need to move away from grants towards loans and investments from private banks and financing institutions. Business models, including 'return on investments', are being developed and tested ona a case-by-case basis. One of the issues for investments is the relatively small budget that NbS requires and the relatively small return they offer. However, innovative mechanisms can evolve as seen by the NCFF (see **case study 4.19**). The Asean Catalytic Green Facility is another example (see **Box 4.6**).

BOX 4.6
Asean Catalytic Green Facility

The ASEAN Catalytic Green Finance Facility (ACGF) is an innovative financing facility designed to scale up green infrastructure projects in Southeast Asia.

Launched in April 2019 under the ASEAN Infrastructure Fund, the ACGF provides loans and technical assistance for sovereign green infrastructure projects on sustainable transport, clean energy and resilient water systems. It aims to catalyze private capital by mitigating risks through innovative finance structures. The facility will mobilize a total of US$1 billion, including US$75 million from the ASEAN Infrastructure Fund, US$300 million from the Asian Development Bank (ADB), US$336 million from German state-owned development bank KfW, 150 million EUR from the European Investment Bank and 150 million EUR from Agence Française de Développement.

Source: https://www.adb.org/publications/asean-catalytic-green-finance-facility

Photo: Women constructing permeable structures as part of the biorights programme in the Building with Nature Indonesia programme. ©Wetlands International.



The Nature + Accelerator Fund is another innovative fund that combines the unique set expertise of leading public and private institutions and platforms: IUCN, Mirova, a network of partners within the Coalition of Private Investment in Conservation (CPIC) and the Global Environment Facility (GEF). The Nature+ Accelerator Fund aims to grow a conservation investment pipeline with adequate risk/return ratio by leveraging risk-tolerant concessional finance from GEF and then developing a financially viable project portfolio with significant positive outcomes for nature and society[41].

'Building with Nature', facilitated by Ecoshape (see **case study 2.7**), is in the process of developing business cases and attracting investments from public and private finance sectors in various ways. In its Indonesia programme, an innovative financing mechanism, called the 'biorights' approach was developed to enable local communities to invest in sustainable practices and be actively involved in environmental conservation and restoration. Micro-credits are converted into grants upon successful delivery of conservation services.

41 https://www.iucn.org/theme/nature-based-solutions/initiatives/nbs-finance-mechanisms-and-funds/nature-accelerator-fund

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CHAPTER 3

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05

ANNEXES



Annex 1

Template for ecosystem-based disaster risk reduction action plan in national disaster risk reduction strategy planning

The objective here is to provide a short template on ecosystem-based disaster risk reduction (Eco-DRR) which countries can draw from when drafting national disaster risk reduction strategies.
The inclusion of targets/goals, objectives and activities directly related to the environment, given its central importance to disaster reduction, can be an asset to a national disaster risk reduction (DRR) strategy.

The Sendai Framework for Disaster Risk Reduction comprises four priority areas, and the first three include goals for the environment and ecosystems. This template for inclusion of Eco-DRR, follows the three priority areas and their goals for the role of ecosystems in a disaster risk reduction strategy. These can be used as a guide for targets and objectives within a national DRR strategy. The template is based on UNDRR (2019) where there is a (or several) target(s) and impact indicator(s), followed by outcome objectives, outcome indicators and activities. This is a very detailed way to formulate a strategy, so each country will adapt it to its own needs.

Example targets and action plan for Eco-DRR

PRIORITY 1

Under *Priority 1 of the Sendai Framework*, policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions. Paragraph 24 b) and d) encourages the assessment of disaster risks and possible effects on ecosystems. An important objective therefore is an assessment of the state of the environment and the impact of disasters on the environment. A key target could therefore be **understanding the environmental drivers of risk of disasters and the impact of disasters on the environment.**

Example: Mozambique's post-disaster needs assessment (PDNA) after Cyclone Ida in 2019, which includes an environment section describing the drivers of risk and the impact of disasters[42].

PRIORITY 2

Priority 2 of the Sendai Framework, paragraph 27 b), suggests the adoption and implementation of strategies and plans aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of environmental resilience. Given that environmental degradation can be a contributing factor to a disaster, an important target would therefore be **to reduce and reverse environmental degradation and loss**.

Example: Morocco's "Programme Oasis Sud" was launched in 2006 to address desertification and land degradation in 180 oases in the south of Morocco.[43]

PRIORITY 3

Priority 3 of the Sendai Framework, paragraph 30 g), suggests promotion of management that preserves ecosystem functions that help reduce risks and 30 n), implementing integrated environmental and natural resource management approaches that incorporate disaster risk reduction. An important objective therefore would be to use ecosystem-based approaches to reduce disaster risk reduction. To respond to both priority 2 and 3, another important target would be **to strengthen environmental resilience and enhance ecosystem services for disaster risk reduction**.

Example: See box on India's National Disaster Management Plan[44].

PRIORITY 4

The Sendai Framework does not refer to ecosystems or environment under Priority 4. This need not stop governments from including environmental considerations as part of enhancing disaster preparedness and 'build back better' – the priority's goals.

India's National Disaster Management Plan 2019 and Ecosystem-based Disaster Risk Reduction (Eco-DRR)

For each hazard, India's plan is devised in several thematic areas which relate to the Sendai Framework priorities 1-4. The plan also includes climate change risk management. Under most of the hazards, one recommendation for climate change risk management is the **promotion of appropriate green and blue infrastructure.**

ECO-DRR UNDER PRIORITY 1:

For many of the hazards enumerated, the plan suggests the elaboration of studies, maps and assessments that include an ecological component. Most are non-specific to Eco-DRR, except the preparation of detailed maps to delineate coastal wetlands, mangroves, shelterbelts and tracts for coastal bio-shields, using best tools, field studies and satellite data.

ECO-DRR UNDER PRIORITIES 2/3:

Eco-DRR features specifically under cyclone/wind, tsunamis, flooding and drought:

- Promote coastal shelterbelts as a mandatory component under national afforestation programmes
- Facilitate integrated water resource management in catchment areas
- Wetland conservation and restoration and catchment area treatment/afforestation are advocated
- Promote water conservation, harvesting, efficient irrigation, afforestation

42 https://reliefweb.int/sites/reliefweb.int/files/resources/pdna_report_mozambique_cyclone_idai.pdf
43 https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/sustainable%20land%20management/Programme_Oasis_Sud.pdf
44 https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf

Example Action Plan for each priority area

Priority 1 – Understanding risk

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Increase awareness of the environmental drivers of risk of disasters and the impact of disasters on ecosystems. *Contributes to SDG target 13.3 and indicators 13.3.1 and 13.3.2*			
RESULT/IMPACT INDICATOR	National policies/programmes/projects to reduce disaster and climate risks incorporate environmental, management measures /ecosystem-based solutions			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
To evaluate the environmental drivers of risk and the impact of disasters on the environment	• Number of studies and assessments on environment and risk • Ha of critical ecosystems lost due to disasters (and value)[#]	• National risk assessment methodology incorporates ecosystem coverage/health if available, environmental degradation, losses • Post-disaster needs assessment (PDNA) includes a chapter on environment • Map of environmental degradation and loss	• Conduct an environmental assessment or studies • Establish a database of sources of environmental data and monitoring • Mapping • (valuation studies)	• Previous environmental assessments and PDNAs • UNCCD and CBD focal points • Satellite imagery • National land cover maps • FAO forest and mangrove cover data • National environmental outlook reports

[#] Sendai Framework Monitor indicators C5 and D4.

