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Chapter 6

Nature-based solutions for adaptation

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Key messages

- National and international policy and actions are increasingly recognizing that nature-based solutions (NbS) play a vital role in climate change adaptation.
- NbS for adaptation are often low-cost options that bring environmental, economic and social benefits to a wide range of stakeholders, including women and poor and marginalized groups.
- The substantial impacts of high-end climate change on biodiversity can limit the effectiveness of NbS and increase societal vulnerability thus reducing adaptation choices.
- A majority of countries' nationally determined contributions (NDCs) and national adaptation plans (NAPs) acknowledge the vulnerability of ecosystems to climate change, as well as their ability to effectively reduce climate impacts. However, the potential of NbS for reducing specific climate risks is rarely explicitly recognized and few goals and targets for implementation of NbS for adaptation are evident in adaptation planning.
- Only a small proportion of climate finance is targeted towards NbS for adaptation. The NbS finance base for adaptation could be amplified, strengthened and diversified by deploying innovative mechanisms that combine public and private sources of funding.
- There has been a marked increase in implementation of NbS for adaptation over the past two decades, but it is unclear whether this trend will continue. Implementation of NbS is taking place in all regions of the world, addressing all key climate hazards through a wide range of approaches, but it is still too early to assess the effects of these interventions systematically.
- The potential of NbS for adaptation can best be fully realized by limiting the risks of dangerous levels of warming and by scaling up ambition and action on protecting, conserving and restoring nature.

6.1 Introduction

There is growing recognition that the global crises of climate change and biodiversity loss are strongly interlinked, with climate change representing a major driver of biodiversity loss, while nature has a fundamental role in both mitigating climate change and enabling us to adapt to it (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019). The growing connections and potential for synergies between climate and biodiversity agendas, and the urgent need for policy and action to secure and harness nature's benefits, are reflected in the growing recognition of nature's contribution to humanity. For example, the fifth United Nations Environment Assembly focuses on "Strengthening Actions for Nature to Achieve the Sustainable Development Goals", and the UN Decade on Ecosystem Restoration will begin in 2021. Most recently, the COVID-19 pandemic and the associated economic crisis have further highlighted the vital importance of our relationship with nature – given the links that have been made between the emergence of the virus and the ongoing destruction of ecosystems and exploitation of wild species (IPBES 2020) – while also delaying urgent action related to the protection and restoration of nature.

Addressing the role of nature in adaptation to climate change is therefore both timely and vital (Global Commission on Adaptation [GCA] 2019). To date, much of the discussion surrounding nature-based solutions (NbS) has focused on their ability to mitigate climate change. However, their role in adaptation is also of central importance (box 6.1), since the effectiveness of most adaptation action, whether using engineered measures or other approaches, is fundamentally dependent on the continued or enhanced provision of ecosystem services (Kapos *et al.* 2019).

Focusing on the national level, this chapter explores progress in uptake and implementation of NbS for adaptation. It first introduces NbS for adaptation and the basis for increasing interest in them, before exploring the impacts of climate change on ecosystems and the role that ecosystems and their services, as well as their management, can play in reducing climate risks and impacts for both people and ecosystems. Following this, the chapter reviews progress in integrating NbS for adaptation into planning and policy at the national level, explores the financing landscape for NbS for adaptation, and describes progress and lessons learned in their implementation. Finally, the chapter highlights barriers to, and enablers for, further scaling-up of NbS for adaptation and provides suggestions for key next steps to advance the contribution of NbS to adaptation globally.

Box 6.1. Defining NbS for adaptation

Nature-based solutions (NbS), a term that has been increasingly used in recent years, is most commonly defined as:

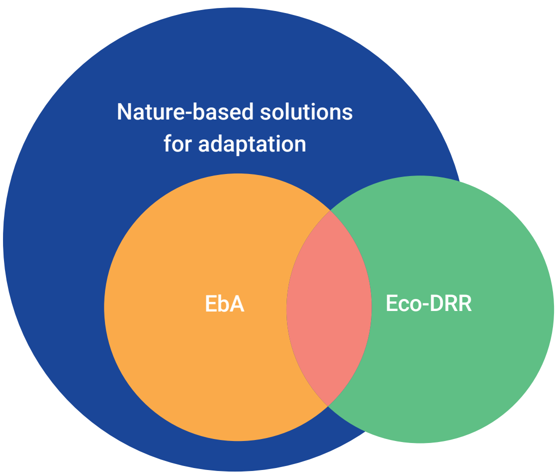
> ***“Actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”***

(International Union for Conservation of Nature [IUCN] 2020)

Climate adaptation is just one of the societal challenges that NbS can be used to address. Others include climate change mitigation, disaster risk reduction, food and water security, human health and socioeconomic development, as well as environmental degradation and biodiversity loss. Many of the activities and approaches that are encompassed by the umbrella term NbS are also associated with other widely used terms specific to particular sectors and disciplines (Ozment *et al.* 2019). Such terms include green infrastructure, natural infrastructure, ecological engineering, ecosystem-based mitigation, ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR).

The latter two terms have particularly strong linkages with NbS that are employed to achieve adaptation benefits – i.e. ‘NbS for adaptation’ – due to their relevance to reducing vulnerability to climate-related hazards. The relationship between these three terms is illustrated in figure 6.1.

Figure 6.1. Relationship between the terms Eco-DRR, EbA and NbS



Ecosystem-based adaptation (EbA): *“The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change”* (Secretariat of the Convention on Biological Diversity [CBD] 2009).

Ecosystem-based disaster risk reduction (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).

Note: Eco-DRR is depicted as being only partially within the term NbS for adaptation as Eco-DRR can also refer to activities and approaches that address non-climatic disaster risk, such as tsunamis and earthquakes. As EbA refers to ecosystem-based approaches to climate change adaptation, it is situated entirely within the scope of NbS for adaptation.

6.1.1 Introducing NbS for adaptation

NbS for adaptation restore, build on and enhance ecosystem services in order to manage climate change risks and impacts, help people (including women and marginal groups) adapt to climate change, and enhance the climate resilience of communities, assets and society. They can be utilized to address a wide range of climate hazards across a wide variety of contexts (table 6.1). They are commonly applied to address four main types of climate-related hazard: i) coastal hazards (including sea level rise, storm surge and coastal erosion); ii) intense precipitation (including floods, soil erosion, and landslides caused by intense precipitation) iii) drought; and iv) rising temperatures (heat stress, urban heat islands and wildfires) (Kapos *et al.* 2019). NbS for adaptation may be implemented on their own or in combination with engineered approaches for reducing climate risk. Often, their design, implementation and management may draw on local and traditional, as well as expert, knowledge.

NbS for adaptation can cost less than hard engineered approaches for addressing climate hazards (Reguero *et al.* 2020; Narayan *et al.* 2016) and generate substantial economic benefits (see, for example, Menéndez *et al.* 2020). When well-designed and implemented, they have the potential to generate larger returns (in a broad economic, rather than financial, sense) because of the multiple societal benefits they deliver in addition to reducing climate risk (table 6.1; Rizvi 2014; Seddon *et al.* 2020a and 2020b). Additional benefits can include environmental benefits (such as carbon sequestration and storage and biodiversity conservation) and socioeconomic benefits such as the provision of food, marketable products, jobs and livelihoods, improved health, and support for cultural and religious values. Most of these benefits can be especially important for women and for poor and marginalized people (Reid *et al.* 2019).

Despite the benefits associated with NbS for adaptation, their successful implementation presents a number of challenges. For example, as adaptation tends to be highly context-specific, there can be some uncertainty around how effective individual NbS will be for addressing hazards of varying severity or in different locations. In tandem with this, it can take a significant amount of time for interventions to reach the stage where they deliver the full level of risk reduction benefits and co-benefits that were initially anticipated; this is particularly the case for interventions that involve restoring badly degraded ecosystems. Furthermore, as some NbS types depend on effective land management across large areas, their successful implementation can require the extensive and sustained engagement of a wide range of stakeholders. Finally, since ecosystems and their services are themselves climate-sensitive, NbS for adaptation must account for, and manage, climate risks to help ensure their long-term viability.