Possible sources of data: Environmental ministries, protected areas and biodiversity schemes, environmental NGOs, academia, intergovernmental reports, climate change adaptation plans, post-disaster needs assessments, satellite imagery

Priority 2 – Strengthening disaster governance to manage disaster risk

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Environmental legislation is enacted to reduce / reverse environmental degradation *Contributes to SDG target 14.5 and 15.3 and indicator 14.5.1* *Contributes to SDG targets 15.1 and 15.3 and indicators 15.1.1, 15.1.2 and 15.3.1*			
RESULT/IMPACT INDICATOR	Land degradation neutrality is achieved (see UNCCD) or disaster risk is reduced (Sendai indicators A-D)			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
To reduce risk of environmental degradation and loss through protection/ restoration of key areas.	• Impact of land use and other policies on ecosystem services* • Number of environmental assessments (SEA, EIA) registered • Ha of protected/restored ecosystem • Proportion of land that is degraded over total land area #	• Strategic environmental assessments (SEA) • Environmental impact assessments (EIA) • Management plans for protected areas • Implementation plans for ecosystem restoration	• Identify policies and plans that support or hinder the environment • Promote the use of SEAs and EIAs • Prioritize areas for protection and restoration • Conduct stakeholder workshops and awareness campaigns • Develop implementation plan for ecosystem restoration • Develop or ensure that protected areas have management plans	• UNEP-WCMC protected area database • National land cover maps • Satellite imagery • UNEP's opportunity mapping • National biodiversity action plans • UNCCD national action programmes

*From UNDRR custom indicators from Resilient Cities campaign. [#] SDG indicator 15.3.1.

Possible sources of data: Environmental ministries, protected areas and biodiversity schemes, environmental NGOs, academia, intergovernmental reports, climate change adaptation plans, post-disaster needs assessments, satellite imagery

Priority 3 – Investing in disaster risk reduction for resilience

STRATEGIC OUTCOME TARGET/GOAL SDG contribution	Ecosystems and their services are enhanced for resilience and disaster risk reduction *Contributes to SDG target 14.2 and indicator 14.2.1* *Contributes to SDG targets 15.1 and 15.2 and indicators 15.1.1, 15.1.2 and 15.2.1*			
RESULT/IMPACT INDICATOR	Increased investments ($) in green/blue infrastructure			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
Ecosystem-based disaster risk reduction (Eco-DRR) is implemented.	• Investments ($) in Eco-DRR at national and local level • Green and blue infrastructure is routinely embedded in projects*	• Projects and programmes for Eco-DRR • Management and implementation plans for green and blue infrastructure	• Embed and mainstream Eco-DRR in national plans and programmes • Secure funding for Eco-DRR projects • Develop implementation and management plan for Eco-DRR/green and blue infrastructure.	• UNEP opportunity mapping • National and local plans, programmes and projects • IGOs and NGOs operating in country • UNFCCC national plans of action and nationally determined contributions • UNCCD national action programmes • CBD biodiversity action plans

*From UNDRR custom indicators from resilient cities campaign

Possible sources of data: Environmental ministries, protected areas and biodiversity schemes, environmental NGOs, academia, intergovernmental reports, climate change adaptation plans, post-disaster needs assessments, satellite image

Priority 4 – Enhancing disaster preparedness for effective response and to 'build back better' in recovery, rehabilitation and reconstruction

Priority area 4 enables preparedness and response for when disasters impact a country. While it is clear that focus will be on saving lives in the first instances, ensuring that the environment is taken into consideration through environmental contingency plans is important to avoid further degradation of important assets such as water resources. Furthermore, disasters impact the environment itself, which provides many important services. They should therefore be taken into account during post-disaster needs assessments (PDNA). Guidance on PDNAs by the Global Facility for Disaster Risk Reduction (GFDRR) includes a comprehensive section on environment[45]. Finally, including the environment in 'build back better' allows for increased resilience, as noted in SFDRR priorities 2 and 3.

Some guidelines for Priority 4 developed by the Partnership on Environment and Disaster Risk Reduction (PEDRR 2015)[46]:

- Ensure disaster response, recovery and reconstruction activities do not have adverse environmental impacts and do not create or exacerbate vulnerabilities to future disasters. Screen disaster response, recovery and reconstruction plans against resilience criteria and sustainability safeguards.
- Consider the environmental impacts of disasters and incorporate ecosystem rehabilitation/restoration/protection measures as part of post-disaster needs assessments and recovery and reconstruction plans.
- Undertake rapid environmental assessments to complement post-disaster needs assessments in order to identify the scope for environmental recovery and reconstruction.
- Leverage country-level experiences on sustainable recovery and reconstruction to share lessons learned and promote best practices.

STRATEGIC OUTCOME TARGET/GOAL *SDG contribution*	Ecosystems and their services are included in preparedness and response, recovery, rehabilitation and reconstruction *Contributes to SDG target 14.2 and indicator 14.2.1* *Contributes to SDG targets 15.1 and 15.2 and indicators 15.1.1, 15.1.2 and 15.2.1*			
RESULT/IMPACT INDICATOR	No net harm to ecosystems or improved ecosystems			
OUTCOME OBJECTIVE(S)	**OUTCOME INDICATORS**	**OUTPUTS**	**ACTIVITIES**	**SOURCES OF DATA**
Ecosystems are not harmed in the response and are enhanced while 'building back better'.	• Presence of environmental contingency plans • Ha of restored ecosystems	• Rapid environmental assessments • Environmental contingency plans • Environmental PDNA	• Post disaster environmental assessments are undertaken. • Environmental contingency plans are made. • Green humanitarian response • Secure funding for environment during 'build back better'	• Sphere handbook Green recovery and response toolkit

45 PDNA Volume B Environment https://documents.worldbank.org/en/publication/documents-reports/documentdetail/773111493642626075/post-disaster-needs-assessment-guidelines-environmentl

46 PEDRR (2015) Advancing implementation of the Sendai Framework for Disaster Risk Reduction (2015-2030) through Ecosystem Solutions.

Annex 2

Summarized survey results

The survey for the Words into Action on Nature-based Solutions comprised 23 questions to collect experts' knowledge on NbS. A total of 43 answers were collected from participants residing in 24 countries, spanning Central America to Europe, Africa and South Asia. Colombia provided the highest number of respondents (five), closely followed by Egypt and the Netherlands (four each). The figure below shows the geographic distribution of the surveyees.

66% of the survey participants are female (F), 32% are male (M) and 2% preferred not to disclose the gender they identify with. As illustrated in the figure below, the respondents are all above 25 years of age, with the majority falling into the age category 35-44 (39%), followed by the category of 55-64 years (29%).

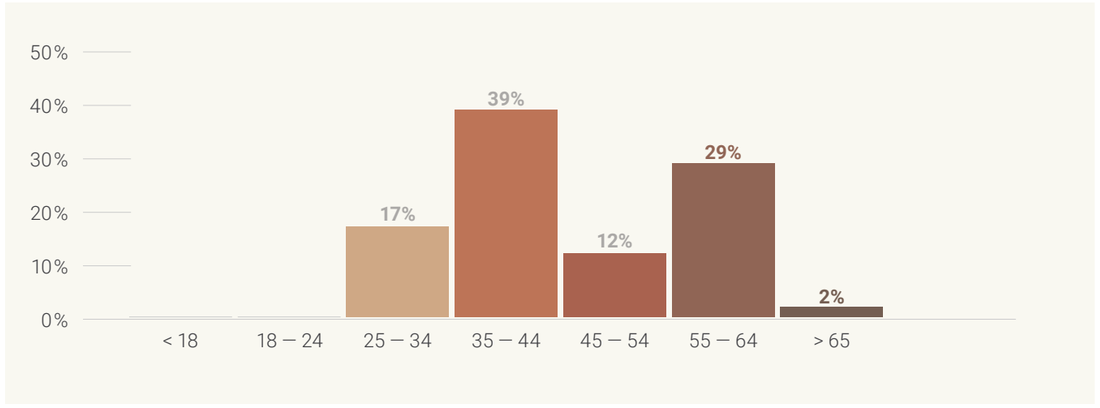
FIGURE

Geographic distribution of survey participants.



FIGURE

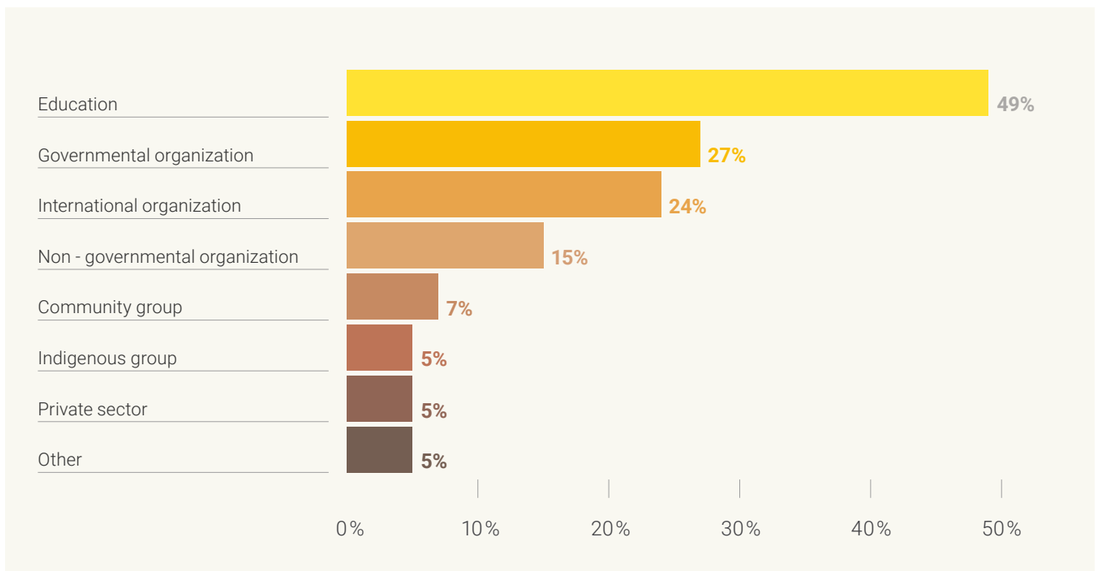
Age category of survey participants.



Survey participants work in or come from a range of sectors, and in some cases more than one (see figure below). Just under half work in education (49%), mainly as teachers but also as researchers or teaching assistants. Governmental and international organization employees make up the next largest groups (27% and 24%, respectively). Non-governmental organizations (NGOs) account for 15% of respondents; 7% are part of community groups and 5% part of indigenous groups. The private sector accounted for 5%, with a further 5% working as consultants or as part of international networks. In addition to directors and programme or project managers, the survey also collected the views of technical experts, including biologists, engineers, country DRR representatives and risk manager specialists.