6.1.2 International policy context

Policy drivers for using nature-based solutions to address climate change and other challenges are growing in various arenas of environmental governance and from global to jurisdictional levels.

The Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) recognizes the importance of ecosystems for mitigation and adaptation, calling on Parties to "note the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity […]", and includes NbS for mitigation in the text referring to REDD+[1] in article 5.2. In addition, "joint mitigation and adaptation approaches for the integral and sustainable management of forests" are also mentioned in this article, along with the importance of non-carbon benefits associated with managing forests to preserve and enhance carbon stocks. Article 7.1 meanwhile encourages Parties to build the resilience of socioeconomic and ecological systems, including through economic diversification and sustainable management of natural resources.

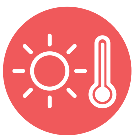
NbS were a major focus of the United Nations Secretary-General's Climate Action Summit in 2019, where participants launched the *Nature-Based Solutions for Climate Manifesto*. In the same year, paragraph 15 of the overarching decision stemming from UNFCCC COP 25 "[u]nderlines the essential contribution of nature to addressing climate change and its impacts and the need to address biodiversity loss and climate change in an integrated manner" (United Nations Framework Convention on Climate Change [UNFCCC] 2020).

Meanwhile, the Convention on Biological Diversity (CBD) has continued to highlight the importance of the relationship between biodiversity and progress on climate change mitigation and adaptation. It has emphasized the value of ecosystem-based adaptation (EbA; see box 6.1) and endorsed the *Voluntary Guidelines for the Design and Effective Implementation of Ecosystem-Based Approaches to Climate Change Adaptation and Disaster Risk Reduction* in 2018. Governments, intergovernmental and non-governmental organizations worldwide have embraced EbA, leading to a proliferation of such projects.

The conservation, sustainable management and restoration of ecosystems that NbS for adaptation entail can also help to meet a wide range of other international objectives. These include: the Sustainable Development Goals (SDGs), in particular SDGs 13 (climate action), 15 (life on land), 6 (clean water) and 14 (life below water); the Sendai Framework for Disaster Risk Reduction, which explicitly recognizes the importance of NbS; the Bonn Challenge on forest and landscape restoration; the New York Declaration on Forests; and the United Nations Convention to Combat Desertification (UNCCD) agenda on land degradation neutrality.

1 REDD+: Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

Table 6.1. NbS for adaptation: examples of applications to reduce impacts related to major climate hazards

Hazard	NbS for adaptation	Potential additional benefits
 **Coastal hazards** • Sea level rise • Storm surge • Coastal erosion	• Mangrove protection and restoration to anchor sediments and dissipate wave energy • Management and restoration of coastal marshes and/or dunes to dissipate wave energy and/or complement engineered protection • Coral reef management and restoration to attenuate wave energy	• Improved fish stocks • Biodiversity conservation • Carbon sequestration and storage • Sediment accretion • Tourism and recreation and associated employment
 **Intense precipitation** • Flood • Soil erosion • Landslide	• Management and restoration of watershed vegetation to enhance infiltration, reduce run-off and peak flows, and stabilize slopes • Agroforestry to enhance canopy interception of rainfall and rainwater infiltration and reduce soil exposure, thereby reducing run-off and erosion • Urban watercourse restoration, and 're-naturing' to reduce assets at risk and secure riverbanks • Maintenance and restoration of urban greenspaces to improve rainwater infiltration and reduce run-off • Management and restoration of wetlands to store floodwater or slow its release and filter sediments	• Increased availability of wild-sourced food and other products • Pollination services • Carbon sequestration and storage • Improved soil fertility • Biodiversity conservation • Improved water quality • Improved physical and mental health among urban populations
 **Drought**	• Management and restoration of watershed vegetation to enhance infiltration, recharge groundwater stores and maintain surface water flows • Establishment of 'Green Belts' to increase water availability, improve soil quality, provide shade and windbreaks	• Increased availability of wild-sourced food and other products • Pollination services • Carbon sequestration and storage • Improved soil fertility • Biodiversity conservation
 **Rising temperatures** • Heat stress • Urban heat islands • Wildfire	• Agroforestry to enhance canopy cover and provide shade • Rehabilitation and restoration of rangelands to repair ecological processes and enhance fire resistance • Creation of urban green spaces to increase vegetative canopies, which provide shade and evaporative cooling	• Carbon sequestration and storage • Improved soil fertility • Biodiversity conservation • Improved physical and mental health among urban populations

Source: Adapted from Kapos *et al.* (2019)

NbS for adaptation feature highly on the agendas of international financing institutions and donors. For example, the Global Environment Facility (GEF), the Adaptation Fund (AF) and the Green Climate Fund (GCF) have all supported numerous projects that use ecosystems to advance adaptation objectives, and bilateral donors, such as Germany's International Climate Initiative (IKI), are also prioritizing NbS for adaptation (see sections 6.4 and 6.5). Furthermore, there is also increasing interest among multilateral development banks and the private sector in using NbS to increase the climate resilience of their investments in, for example, infrastructure (Inter-American Development Bank [IDB] 2019). This is an important development as financial institution and private sector investment will be key to scaling up implementation of NbS for adaptation.

Box 6.2. Ecosystem services

'Ecosystem services' are the ecological characteristics, functions or processes that directly or indirectly contribute to human well-being: that is, the range of benefits that people derive from functioning ecosystems (Costanza *et al.* 1997; Millennium Ecosystem Assessment 2005; Costanza *et al.* 2017). These services can be broadly categorized as provisioning, regulating, cultural or supporting.

Provisioning services result in material benefits that people obtain from ecosystems, such as food, fuel, fibre, fresh water and genetic resources. Regulating services from ecosystem processes include air quality maintenance, climate regulation, erosion control and water purification. Non-material benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences comprise cultural services. Lastly, supporting services are those that are essential for the generation of all other ecosystem services, such as primary production, production of oxygen and soil formation (Millennium Ecosystem Assessment 2005).

6.2 Biodiversity and climate risks

All three aspects of biodiversity – diversity within species, between species and of ecosystems – are impacted by climate change. Effective adaptation considers these aspects of ecological vulnerability and how this can in turn affect social vulnerability, including of youth, women, indigenous peoples and local communities. By specifically aiming to address broad societal goals such as human well-being, NbS go beyond some more narrowly defined approaches to adaptation (Seddon *et al.* 2020a).

6.2.1 Implications of climate change for biodiversity

Ecosystems can be broadly categorized into terrestrial, freshwater, coastal and marine. An ecosystem is a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (Secretariat of the Convention on Biological Diversity 2010). Along with the services they provide (box 6.2), ecosystems play a key role in building the resilience of social systems.

Climate risks to ecosystems and their services are affected by multiple factors, including magnitude and rate of warming, geographic location, levels of ecosystem degradation, levels of ecosystem development and vulnerability, connectivity and fragmentation of ecosystems, local ecosystem tipping points, and selection and implementation of adaptation and mitigation options (Intergovernmental Panel on Climate Change [IPCC] 2018). Risks to species, ecosystems and ecosystem services can be addressed by adopting and accelerating mitigation and climate-informed natural resource management and conservation. Climate change can also alter ecosystems and their services, and may undermine the performance of NbS that rely on them (Calliari *et al.* 2019). Table 6.2 highlights some of the ways in which ecosystems and NbS interact with high- and low-risk climate scenarios.

Evidence of past climatic change indicates that ecosystems were strongly impacted by rates of climate change that were significantly lower than those currently projected under high warming scenarios (for example, Representative Concentration Pathway (RCP) 8.5). As such, under mid- and high-end climate scenarios (see table 6.2), many species are not expected to migrate at rates fast enough to follow suitable climatic conditions (Settele *et al.* 2014). An ecosystem's inherent sensitivity to the impacts of climate change and its capacity to adapt vary across ecosystems, meaning that some ecosystems are more vulnerable than others. However, these traits can be strongly influenced by the management approaches adopted. For example, ecosystem sensitivity to climate change can be reduced, and its capacity to adapt increased, by addressing non-climatic pressures on ecosystem function (such as invasive species, habitat loss and fragmentation) and by increasing genetic, species and functional richness through active management or through allowing degraded areas to regenerate naturally (Seddon *et al.* 2020a).

Applying NbS to address slow-onset events is often overlooked, with limited or no research available on specific NbS to tackle these issues. These include risks and impacts of events such as increasing temperatures, loss of biodiversity, desertification, land and forest degradation, glacial retreat and related impacts, sea level rise, ocean acidification and salinization (UNFCCC 2018). However, many NbS utilized to address more extreme events can also be harnessed to build resilience against these slow-onset events. For example, protection, management and restoration of mangroves, sand dunes and coastal marshes

Table 6.2. Examples of potential impacts under low- and high-end climate scenarios

Low-end climate scenarios	High-end climate scenarios
► Risks to natural and human systems are expected to be lower at 1.5°C than at 2°C of global warming (high confidence), as lower rates of change help maintain the ability of natural and human systems to adapt. ► Terrestrial and wetland ecosystems and the services they provide will suffer less if warming is limited to 1.5°C, rather than to 2°C, with the percentage of terrestrial land area projected to be affected by ecosystem transformations standing at 13 per cent at 2°C and approximately 4 per cent at 1.5°C. ► Large-scale changes are observed in ocean ecosystems, with critical thresholds expected to be reached at 1.5°C. ► Warming towards 1.5°C will see increases in water temperatures that are expected to drive some species (such as plankton and fish) to migrate to higher latitudes and cause novel ecosystems to assemble. Species that are less able to relocate (e.g. corals) are projected to experience high rates of mortality and loss. ► Risks to ecosystems in oceans include declining ocean productivity, shifts of species to higher latitudes, ecosystem damage (such as to coral reefs and mangroves), loss of productivity in fisheries, and changes to ocean chemistry (for example, acidification).	► High-end scenarios project an increased risk of global extinctions – the fraction of species at risk of climate-related extinction is 5 per cent at 2°C warming, rising to 16 per cent at 4.3°C warming. ► Although the adaptive capacity of ecosystems and species is substantial, many will neither be able to cope with increased extreme events and variability, nor adapt to the projected high rates and magnitudes of climate change. This will ultimately result in their loss, along with the services they provide to people. ► Species with long generation times show limited adaptive capacity at high rates of climate change, due to the inherent adaptive capacities of many species being exceeded. ► Under high magnitudes of climate change, species with restricted populations (for example, in isolated habitats or on mountain tops) are expected to undergo adverse effects, reducing their abundance, resilience and viability. ► Terrestrial and freshwater ecosystems are at risk of abrupt and irreversible regional-scale change in their composition, structure and function under large magnitudes and high rates of climate change.

Sources: Settele *et al.* (2014); IPCC (2018); IPBES (2019)

can build resilience as sea levels rise, while simultaneously protecting against extreme events such as coastal storms and surges (Kapos *et al.* 2019).

Many ecosystems that play a critical role in nature-based approaches to adaptation are themselves highly vulnerable to climate change. Mountain ecosystems, for example, play a critical role as 'water towers' reducing drought risk for surrounding communities. However, mountain ecosystems are among the most vulnerable to the negative impacts of climate change due to their low adaptive capacity (Immerzeel *et al.* 2020).

Climate change is having impacts on most ecological processes, with species across terrestrial, freshwater and marine ecosystems exhibiting changes in genetics, physiology, morphology and phenology. Shifting species distribution is another significant impact, which in turn has knock-on effects on food webs, resulting in new interactions between species (Scheffers *et al.* 2016). Risks to people from these changes include reduced and/or unpredictable fishery and crop yields, loss of genetic diversity in wild crop varieties, and increasing impacts of pests and diseases.

The exposure, sensitivity and adaptive capacity of ecosystems both directly and indirectly affects their ability to act as a sink for carbon dioxide emissions and to reduce socioeconomic vulnerability to climate change (Seddon *et al.* 2020a). Although many natural systems are usually well adapted to natural disturbance regimes and can recover from major hazards (such as grasslands' ability to recover after fires), others are more sensitive (for example, forest dieback due to drought and heat stress) (Allen *et al.* 2010; Seddon *et al.* 2020a). Non-climatic stressors such as land-use change can induce additional disturbances that prevent adequate recovery. Furthermore, even in the absence of additional non-climatic stressors, increases in the frequency and intensity of climate hazards can compromise the adaptive capacity of ecosystems, potentially leading to a transition that results in a new community of species or the formation of a new ecosystem altogether (Seddon *et al.* 2020a).

Across marine, terrestrial and freshwater ecosystems, shifts in species distribution, changes in phenology, altered population dynamics, and changes in the composition of species assemblage or the structure and function of

Box 6.3. Addressing coastal hazards in the Mesoamerican Reef region

The Mesoamerican reef is home to the world's second longest barrier reef. Stretching across more than 1,000 kilometres of coastline in Mexico, Belize, Guatemala and Honduras, it is also the largest transboundary reef system in the world. This hotspot for biodiversity is home to endangered marine turtles, more than 60 types of corals and over 500 fish species. Coastal and marine resources in the region provide essential ecosystem services and boost national economies by sustaining key economic sectors including fisheries and tourism and supporting the livelihoods of more than 2 million people.

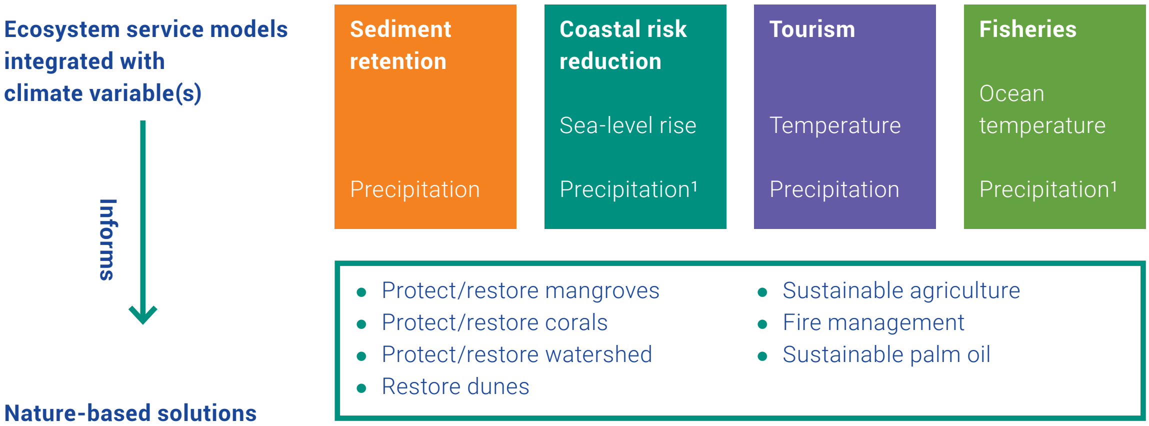
While the Mesoamerican reef helps protect coastal communities against adverse effects of climate change, the ecosystems and species of this region are vulnerable to climate change impacts. For example, erosion and inundation of coastal areas due to storms and sea level rise, coral bleaching through increased ocean temperatures, and changes in ocean parameters such as pH, leading to ocean acidification, are key climate change impacts affecting the region.

Climate-Smarting Marine Protected Areas and Coastal Management in the Mesoamerican Reef Region (the 'Smart Coasts' project), funded by the German Government's International Climate Initiative (IKI), was initiated to strengthen capacities in coastal communities and government institutions. It is implemented by the World Wildlife Fund for Nature (WWF), Stanford University and Columbia University in partnership with government agencies, coastal-marine resource co-managers, local communities and civil society groups from all four countries.

This project integrates climate change scenarios and adaptation options into a participatory decision-making process that can inform marine protected areas as well as coastal zone management and development policies. The project will enhance knowledge and capacities at local and national levels, contribute to national adaptation policies and action plans and make best practices available in relevant national and international forums. It takes an inclusive approach to implementation: women and men are offered equal opportunity to participate in its activities, including but not limited to meetings and workshops, analysis of local vulnerability and provision of recommendations to reduce vulnerability.