FIGURE

Sectors and corresponding share of respondents



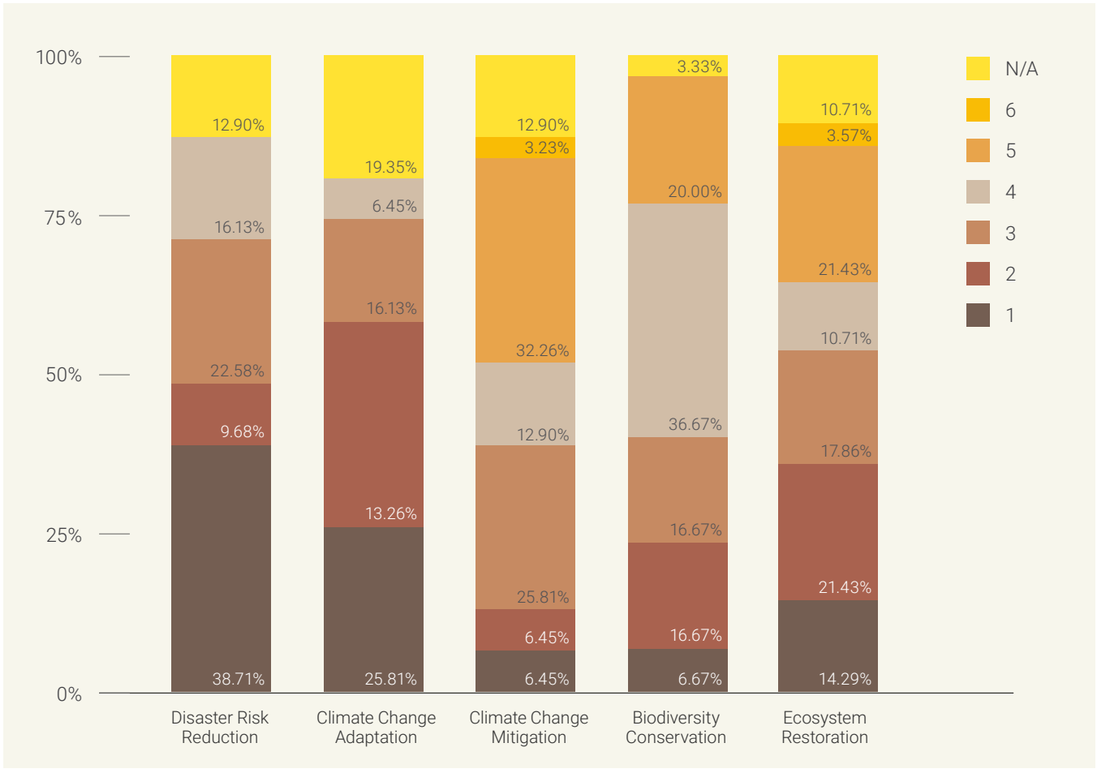
Respondents' projects

Respondents work across the world, with the majority of their projects being developed in the regions of Latin America and the Caribbean (20 responses), Africa (14 responses) and Europe and Central Asia (11 responses). The regions of Middle East and North Africa, South Asia, East Asia and the Pacific follow closely with 8, 7 and 6 responses, respectively. The respondents run projects at different scales, with the national scale being mentioned by 37% of surveyees, followed by regional and local scale with 32% and 24% of respondents, respectively. The remaining 7% of respondents work at different scales, going from local to global level.

The objectives of the respondents' projects vary, with disaster risk reduction (DRR), climate change adaptation (CCA) and climate change mitigation (CCM) being the most frequently mentioned (31 responses each). Biodiversity conservation and ecosystem restoration have also been mentioned frequently with, respectively, 30 and 28 respondents mentioning them. In terms of ranked importance, DRR appears as the most important objective of projects, with 39% of responses ranking it as the first objective (see figure below). CCA is ranked first among NbS projects 26% of the time it is mentioned, followed by ecosystem restoration, which is ranked first 14% of the times it is mentioned. The objectives most frequently identified as non-applicable (N/A) are CCA (six responses), DRR and CCM (both four responses). Interestingly, N/A CCA appears in combination with DRR being ranked as most important project objective and vice versa (i.e. N/A DRR with CCA being ranked as most important objective). In cases where neither DRR nor CCA are applicable, CCM is always ranked as the most important objective of NbS projects.

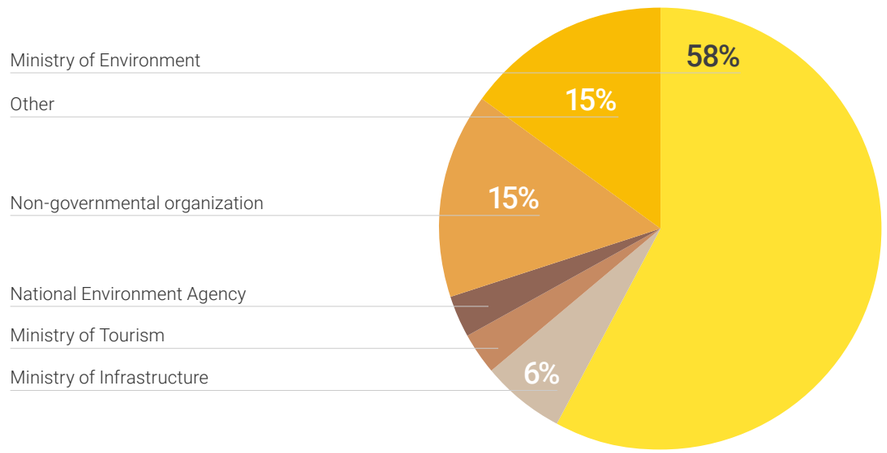
FIGURE

Ranked importance of NbS project objectives (1 being the most important objective; 6 the least important objective and N/A indicating the non-applicabilty of the objective in the NbS project).



In terms of integration of ecosystems into DRR projects, respondents gave the most importance to the planning and implementation phase of projects, with 75% using this channel to integrate ecosystems in their DRR projects. In second place were risk assessments, with 57% of respondents using such assessments to integrate ecosystems in DRR strategies, followed by cost-benefit analyses (32%), monitoring (21%) and life cycle assessments (6%).

Looking at planning and implementation, the survey finds that NbS projects in the country/countries where respondents work are mostly planned and implemented by the ministry of the environment (58% of responses). NGOs were mentioned by 15% of respondents. Additionally, respondents identified involvement of the ministry of infrastructure (6.1%) and the ministry of tourism and the national environmental agency (both 3%). Interestingly, neither the ministry in charge of disaster management nor the private sector are involved in the respondents' NbS projects. The sector of education was also mentioned by two respondents. The geographical scale at which the project was being undertaken influenced the type of institutions mentioned. For instance, at the local and regional scale the shore protection authority and the environment secretariat were mentioned as the main institutions, while bigger projects work at horizontal / cross-sectoral levels, including all ministries and NGOs.



NbS champions

Numerous examples were listed by the respondents showcasing 'NbS champions'. The table below provides an overview of the examples and a brief description of the project.