The analyses built on previous work in the region, applying science-based tools including ecological risk assessments and cost-benefit analyses that integrated climate change and social development scenarios, ecosystem services modelling and green versus grey infrastructure. Climate-risk information – which included sea level rise, sea surface temperatures, surface air temperature, extreme heat, and precipitation – was developed in consultation with stakeholders and incorporated into ecosystem service models on coastal protection, sedimentation, fisheries and tourism. Based on this information, stakeholders identified and prioritized NbS through a participatory decision-making process (see figure 6.2). In addition to informing relevant policy and management frameworks, adaptation measures will be implemented in selected coastal areas of Mexico, Belize, Guatemala and Honduras.

Figure 6.2. Inclusive framework used for NbS decision-making process in the Smart Coast project



1 Precipitation is integrated into coastal risk reduction and fisheries models through its indirect effects on sediment export which can influence coral health

Sources: World Wildlife Fund for Nature (WWF) (undated); Reynolds (2019); Arkema *et al.* (2015)

ecosystems, are already evident and accelerating (IPBES 2019). Changes are being seen across the organism, population, species and community levels. At the scale of organisms (such as individual plants and animals), genetic, physiological and morphological changes have been identified, while at the population level, changes in phenology, abundance and population dynamics have been observed. Changes in species distribution have ranged from shifts in fisheries to changes in pollinator ranges and abundance. In communities, interspecific relationships are changing due to redistribution of species where existing interactions are distributed and new interactions forming. These can lead to trophic disruptions and phenological mismatches. Changes in productivity have also been observed in communities in both terrestrial and aquatic systems (Scheffers *et al.* 2016). Finally, studies show that species are undergoing changes in their genetics, indicating evolutionary adaptation to human-induced climate change. For example, studies on pink salmon indicate an increased frequency of a genetic marker for late-migration timing (Kovach, Gharrett and Tallmon 2012).

6.2.2 Effectiveness of nature-based solutions

NbS for adaptation tend to be highly context-specific, adding to uncertainties about their effectiveness under changing climate conditions. In some cases, NbS may therefore be less effective for adaptation under future climate scenarios, in particular those involving high-magnitude climate hazards (Kapos *et al.* 2019).

Since ecosystems are already in the process of transitioning, reduced ecological resilience can lower the potential of NbS to support adaptive capacity in the long run (Scheffers *et al.* 2016; Lavorel *et al.* 2015). Severely altered ecosystems (such as mass coral mortality from bleaching) are unlikely to be able to adapt quickly enough (Graham *et al.* 2015). A study on the effectiveness of mangroves indicates that it is highly likely (>90 per cent probability) that mangroves are unable to initiate sustained accretion when relative sea level rise rates exceed 6.1 mm yr-1. This threshold is likely to be surpassed on tropical coastlines within 30 years under high emissions scenarios (Saintilan *et al.* 2020), potentially limiting their ability to safeguard coastlines against rising sea levels.

Altered ecosystems could, in some cases, provide similar or novel adaptation services (Lavorel *et al.* 2015; Lavorel *et al.* 2019). Adaptation services are identified as ecosystem properties that facilitate societal climate adaptation by supporting current ecosystem service bundles, supplying novel services and moderating or enabling ecological transformation. Floodplain ecosystems are one example of a system that is likely to persist with an altered vegetation structure (probably with reduced extent) due to attributes such as high diversity of tree species, drought-resistant life-cycle stages, and high connectivity for recolonization via riparian vegetation.

6.3 Planning

Similar to the analysis in chapter 3, this section summarizes available information on the degree to which countries' planning for adaptation incorporates NbS for adaptation, drawing primarily on nationally determined contributions (NDCs) under the Paris Agreement and national adaptation plans (NAPs) for which relevant analyses are available (no comprehensive analysis on the role of nature in the adaptation components of national communications is currently available). This section also explores progress both at sectoral and subnational scales, and on broader transboundary scales that in many cases are essential to secure ecosystem services and their contribution to resilience.

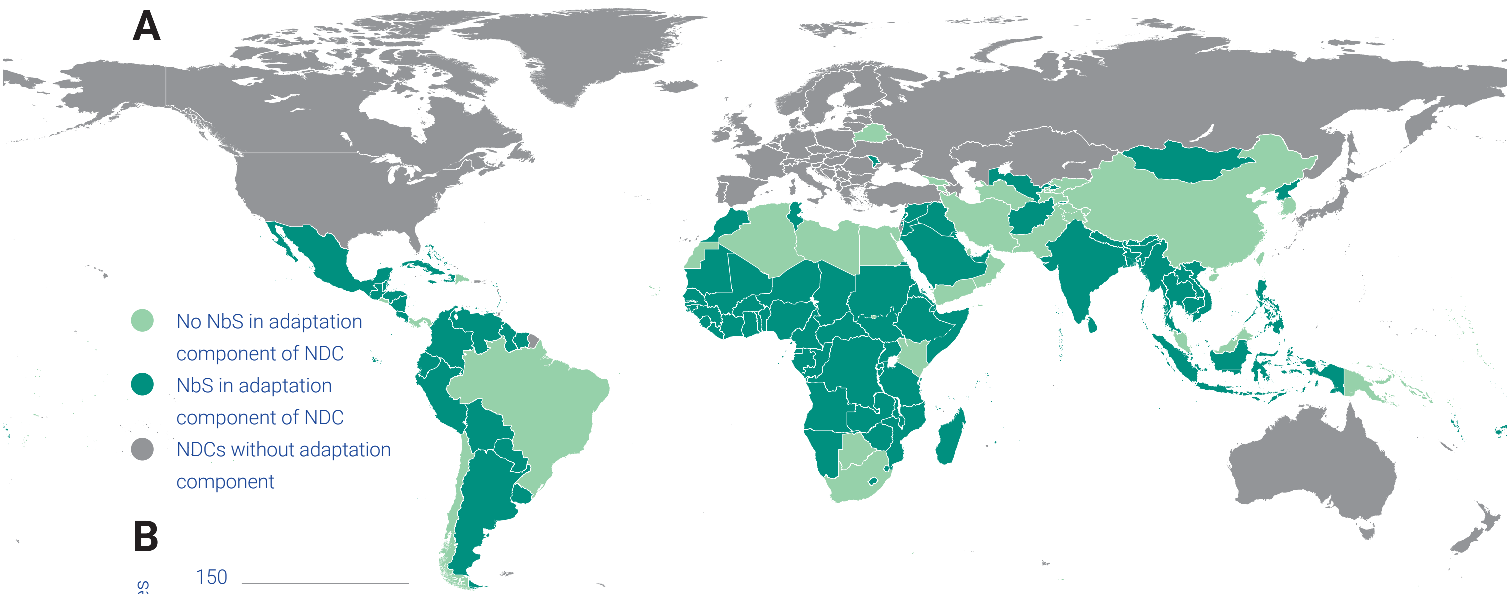
Analyses of NDCs show that between just under half (Pauw *et al.* 2016) and two-thirds (Seddon *et al.* 2020b) of countries' original NDC submissions acknowledged in their adaptation components that ecosystems and biodiversity are vulnerable to climate change (figure 6.3, Panel B). Low- and lower middle-income countries account for just over half of such submissions (Seddon *et al.* 2020b). Most NDCs assessed (106 out of 168) list ecosystem protection as an important motivation for adaptation planning, and include ecosystems in their overall statements of adaptation needs and approaches.

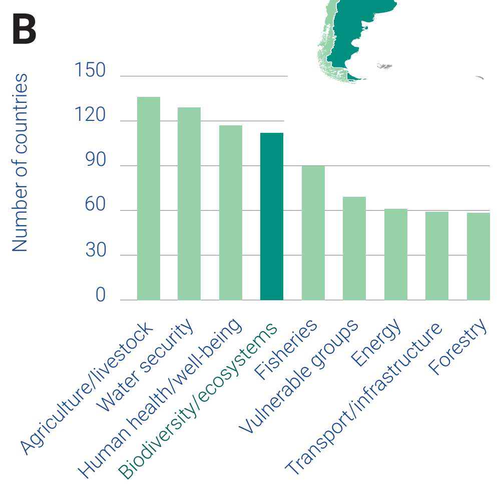
According to Seddon *et al.* (2020b), over 60 per cent of countries (104 nations) included aspects of NbS (EbA or conservation action) in the adaptation component of their NDCs (figure 6.3, Panel A). This is especially frequent among poorer nations; over 90 per cent of NDCs from least developed countries (LDCs), but only 26 per cent from high-income countries, include plans corresponding to NbS in the adaptation components of their NDCs. However only 30 of the NDCs that address NbS in the context of adaptation include relevant measurable targets that are distinct from broader adaptation goals (www.nbspolicyplatform.org).

Annex I countries' seventh National Communications to the UNFCCC show a similar pattern. In nearly all of these, the adaptation sections explicitly explore climate-change-related risks to ecosystems and biodiversity. Some highlight the general utility of ecosystem-based approaches for reducing climate-related risks in general, but few reflect on any explicit plans for deploying these approaches in relation to specific climate risks – and if they do, any such plans are usually in reference to flood control or reducing urban heat island effects.

As required in preparation for UNFCCC COP 26, countries are in the process of revising their NDCs with a view to enhancing ambition and the probability of achieving the goals of the Paris Agreement. Of the few 2020 submissions (11 as at 1 Sept 2020), only Andorra, Chile, Moldova and Singapore include explicit reference to NbS in the context of adaptation – the first appearances of this terminology in NDCs – and aim to increase and mainstream their use

Figure 6.3. Nature-based solutions in adaptation components of nationally determined contributions in developing countries





A Countries that include nature-based solutions (incl. ecosystem-based adaptation or conservation) in the adaptation components of their NDCs submitted until September 2019.

B Sectors that are most frequently considered to be vulnerable to climate change in the first round of NDCs. Biodiversity and/or ecosystems rank fourth

Note: Analysis presented in Panels A and B of Figure 6.3 are based on analysis of 142 NDCs with adaptation components.
Source: Seddon *et al.* (2020b)

across sectors. They highlight, in particular, drought and flooding as hazards for which NbS are helpful approaches. For example, Singapore explicitly aims to 'naturalize' many of its waterways as a means of reducing flood risk and to conserve and restore mangroves to reduce the impacts of sea level rise.

Another major vehicle for adaptation planning under the UNFCCC is the national adaptation plan (NAP) process. This can be an important enabler for planning and implementing NbS through providing a framework and, potentially, financial resources for implementation at scale. The UNFCCC Technical Guidelines (Least Developed Countries Expert Group of the United Nations Framework Convention on Climate Change 2012) emphasize that the NAP process is to be inclusive of vulnerable groups, communities and ecosystems, promote the integration of gender perspectives and encourage countries to recognize the need to protect and build ecosystem resilience. All of the elements of the NAP process include key entry points for applying an ecosystem perspective (box 6.4), including through vulnerability assessments and explicit consideration of ecosystem-based approaches to adaptation.

A review undertaken for the NAP Global Network showed that all 19 of the NAPs submitted to the UNFCCC by March 2020 included some consideration of ecosystems and their vulnerability to climate change, and that most had identified ecosystem services at risk from climate change (Terton and Greenwalt 2020). The majority of NAPs referred explicitly to EbA and all included measures corresponding to EbA. The measures proposed mostly addressed forests, freshwater and coastal ecosystems, which were also those most commonly identified as vulnerable. However, it was often not made explicit how the individual measures described were expected to address climate-related hazards and risks and deliver measurable adaptation outcomes, or who the beneficiaries would be. Several countries had made efforts to link their NAPs to sectoral plans, including national biodiversity strategies.

Planning for NbS that contribute to adaptation is often needed and/or takes place in contexts where the focus is not climate change per se and at scales other than national. National biodiversity strategies and action plans (NBSAPs), which countries develop under the CBD, are one important example. The CBD has emphasized the potential and importance of

Box 6.4. Entry points for NbS for adaptation in the NAP process

In principle, all four elements of the NAP process as laid out in the NAP Technical Guidelines (Least Developed Countries Expert Group of the United Nations Framework Convention on Climate Change 2012) should incorporate NbS for adaptation, but specific attention to particular areas makes appropriate emphasis on the contribution of NbS more likely (UNEP 2019; Food and Agriculture Organization of the United Nations [FAO] and United Nations Development Programme [UNDP] 2020).

Figure 6.4. Entry points for NbS for adaptation in the NAP process

A2: Stocktaking: Identifying available information on climate change impacts, vulnerability and adaptation…

- Including ecosystems, ecosystem services and ecosystem dependencies in information compilation
- Engage experts on ecosystems and climate and relevant institutions

A4: Comprehensively and iteratively assessing development needs and climate vulnerabilities

- Identifying existing policy objectives on conservation, management & restoration of ecosystems
- Examine potential for synergies with other multilateral environment agreements

B2: Assessing climate vulnerabilities and identifying adaptation options at sector, subnational, national and other appropriate levels

- Include assessments of ecosystem vulnerabilities
- Include ecosystem and ecosystem service dependencies in other vulnerability assessments

B3: Reviewing and appraising adaptation options

- Assess costs and benefits of adaptation options in ecosystems, as well as economic and social terms
- Examine potential for synergies with other multilateral environment agreements

B5: Integrating climate change adaptation into national and subnational development and sectoral planning

- Involve environmental institutions as stakeholders
- Examine potential for synergies with other multilateral environment agreements

D1: Monitoring the NAP process

- Include monitoring of the status and vulnerability of ecosystems in the NAP monitoring and evaluation framework
- Include progress and impacts of implementing NbS for adaptation in the NAP monitoring and evaluation framework

D2: Review the NAP process to assess progress, effectiveness and gaps

- Draw on and expand existing ecosystem monitoring as needed to inform this process

C1: Prioritising climate change adaptation in national planning

- Include the 'potential to complement national goals on protecting and enhancing ecosystem structures' among the criteria for prioritising implementation
- Examine potential for synergies with other multilateral environment agreements

C2: Develop a (long-term) national adaptation implementation strategy

- Including an ecosystem-based approach in the implementation strategy and in implementation itself

C3: Promoting coordination and synergy at the regional level and with other multilateral environmental agreements

- Involve sectors directly involved with and/or dependent on ecosystems, including in a transboundary context

Source: Least Developed Countries Expert Group of the United Nations Framework Convention on Climate Change (2012)

EbA. Many countries have assessed climate vulnerability of species and ecosystems to inform their NBSAPs, and some have planned action to reduce that vulnerability, including reducing other anthropogenic pressures, as specified in the CBD's Aichi Biodiversity Target 10.[2] While at least half of countries' NBSAPs include actions on ecosystem restoration, few explicitly address the restoration of ecosystem services or restoration for adaptation or to strengthen climate resilience (United Nations Development Programme [UNDP] 2016). The emerging post-2020 framework for the CBD, along with the UN Decade on Ecosystem Restoration, is likely to provide further opportunity for increasing coherence between planning for adaptation using NbS and action under the CBD, especially on ecosystem restoration.

NbS have also begun to be considered in sectoral planning processes, as they have the potential to contribute to resilience in sectors ranging from infrastructure (IDB 2019) and energy to water, agriculture and cities, and in some cases are being included substantively in sectoral plans (see box 6.5 for examples).

National plans are not the sole determinant of adaptation action at subnational and local scales: subnational plans and strategies may also incorporate NbS. This is especially notable in relation to local adaptation plans for cities. Of the 210 cities across the world that disclosed their adaptation actions to the Carbon Disclosure Project (CDP) in 2016, 101 reported planting trees and creating green spaces as actions taken to adapt to climate change, especially for reducing heat island effects and flood risk (Carbon Disclosure Project [CDP] 2016). Local adaptation planning is also relevant beyond the urban environment; for example, a GEF-funded project in Djibouti led to the development of district-level adaptation plans, which included NbS in the form of watershed and mangrove rehabilitation, for two regions of the country home to nearly 80,000 people in total.