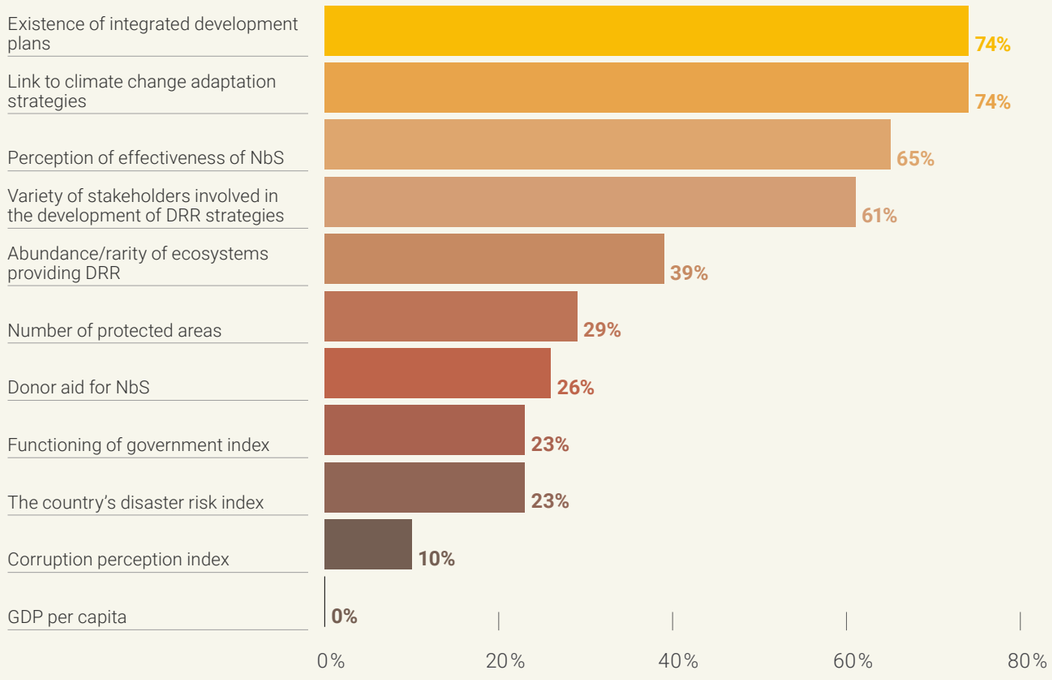
Project	Description
Kenyan coast	Community participation in mangrove conservation and rehabilitation on Kenyan coast for disaster reduction and economic empowerment.
Japan	• Recovery of wetland patch in the Tokachi River. • Retention pools in the Chitose River. • Eco-DRR: ecology-based disaster risk reduction: erosion control of Ashio mountains by continuous afforestation.
Egypt and IUCN	Mangrove tree planting along Red Sea Coast for protection of ecosystems, infrastructure and communities. As a result of the project, lessons learned and guidelines for implementation have been put together.
Bogotá, Colombia	In the high mountain ecosystems surrounding Bogota and adjacent municipalities, vulnerability assessments of climate change adaptation include disaster risk. The main objective of the project is to guarantee the regulation of water, considering climate change scenarios. This component has been included in the land use plans of several municipalities and the department of Cundinamarca. It is important to consider the link between ecosystem-based adaptation and disaster risk reduction, as proposed by the CBD guidelines. Adaptation actions in the field include several co-benefits for the wellbeing of the local population and ecosystem's integrity. These actions include ecosystem restoration, regenerative agriculture, agroecology and other activities that build resilience at farm level and at the same time contribute to water regulation in key watersheds prioritized.
EU cities	The CLEVER Cities project uses nature-based solutions to address urban challenges and promote social inclusion in cities.
Costa Rica	National wetland project and its wetland rehabilitation work.
Guatemala and IUCN	Safe Heavens: Protected areas for disaster risk reduction and climate change adaptation. The Monterrico Multiple Use Natural Reserve (MMUNR) is susceptible to floods arising from natural but also human-made causes outside the reserve. The Centre for Conservation Studies (CECON) updated the reserve's management plan to include people's concerns about floods. It created a conceptual ecological model (CEM) for the Monterrico Reserve that shows its links to and relationships with its surroundings, and established a permanent stakeholder engagement process. It also brought together insights gained from these steps into a new reserve management proposal. This process achieved the following for the management of the reserve: a) a new scale of management actions; b) broader governance arrangements; and c) wider scope of management. Analysis of this case study highlights some lessons which are expected to improve management of the reserve. These are: a) the reserve alone will not be able to control flood risk inside its territory; b) an integrated water management approach should be taken in managing the reserve; c) conservation and watershed restoration actions outside the reserve's limits should be established.
Ecuador	In order to cope with climate change in the Ecuadorian coastal mountain range, several adaptation measures and activities, some combining DRR, were implemented. These included: • The implementation of eight farms with 'analog forestry' – an approach to ecological restoration which seeks to recover ecosystem services lost in harvested forests, using native species to promote the connectivity of wooded patches and to help maintain water springs that supply the local population and provide habitat and food to local fauna and generate economic income for local inhabitants. • The recovery of 10.5 km of linear riverbanks and the slope of an *albarrada* (traditional dry water supply system) and implementation of a system to filter the water for the consumption of the population. • The conservation of more than 6,000 hectares of forest and a new management approach for 128 hectares of coffee, including agroforestry, organic coffee farming and using climateresistant species. • The implementation of 12 agroecological farms which promote the viability and enrichment of the diet of local families and generated income. More detailed information about these pilot measures can be found at: http://cordilleracostera.org/portal/index.php/publicaciones
South Africa	Ecosystem-based disaster risk reduction and climate change adaptation: a case study of Moolmanshoek wetland, Free State Province.
Indonesia & Wetlands International	Building with Nature Indonesia. Reduction of flooding of coastal villages, prevention of coastal erosion and salinization of agricultural land through natural regeneration of mangrove ecosystems in Demak, north coast of Central Java. Enabling regeneration of mangroves through engagement of local villagers, enhancing muddy coasts and supporting other enabling factors. This solution came after many years of hard infrastructure works to protect the coastline, which resulted in increased erosion and did not stop coastal flooding.
Jamaica, Dominican Republic and GrenadaTNC & IFRC	Resilient Islands in the Caribbean: This four-year initiative helped communities adapt to climate change in Jamaica, the Dominican Republic and Grenada, uniting science and communities to rethink community resilience and implement better solutions to protect vulnerable Caribbean islands. Local mitigation and adaptation can provide solutions to protect coastal communities. https://coastalresilience.org/project/resilient-islands/
Vanuatu, Indonesia and MyanmarTNC, GDPC & IFRC	The goal of Resilient Coastal Cities is to enhance local collaboration and problem solving to support effective climate change adaptation within the humanitarian cycle of preparedness, response and recovery. To do this, community resilience approaches have been designed and implemented in specific coastal cities in Vanuatu, Indonesia and Myanmar. The Nature Conservancy (TNC), the American Red Cross Global Disaster Preparedness Center (GDPC) and the International Federation of Red Cross and Red Crescent Societies have formed a unique and innovative partnership joining the world's largest conservation non-profit organization with the world's largest humanitarian organization to address the increasingly detrimental impacts from natural hazards. https://coastalresilience.org/project/indonesia/
Greece	Landscape fire management https://gfmc.online/allgemein/press-release.html
Sri Lanka IUCN & ChildFund	NbS, Eco-DRR and EbA have been introduced through youth organizations in four districts in Sri Lanka, using activities such as water conservation and management to mitigate drought and boost flood resilience, together with alternative livelihoods to reduce pressure on natural capital and improve understanding of water cycles, erosion, hydrology and geology in ecosystem-based land use planning. Landscape approaches are also being promoted to minimize ecosystem damage, which in turn improves disaster resilience. These youth groups successfully work with government agencies in their respective districts, maintain pilot projects that are upscalable and train government officials on principles of NbS, Eco-DRR and climate adaptation.
European cities	Many European cities have good practice examples, including integrated NbS/grey infrastructure solutions. https://covenantofmayors.eu/

NbS for DRR projects

The survey shows that several aspects are important for integrating NbS into DRR strategies. With 74%, both integrated development plans and links to CCA strategies stand out as crucial factors for the integration of NbS into DRR strategies. The perception of NbS effectiveness is also seen as an important factor by 65% of respondents. Similarly, with 61% variety of stakeholders involved in the development of DRR strategies is believed to affect the integration of NbS into DRR. Of all indicators, GDP per capita was the only one that no surveyee considered important. In addition to the available indicators, time and awareness of NbS were mentioned as factors that influence the uptake of NbS into DRR strategies, considering that NbS are long-term solutions.