Effective NbS for adaptation require system-scale approaches. For many locations, this will involve planning and coordination across national or jurisdictional boundaries, for example in managing hydrological catchments to address water supply and flood control (box 6.6). The need for NbS design to incorporate risk identification and risk management beyond the intervention site is highlighted in IUCN's Global Standard for NbS (IUCN 2020).

Successful adaptation from the national through to local scales requires coherence, integration and consistency between local decisions and actions and national-level strategies (Dazé, Price-Kelly and Rass 2016). If the use of NbS for adaptation is to be scaled up along with the associated potential socioeconomic and environmental co-benefits, NbS will need to be incorporated in more concrete terms into relevant planning processes that cross scales and sectors.

The NAP process can play a significant role in this. Area-based planning frameworks such as integrated water management or integrated coastal zone management, given their emphasis on landscape-scale ecosystem management and a holistic systems perspective, can also help facilitate vertical, as well as horizontal/cross-sectoral harmonization of adaptation action and support planning for NbS in adaptation.

There is also scope to incorporate into mitigation planning the role of ecosystems in providing NbS for adaptation. For example, the Paris Agreement emphasizes the importance of incentivizing, as appropriate, non-carbon benefits associated with REDD+ action and joint adaptation-mitigation action (UNFCCC 2016). However, despite some examples in spatial planning for REDD+ (Epple *et al.* 2016), there is as yet limited understanding and experience of planning for mitigation co-benefits from adaptation action or for enhanced benefits for adaptation from mitigation action. Critically, NbS planning needs to account for climate risks to ecosystems and include measures to address them in order to avoid investment in solutions that may be ineffective or short-lived.

Box 6.5. Examples of sectoral adaptation plans that include NbS for adaptation

Uruguay's NAP focuses specifically on the **agriculture sector**, with ecosystems and natural resources highlighted as one of the four major pillars around which it is organized. EbA plays a central role, with an emphasis on action at the landscape scale to achieve conservation, sustainable management and restoration of ecosystems to provide ecosystem services. Valuation of these services is seen as central to designing policies that account for their contribution to resilient production systems.

In its 2020 NDC submission, **Chile** both emphasizes the importance of NbS for adaptation and anticipates adaptation plans for 11 priority sectors. Its 2016 National Communication highlights the potential importance of EbA for the **water, infrastructure and agriculture sectors**.

Saint Lucia's *Sectoral Adaptation Strategy and Action Plan* for the **Water Sector** specifically prioritizes EbA solutions (including maintenance of vegetative buffers and protection of wetland ecosystems) as a strategic objective in strengthening preparedness for climate variability and extremes.

2 "By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning."

Box 6.6. Transboundary planning/ implementation

The commissions that oversee management of some transboundary hydrological systems provide a useful medium for adaptation planning. The Mekong River Commission has highlighted the potential importance of EbA in the countries of the Lower Mekong Basin (Mekong River Commission [MRC] 2014), while the Lake Victoria Basin Commission has developed a Climate Change Adaptation Strategy and Action Plan for the basin that emphasizes the importance of reducing the vulnerability of ecosystems and their services.

The private sector may also play a role in transboundary planning and implementation of NbS for adaptation. Facilitated by existing legal frameworks for protecting watershed forests and for compensating landowners who preserve forests that are important for water, Itaipú Binacional (a hydroelectric company that supplies 91 per cent of Paraguay's and 15 per cent of Brazil's electricity) worked with authorities and communities on both sides of the border to restore forest in the transboundary watershed supplying the dam. This resulted in reduced erosion and sedimentation and secured an improved water supply.

6.4 Financing NbS for adaptation

While NbS for adaptation have gained traction worldwide, securing the investments required to operationalize and sustain them continues to pose a major challenge. These funding needs are immense, far exceeding the current investment in NbS. As described in chapter 4 of this report, needs range from US$140 billion to US$300 billion annually by 2030, rising to between US$280 billion and US$500 billion by 2050 (UNEP 2018). Long a concern of the conservation community (IUCN 2018; Thiele *et al.* 2020), the topic of NbS finance[3] is now entering high-level global climate agendas.

Politically, there are urgent calls to raise the ambition for financing for NbS. For example, NbS was one of nine action areas at the 2019 Climate Action Summit, where the initiatives under discussion included increasing commitments from governments, private sectors, philanthropy, multilateral development banks and financial institutions to advance innovative, green climate finance and technical assistance, in order to scale up NbS investment in climate action (UN Climate Action Summit 2019). Furthermore, the next UNFCCC Forum of the Standing Committee on Finance will focus on financing NbS. These calls also includes considerations of how existing finance flows could be better oriented or redeployed towards NbS. The UN Decade on Ecosystem Restoration Strategy for example notes that fossil fuel subsidies total in excess of 1 trillion dollars a year and that a large proportion of these subsidies should be diverted to ecosystem restoration in order to manage climate change and degradation globally (UNEP 2020).

NbS are frequently a far cheaper and more cost-effective option than employing artificial technologies or taking remedial measures after natural functions have been lost. For example, every dollar invested in coastal ecosystem conservation in the United States is estimated to reduce the burden on US taxpayers by US$4 in terms of avoided costs, losses and damages from storm-surge effects and other natural hazards (Multihazard Mitigation Council [MMC] 2005). In southern Vietnam, the restoration of 12,000 ha of mangroves has saved an estimated US$7.3 million/year in dyke maintenance, a figure that is more than six and a half times the costs of planting (Powell *et al.* 2011). On the west coast of Sri Lanka, long-term climate adaptation benefits and costs saved were found to be more than twice as high as the costs of conserving coastal and estuarine ecosystems (De Mel and Weerathunge 2011).

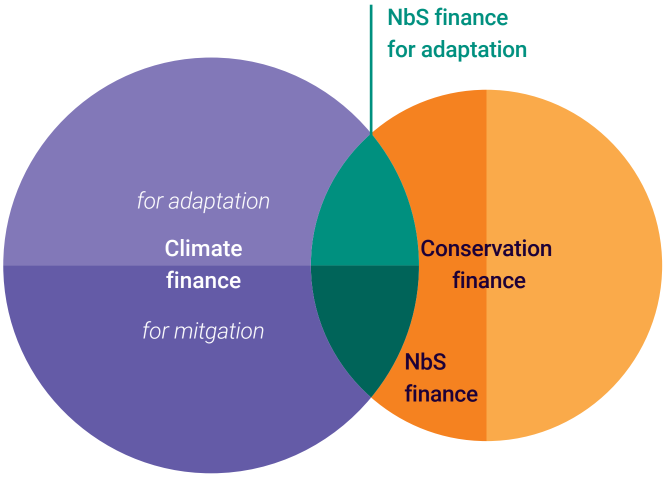
To respond to the growing recognition of its value and cost-effectiveness, NbS finance requires strengthening. Major gaps remain – not just in the availability of funds, but also in information and understanding about NbS financing needs, opportunities and solutions. The following sections address four key questions that are fundamental to advancing the NbS finance agenda: What is/are the scope, source and trends in global finance and investment flows to NbS? Are current funding levels sufficient? What can we learn from recent financing innovations? And what do we need to do to address NbS finance gaps?

6.4.1 Tracking NbS funding status and gaps

Gauging the current status of NbS funding, or tracking trends over time, is challenging. While this reflects the difficulties faced in estimating adaptation financing and costs more generally (figure 4.1), the specific characteristics and complexities of NbS pose a number of unique challenges. One is the rather nebulous nature of NbS financing, which in general nestles somewhere between 'climate finance' and 'conservation finance' (figure 6.5). In some cases – often in cities – NbS financing is instead part of general capital planning. New York City's watershed protection (US$1.5 billion over 10 years) and green stormwater infrastructure plan (~US$2 billion) are large-scale NbS programmes (City of New York

3 As this chapter is concerned specifically with nature-based solutions to climate adaptation, the use of the term 'NbS finance' should be taken to refer specifically to climate adaptation.

Figure 6.5. Visualizing the relationship between NbS finance for adaptation, climate finance and conservation finance



Note: This figure illustrates that NbS finance for adaptation is situated in the overlap between climate and conservation finance. For simplicity, it does not include other overlapping and intersecting funding categories, including infrastructure finance, disaster risk reduction finance, grey-green, hybrid, EbA amongst others. Relative sizes of the funding categories presented in this figure is not to scale.

Box 6.7. A snapshot of private capital and implications for NbS

Conservation investing

Globally, just over US$8 billion of private capital was committed to conservation investing between 2004 and 2015, averaging just under US$1 billion a year (Hamrick 2016). Much of this investment appears to be oriented towards, or motivated by, climate-related goals.

Climate bonds

By the end of 2019, certified climate bonds were worth ~US$100 billion, representing some 13 per cent of the green bonds market (Climate Bonds Initiative [CBI] 2020). In 2018, the issue was US$23.3 billion (CBI 2019) – around twice as high as total Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) bilateral assistance to climate in the same year.

Impact investing

Total US-domiciled assets under management using sustainable, responsible and impact-investing strategies grew from US$8.7 trillion at the start of 2016 to US$12.0 trillion at the start of 2018, an increase of 38 per cent. This represents 26 per cent – or one in four dollars – of the US$46.6 trillion in total US assets under professional management (The Forum for Sustainable and Responsible Investment [US SIF] 2018).

Natural capital

A recent survey of private asset owners and managers found that the single biggest factor driving them to natural capital, cited by almost half of investors, was 'resilience against climate change' (Cooper and Trémolet 2019).

2019; The Nature Conservancy [TNC] 2020). Medellin's Green Corridors programme and Madrid's El Bosque Metropolitano on urban forestation to combat heat are other examples (C40 Cities Climate Leadership Group and Nordic Sustainability 2019; Cool Coalition 2020).

Most funding statistics do not distinguish NbS as a distinct category or specifically record NbS investments and spending. Even when there are disaggregated data, the many different (and often overlapping) terms and categories used to refer to environmentally oriented adaptation approaches often lead to confusion. The question arises as to whether 'NbS funding' is synonymous with, for example, funding for 'blue solutions', 'green solutions', 'green infrastructure', 'building with nature' or 'ecosystem-based adaptation'? Indicators specific to finance are largely absent in publications on NbS (Raymond *et al.* 2017), a gap that has been argued to serve as a constraint to mainstreaming (Somarakis *et al.* 2019).

The fact that NbS are almost always blended or integrated with other approaches and solutions – or are often not even conceived or presented as climate adaptation activities in the first place – increases the confusion and leads to possible underreporting. Particularly in the private sector, investments in natural capital are often a subset of larger categories, such as environmental, social and governance (ESG) financing, sustainable finance, green finance or impact investments (Cooper and Trémolet 2019) – if they recognize (and report on) 'nature-based' investments at all (box 6.7). The data that does exist, however, suggests that NbS continue to account for only a small share of total climate adaptation funding.

Worldwide, only around 24 per cent or US$7 billion of public funding to climate adaptation in 2017/18 was destined for agriculture, forestry, land use, and natural resource management (Buchner *et al.* 2019). Of this, only a small portion is destined for NbS. Less than 1 per cent of global climate finance goes to coastal protection, infrastructure and disaster risk management, including NbS (Seddon *et al.* 2020a).

In 2018, the World Bank Group allocated over US$7 billion for adaptation, of which US$750 million or 11 per cent fell into the category of 'environment and natural resources', with projects ranging from landscape restoration and resilience to strengthening entrepreneurship in productive forest landscapes (World Bank, undated).

Between 2010 and 2018, a total of US$111 billion in bilateral aid from the Organization for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC) countries was tagged as having climate adaptation as a significant objective, of which just over a quarter was for projects where adaptation was the principal objective. Of this, US$9.6 billion and US$20.3 billion respectively (31% and 18% of total) was also categorized as environmental and forestry spending – giving an idea of the broad resource envelope available for NbS. While the funding to environment and forestry-oriented climate adaptation projects has been steadily increasing in absolute terms over the last decade (more than 30%, from US$2.2 billion to US$2.8 billion, for funding with climate adaptation as a principal or significant objective), its share in overall climate adaptation funding has however progressively decreased (from 27.7% to 17.1%) (OECD, 2020b)[4].

An analysis of NbS for adaptation financing through four major international funding facilities – the Global Environment Facility (GEF), the Green Climate Fund (GCF), the Adaptation Fund (AF) and the International Climate Fund (IKI) – shows a total investment of US$18.8 billion directly in support of climate change mitigation and adaptation over the last 30 years (table 6.3), supplemented by over US$75 billion in co-financing. Projects with a focus on, or containing elements related to, NbS for adaptation account for only 13 per cent of this figure. Only a fraction of these investments are for on-the-ground implementation, while a large proportion of funding is for 'soft' activities such as policy formulation, institutional strengthening, technical capacity-building and awareness-raising (see section 6.5 for further analysis).

6.4.2 Understanding NbS financing needs

Limited access to finance is a key barrier to scaling up NbS implementation (Cooper and Matthews 2020). There is growing consensus about the need to identify new and additional financial mechanisms for NbS (Kapos *et al.* 2019; Seddon *et al.* 2020a). This extends beyond merely generating more funding and it is generally accepted that environmental and climate finance have multiple dimensions and requirements. It is also necessary, for example, to operate effective systems to plan, mobilize and administer financial resources, as well as to set in place the conditions and incentives that will enable, encourage and even demand long-term investments (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ] 2019; Lazić and Emerton 2020). Most 'finance solutions'

4 Calculated from data sourced at https://stats.oecd.org/Index.aspx?DataSetCode=RIOMARKERS: 'Aid activities targeting Global Environmental Objectives'. All values expressed in constant 2017 US$, and refer to total flows of bilateral allocable aid to developing countries. Obtained from dataset on bilateral commitment data on aid in support of environment sustainability and aid to biodiversity, climate change mitigation, climate change adaptation and desertification from the Development Assistance Committee (DAC) Creditor Reporting System (CRS) database. Total 'Climate Adaptation' refers to total, all sectors. 'Forestry' refers to sector 312: III,1,b Forestry, Total, marked with climate change adaptation as principal or significant objective. 'Environment' refers to sector 410: IV.1. General Environmental Protection, Total, marked with climate change adaptation as principal or significant objective. In their reporting to the DAC CRS, donors are requested to indicate for each activity whether or not it targets environment and the Rio Conventions (biodiversity, climate change mitigation, climate change adaptation and desertification). A scoring system of three values is used, in which aid activities are "marked" as targeting environment as the "principal objective" or a "significant objective", or as not targeting the objective.

therefore look to combine mechanisms and strategies that generate, manage and deploy financial resources and align incentives to achieve nature conservation outcomes (Meyers *et al.* 2020).

It is also important to recognize that NbS often have particularly complex and wide-ranging financing needs. They typically incur a relatively high burden of opportunity costs (for example, foregone land and resource use options) and transactions costs (for example, participation in planning, management and enforcement). Another challenge (not insurmountable or different to 'grey' infrastructure) is the need for ongoing operating funds for maintenance. This does not necessarily mean that NbS are a more expensive option than 'grey' alternatives. Ample evidence suggests that they are often far cheaper and more cost-effective (see, for example, Reguero *et al.* 2020). It does however translate into an additional layer of funding needs, which are often indirect, are usually incurred by local populations (who may not always be the primary recipients of their adaptation benefits) and frequently demand imaginative and carefully thought-through approaches that take special account of i) the diversity of NbS cost-bearers and their differential financing needs, and ii) the strong equity principles that must be factored into funding, benefit-sharing and cost recovery.

Another important characteristic is that NbS are almost always justified and selected at least partially due to their ability to generate a broad range of public benefits and co-benefits, that include, but are not limited to, their primary adaptation objective. Often only a fraction of NbS (and usually a much smaller proportion than is the case with other adaptation approaches) can be financed, and maintained as purely commercial ventures or with full cost recovery. Many NbS also revolve around the management or improvement of public or communally held assets (including land). In most countries, regulatory and institutional frameworks only allow for very limited private investments in such assets, and place strict controls over the ownership of any benefits or revenues that are generated. This can act as a barrier to private finance. Modifying these frameworks and controls can enable private investment and the scaling-up of NbS benefits.