FIGURE

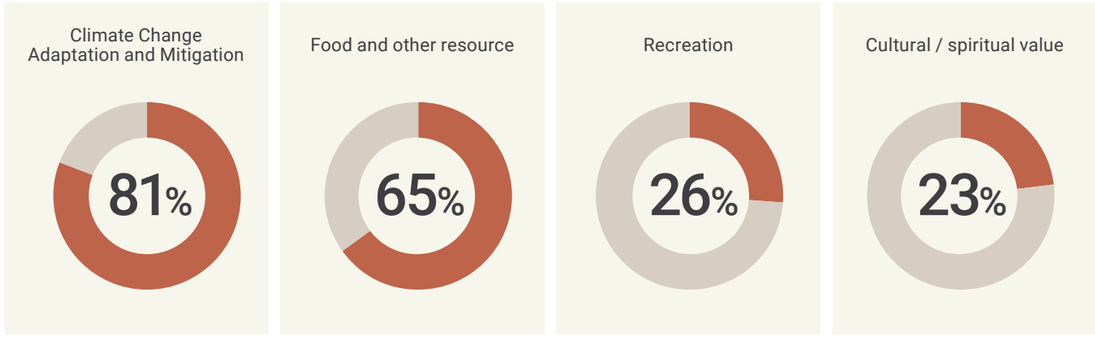
Decreasing order of indicators that influence if and to what extend NbS are integrated into national disaster risk reduction strategies, according to the respondents.



As for public acceptance, the majority of respondents agrees that climate change adaptation and mitigation (81% of respondents) and food and other resources (65%) have important roles to play. Recreation and cultural/spiritual value of NbS are also recognized as contributing to public acceptance by 26% and 23% of respondents, respectively. Additionally, respondents mentioned the following aspects as contributors to public acceptance of NbS: aesthetics/attractiveness; ethical responsibility; public management; and ecosystem enhancement. One respondent said that the acceptance of NbS is "case specific and co-benefits should be communicated specifically".

FIGURE

Co-benefits of NbS that contribute to public acceptance with corresponding share of respondent.



Respondents, however, also mentioned a number of barriers experienced by their projects, which can be classified as: different interests, lack of knowledge, lack of trust and lack of an integrated approach. The figure below summarizes the respondents' perceived barriers to NbS implementation:

Different interests

- Conflicts among different users.
- Conflicts, especially with sectors such as agriculture/ infrastructure or mining.
- Donors & governments need to be won over as they, by default, choose hard infrastructure solutions.
- Strong lobbying by corporates for hard, concrete, engineered solutions.
- Competition for space and funding with other, technology-driven sustainability solutions (e.g., solar panels).
- Lack of public and private funding (i.e., other goals are prioritized).
- Competition with other projects that provide greater economic benefits in the short term.
- Lack of interest.
- Lack of political and financial support.

Lack of awareness and knowledge

- 25. Inadequate knowledge base for NbS.
- Lack of knowledge both at societal and stakeholder level.
- Few proven experiences.
- Lack of public understanding of the concept and practice.
- Lack of awareness.
- Lack of expertise and competence.
- Lack of economic valuations on NbS approaches to make the business case for NbS and complement the engineering proposals.
- Lack of knowledge of climate influence on NbS approaches.
- Lack of awareness of multiple benefits.
- Lack of model examples of hybrid solutions.
- Lack of dissemination of scientific evidence.
- Lack of translation of scientific knowledge into local contexts.

Lack of trust

- Decision-makers do not trust nature-based solutions.
- Disbelief that NbS can be done on a larger scale; belief that grey infrastructure is the solution.
- Poor social acceptance.
- Lack of public acceptance.

Lack of integrated approach

- Many actors are trying to practice NbS without proper coordination. There is lack of synergy and proper integration into development strategies.
- Traditional legislation and institutional self-protection and resistance against transversal (horizontal, cross-sectoral cooperation).
- Siloed governmental organizations.
- Lack of comprehensive approach.

Ways forward

It is essential to include ecosystems in disaster risk assessments so as to understand their role in risk reduction. The following table provides an overview of tools and steps mentioned by respondents for including ecosystems in disaster risk assessments:

Tools/steps to include ecosystems in disaster risk assessments	Description
Environmental and social Impact assessment	The purpose is to assess and predict potential adverse social and environmental impacts and to develop suitable mitigation measures
Life cycle assessment	An analysis technique to assess environmental impacts associated with all the stages of a product's life
Using a baseline that includes ecosystem assessment	A process to obtain a benchmark of prevailing conditions prior to disaster impacts
Evaluation and valorization of ecosystem services	The estimation of the monetary value of ecosystem services facilitates communicating the value of ecosystems to different stakeholders
Capitals framework	A model serving to assess the assets and deficits of a community (including natural capital)
Integrated assessment models	A model that links features of society and economics with the biosphere
Sustainable impact assessment	An approach for exploring the combined economic, environmental and social impacts of a proposed action
Present and future scenarios	Constructed snapshots of possible futures based on different starting points
Ecosystem services shared-value assessment	A questionnaire-based tool helping communities to evaluate their relationship with the wetland on current and future values
Enhance vulnerability and capacity assessment	A participatory process to assist communities in the assessment and analysis of disaster risks and the identification of solutions to address these
Restoration opportunities assessment methodology	A framework for countries to identify and analyse areas that are primed for forest landscape restoration
Payment for ecosystem services	A variety of arrangements through which the beneficiaries of environmental services reward those whose lands provide these services with subsidies or market payments
Soil and water assessment tool	A model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change
Cost-benefit analysis	An instrument to help decision-making, comparing the benefits generated by a project with its costs

Monitoring NbS is another important aspect; 14 respondents mentioned the need to monitor NbS or ecosystem-related variables. The following indicators are used in projects to monitor NbS, recognizing that time intervals at which these are monitored vary depending on the occasion and need:

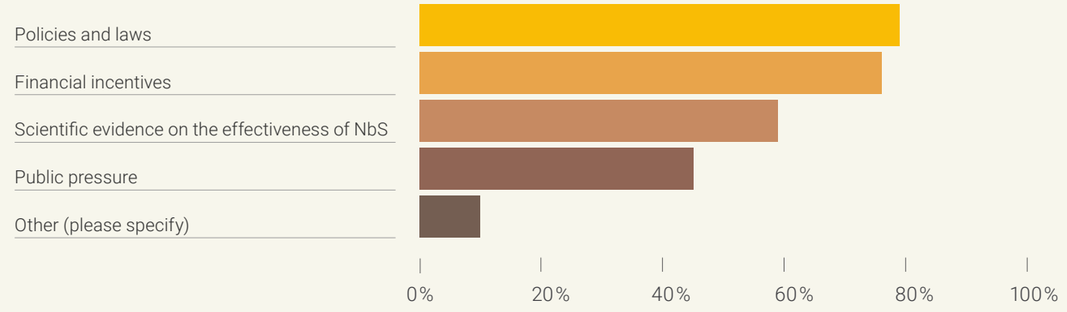
Indicators for monitoring NbS	
Diversity	Species diversity, biodiversity index
Condition	Environmental performance; ecosystem health and well-being; state of the rehabilitated wetland; forest coverage fragmentation; ecological connectivity; leaf area index; dissolved oxygen
Land use	Protected areas, land cover, land use types
Land degradation	Erosion rates and pollution
NbS impact	Runoff speed reduction, harvested water in a river basin

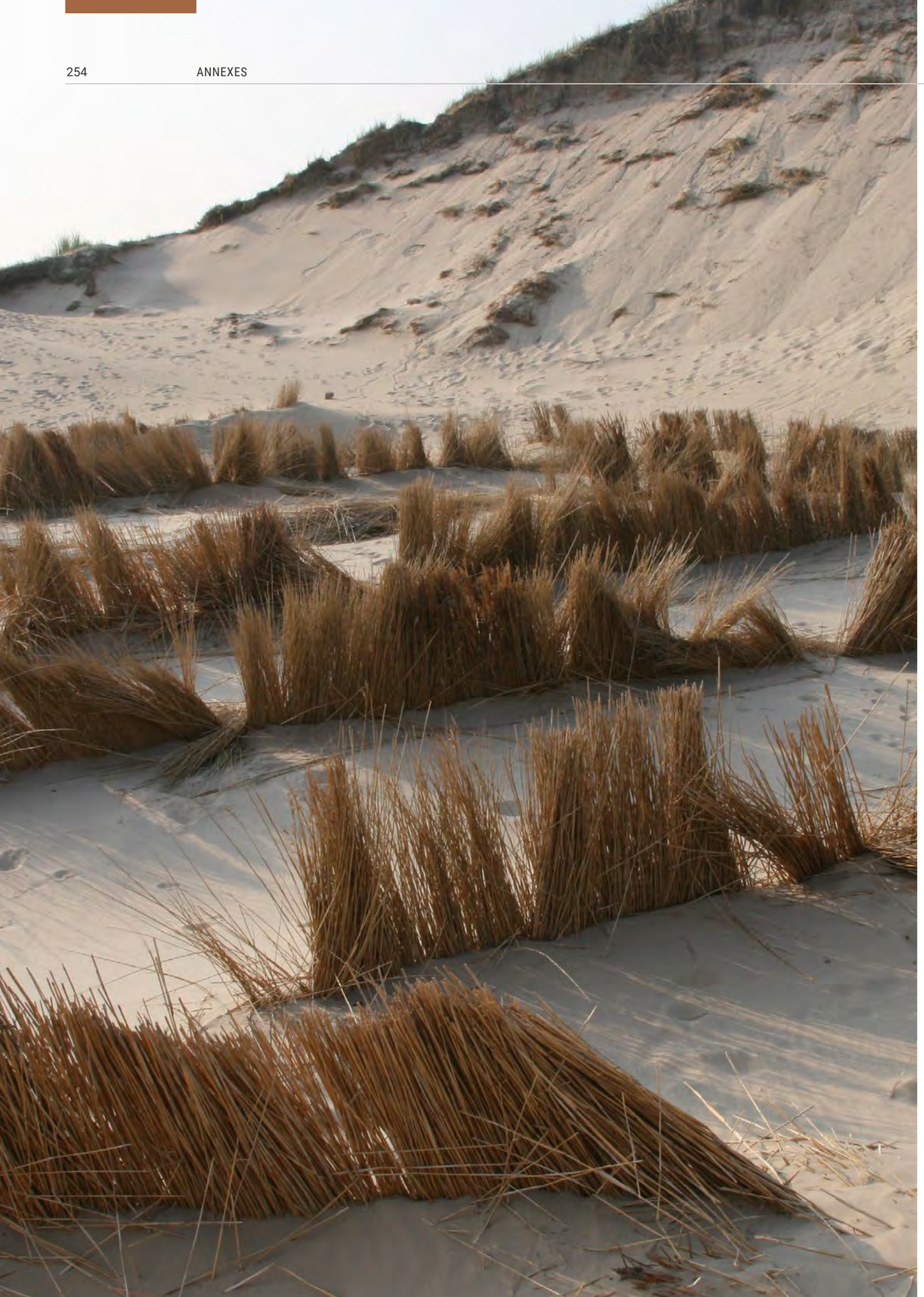
Disasters can cause loss and damage to ecosystems and the services they provide. However, only few countries/countries where respondents work monitor ecosystem-related disaster loss by estimating the monetary value of loss in terms of costs incurred by the disaster and costs of rehabilitating the affected area or replacing the lost ecosystems and their value.

Mainstreaming NbS requires it to be scaled up. Policies and laws as well as financial incentives are key to the scaling up NbS, according to 79% and 76%, respectively, of responses. Additionally, 59% of respondents believe that scientific evidence is needed to demonstrate the effectiveness of NbS, while 45% highlight the need for public pressure. Finally, respondents mention awareness and education as well as multidisciplinary approaches as factors that help to upscale NbS projects.

FIGURE

Aspects needed to scale up NbS projects with corresponding share of respondents.





Regarding policies and laws, which respondents believe to be the most important factor in upscaling NbS, the survey identified a number of pieces of legislation that promote or support the implementation of NbS, as shown in the table below:

Country	Legislation promoting NbS
Kenya	Forest Conservation and Management Act, 2016.
Ecuador	The National Water Secretariat (SENAGUA) issued guidelines on nature-based solutions (NbS) for water management in Ecuador, which include the EbA approach.
Colombia	Law 1523/2012 & Law 1931/2018. These laws are not specific to nature-based solutions but are articulated to implement nature-based projects.
Nigeria	The National Policy on Environment ensures sustainable development based on proper management of the environment. In particular, it aims to: a) secure a quality of environment adequate for good health and well-being; b) conserve and use the environment and natural resources for the benefit of present and future generations; c) restore, maintain and enhance ecosystems and ecological processes essential for the functioning of the biosphere and to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems; d. raise public awareness and promote understanding of the essential linkages between the environment, resources and development, and encourage individual and community participation in environmental improvement efforts; and e) co-operate in good faith with other countries, international organizations and agencies to achieve optimal use of transboundary natural resources and effective prevention or abatement of transboundary environmental degradation.
South Africa	The National Disaster Management Act, the National Environment Management Act, the Biodiversity Act.
Sri Lanka	Mitigation proposals in environment impact assessments, strategic environment assessments on macro-scale planning, climate change adaptation policies and practices.
Germany	White paper: Green spaces in the city https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/bauen/wohnen/weissbuch-stadtgruen-en.pdf?__blob=publicationFile&v=4

Annex 3

Annex 3 Sustainable Development Goals and other international framework agreements

Sustainable Development Goal	Relevant Aichi Biodiversity Target	Relevant Sendai Target	Relevant Ramsar Target	Relevant UNCCD Target	from 148 NDCs approx % of goals relevant
1. End poverty in all its forms everywhere	2, 6, 7, 14	A1, B1, C1, E1, E2	1, 2, 9, 11, 13, 15, 18	2	42%
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	4, 6, 7, 13, 18		1,3, 10,13, 15, 16,18,19	2	94%
3. Ensure healthy lives and promote well-being for all at all ages	8, 13, 14, 16, 18			2	70%
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	1, 19				66%
5. Achieve gender equality and empower all women and girls	14, 17, 18		10	2	41%
6. Ensure the availability and sustainable management of water and sanitation for all	8, 11, 14, 15		1,2,3, 5, 6, 7, 8, 9, 12, 15, 16, 18, 19	1,2,3	89%
7. Ensure access to affordable, reliable, sustainable and modern energy for all	5, 7, 14, 15, 19				100%
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	2, 4, 6, 7, 14, 16		1,3,9,13	2,4	82%
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	2, 4, 8, 14, 15, 19		3,14,15,17		92%
10. Reduce inequality within and among countries	8, 15, 18, 20				10%
11. Make cities and human settlements inclusive, safe, resilient and sustainable	2, 4, 8, 11, 14, 15	A1, B1, C1, D1, D5, E1, E2	1, 3, 5, 6, 7, 8, 9, 13, 15, 16, 19		90%
12. Ensure sustainable consumption and production patterns	1, 4, 6, 7, 8, 19			1,2,4	85%
13. Take urgent action to combat climate change and its impacts	2, 5, 10, 14, 15, 17	A1, B1,E2	1,6, 7, 13, 16, 19	3	100%
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15, 17, 19		1, 3, 5, 6, 7, 9, 11, 12, 13, 14,15,18		70%
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss	2, 4, 5, 7, 9, 11, 12, 14, 15, 16	D4, C5	1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16,17,18,19	1,3,4	90%
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	17				8%
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	2, 17, 19, 20			5	92%

GLOSSARY

Bioswales Generally strips of vegetated areas designed to redirect and filter surface runoff water.

Blue, green and grey infrastructure Engineered (grey) or natural (blue and green) structures designed to protect people from weather-related risks. Grey structures can be such things as dykes and levees; blue and green infrastructure are ecologically engineered structures that use a wide range of natural features. Green infrastructure refers to landscape elements, such as trees, parks and forests, while blue infrastructure involves water-based elements, such as rivers, canals and ponds.

Carbon sequestration The process of storing carbon from the atmosphere in carbon sinks, natural or artificial reservoirs that absorb and store the atmosphere's carbon.

Coastal field schools Training sessions held as part of the 'Building with Nature' programme (see Ecoshape below), where communities learn how to increase their income from coastal livelihoods while at the same time protecting coastlines.

Convention on Biological Diversity An international convention that entered into force in 1993 to conserve biological diversity, sustainably use the components of biological diversity and fairly and equitably share the benefits of genetic resources.

Ecoshape A foundation formed under Dutch law that manages the public-private innovation programme 'Building with Nature', which carries out and monitors 'nature-based solutions' for disaster risk reduction.

Gabion walls Partially flexible block constructions made of box-shaped wire baskets filled with rock fragments that serve as retaining walls for slope stability and erosion protection and present an alternative to concrete structures.

Geographic information system (GIS) A framework for gathering, managing and analysing spatial data, organized and visualized using maps and 3D images.

Global Platform for Disaster Risk Reduction A biennial multi-stakeholder forum established by the UN General Assembly to review progress, share knowledge and discuss the latest developments and trends in reducing disaster risk. The Global Platform for Disaster Risk Reduction is a critical component of the monitoring and implementation process of the Sendai Framework for Disaster Risk Reduction (2015-2030).

Global Network of Civil Society Organisations for Disaster Reduction (GNDR) International network of organizations working together to influence policies and practices to improve the lives of people affected by disasters worldwide.

Natural Hazard Triggering Technological Disasters (NATECH) Natural hazard events can impact infrastructure processing, storing or transporting dangerous substances, leading to fires, explosions and the release of hazardous substances which can cause major social, environmental and economic harm.

Net primary production The carbon dioxide that vegetation takes in through photosynthesis, minus what it releases during respiration.

No-take zone An area set aside by governments where no extractive activity, such as fishing, hunting, logging, mining or drilling, is allowed. No-take zones usually make up part of larger protected areas and offer a greater amount of protection to ecosystems, habitats and species.

Permeable pavements These are pavements with high porosity that allow water to filter through, reducing runoff and returning water to underground aquifers. They also allow for the evaporation of water at or below the surface, thereby cooling the surface, which is especially beneficial in cities (see urban heat island).

PIANC A global organization providing guidance and technical advice on sustainable waterborne transport infrastructure for ports, marinas and waterways.

Protection forest Forests that mitigate or prevent the impact of natural hazards, including rockfalls, avalanches, erosion, landslides, debris flow and flooding, on people and their assets in mountainous areas. A protection forest generally covers a slope between a potential hazard zone and exposed people and/or assets.

Ramsar Wetlands Convention An international treaty signed in 1971 providing a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Resilience The capacity of a system to absorb shocks and reorganize so as to maintain the same functions and structure as prior to a disturbance.

Sphere environmental stability standards A set of universal minimum standards to improve the quality of humanitarian responses in situations of disaster and conflict and to enhance the accountability of the humanitarian system to preserve and restore the environment as an integral part of overall humanitarian response and recovery activities.

'Sponge' cities A city that mainstreams urban water management into urban planning policies and designs so as to implement, maintain and adapt infrastructure systems to collect, store and treat (excess) rainwater. Sponge cities act like a sponge, absorbing rain water, which is then naturally filtered by the soil and allowed to reach urban aquifers.

'Spongy' terraces The application of terrace farming practices to capture, store and reuse water in uphill areas. It also stabilizes runoff rates, which reduces landslide and flood risk downstream.

Synthetic organic contaminants Human-made compounds used for a variety of industrial and agricultural purposes, including pesticides and herbicides.

TEEB – The Economics of Ecosystems and Biodiversity A global initiative focused on "making nature's values visible". Its principal objective is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels and help decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity.

Urban heat islands Urban areas can become 'islands' of higher temperatures relative to outlying areas when buildings, roads and other infrastructure absorbing and re-emitting the sun's heat are highly concentrated and greenery is limited.

Working with nature database PIANC (see PIANC) is building a database of projects and initiatives whose methodology is relevant to the 'working with nature' philosophy (i.e. navigation development projects that prioritize ecosystems and win-win solutions).

UNDRR
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WORDS INTO ACTION

NATURE-BASED SOLUTIONS FOR DISASTER RISK REDUCTION

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