6.4.3 Financing mechanisms for NbS

The diversity and heterogeneity of NbS financing needs requires a similarly wide-ranging portfolio of financing mechanisms that can be tailored to different situations, sectors and stakeholders. Yet, while a large volume of literature now exists on financing mechanisms for conservation and adaptation more generally (see, for example, Climate Finance Advisors 2019; Lo, Wu and Lin 2016; Meyers *et al.* 2020; Tonkonogy, Mazza and Micale 2018), there is as yet little guidance that looks specifically at NbS (see, for example, Droste *et al.* 2017; Somarakis *et al.* 2019; TNC 2018). This literature suggests that there is a wide range of financing mechanisms with potential application to NbS, some of which are already widely used and others that are still emerging (table 6.4).

Despite the wide array of financing mechanisms that have the potential to be used to fund NbS, there remains a heavy reliance on government and philanthropic sources (including international development assistance as well as domestic funding) – traditionally the foundation of both conservation and adaptation finance. Many of the more innovative mechanisms have been applied and tested (and often funded) as part of externally driven 'projects', and remain as pilot schemes. Issues of scalability, long-term sustainability and mainstreaming remain a major concern.

One barrier to deploying a broader (and more innovative) range of financing mechanisms in support of NbS is undoubtedly a lack of information. Articulating the multiple benefits of NbS in financial terms is challenging for many reasons, including limited or restricted data, limited research regarding quantified benefits, and a lack of coordinated knowledge transfer (Somarakis *et al.* 2019). There is a need to be able to provide convincing evidence to potential investors and project developers that NbS can be effective, sustainable and – if relevant – generate an adequate return in adaptation and/or commercial terms. Despite a growing evidence base on the benefits and cost-effectiveness of NbS investments, this information is still not widely known, or is not communicated in a form that is accessible and convincing to investors and decision makers. Similarly, there is an urgent need to share information about the successes and lessons learned from piloting innovative NbS financing mechanisms, if they are to be taken up and replicated more broadly.

Another significant barrier to diversifying, scaling up and mainstreaming NbS financing mechanisms is unsupportive policy, legal and institutional conditions. This touches on a wide range of factors, ranging from improving fiscal and economic incentive structures and dismantling barriers, through developing new markets and pricing systems, to clarifying land and resource tenure regimes. This is a particular concern in relation to mobilizing private investment flows.

A recent World Bank Group (2020) report on Mobilizing Private Finance for Nature stresses that "governments and regulators, supported by financial institutions and multilateral development banks, hold the key to mobilizing private finance at the scale needed to transform the way we build, produce, and consume in order to protect nature while fostering sustainable poverty reduction." It highlights that the public sector needs to create a supportive enabling environment with efficient and effective incentives, standards and regulations, and to provide data and finance.

Blended or hybrid solutions and clustering projects have been suggested as ways of potentially making NbS more attractive to investors and helping increase investment (Cooper and Matthews 2020). Environmental fiscal reforms that include NbS (table 6.4) can be explored as a component of post-pandemic recovery. Providing catalytical capital is another way in which government and multilateral development banks can mobilize private investment (World Bank Group 2020).

Box 6.8. Financing NbS: Itaipú Dam in Paraguay and Brazil

Constructed in 1984, Itaipú Dam is one of the world's largest hydroelectric dams and produces 90 per cent of Paraguay's electricity and 16 per cent of Brazil's. Itaipú Binacional was set up as a company mandated by both countries to administer the plant's construction and operation. The company's mission is to generate quality electrical energy via socially and environmentally responsible practices that foster sustainable economic, tourist and technological development in Brazil and Paraguay.

It was recognized early on that sediment blockage and unreliable flows during periods of dry weather would pose significant challenges to the dam's efficient functioning and performance. Itaipú Binacional therefore pioneered a series of watershed restoration programmes, one such example being the Cultivating Good Water initiative situated on the Brazilian side. This 15-year programme involves a series of sub-programmes and initiatives aimed at improving water quality and flows in the Paraná watershed. It achieves a broad range of social and environmental goals, including food security, poverty alleviation, health and sanitation, climate change mitigation and adaptation, and biodiversity support.

The initiative is led by Itaipú Binacional, with implementation support from hundreds of organizations including governments, city administrators, NGOs, farmers, schools, community associations, businesses and others. A range of stakeholders fund this initiative, blending several financing types from three groups that provide roughly equal support (one-third): i) Itaipú Binacional, ii) municipalities and iii) communities and farmers. This cross-community approach has helped sustain the programme in the long term, creating buy-in from all the necessary stakeholders.

Sources: Rycerz *et al.* (2020); Itaipú Binacional (2020)

Table 6.3. Funding distribution of NbS projects or projects including NbS components of several funding institutions[1]

Funding source	GEF (1991–2020)	GCF (2015–2020)	AF (2010–2020)	IKI (2008–2020)	Total
Climate funding with co-financing (US$ billion)	66.77	23.1	0.742	3.556	94.17
NbS funding (US$ billion)	8.61	2.02	0.504	0.92	12.05
NbS funding (% of total)	13%	9%	68%	26%	13%

1 This analysis includes NbS relevant for adaptation, even if they are primarily focusing on carbon or biodiversity or are hybrid projects. There are many projects that focus on NbS for adaptation and also include other project components.

Sources: Own estimates based on the GEF, GCF, AF and IKI funding databases

Table 6.4. Selected NbS financing types and examples

Financing category	Financing types	Examples of financing types	Case examples
Public funding (domestic)	Institutional budgets	Routine budget allocations to the public agencies and authorities responsible for implementing NbS or managing land, resources and services upon which they depend (for example Ministry of Environment, national parks).	Raingardens in Rotterdam installed in 2016 as part of the city's climate adaptation strategy to enable water retention and increase flood protection (Frantzeskaki 2019).
	Direct public investment	Publicly funded NbS measures and projects, typically at the domestic/national scale.	Watershed forest restoration to support functioning of the Itaipú Dam in Paraguay/Brazil by the public (municipalities) and private (dam authority) sectors (Inter-American Development Bank [IDB] 2020).
	Environmental fiscal reforms (EFRs)	Governments could include EFRs as part of crisis recovery plans. These could be used to realign incentives with sustainable practices (World Bank Group 2020).	Reforming agricultural subsidies and land ownership complemented with investment in social, development and job-creation programmes (World Bank Group 2020) with potential to include NbS.
	Other types: Fiscal revenues and earmarking, ecological-fiscal transfers, subsidies or preferential finance		
International development transfers	Grants (public)	Grants for NbS activities from international development agencies such as: the Department for International Development (DFID)/UK Aid, the United States Agency for International Development (USAID) and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.	The International Climate Initiative (IKI) has funded many global initiatives, including NbS, for example the Ecosystem Based Adaptation in Mountain Ecosystems project in Nepal, Peru and Uganda (International Climate Initiative 2020a).
	Global financing facilities (public)	Large international funding facilities such the Global Environmental Facility, the Green Climate Fund and the Adaptation Fund, include funding for NbS-related projects.	The Adaptation Fund has committed US$720 million since 2010, including 100 concrete adaptation projects, of which some are NbS for example Enhancing Climate Resilience of Rural Communities Living in Protected Areas of Cambodia (Adaptation Fund, undated a).
	Microfinance	Microfinance uses intermediated, concessionary finance to enable inclusive microfinance solutions that allow communities vulnerable to climate change to adapt and build resilience (OneWorld Sustainable Investments and Oxford Policy Management 2018).	The Microfinance for EbA project provides vulnerable populations in the Andean region of Colombia and Peru with microfinance services, allowing investment in activities related to ecosystem sustainability to improve their income and resilience (Climate Technology Centre and Network [CTCN], undated).
	Other types: Loans, debt-for-nature swaps		

Financing category	Financing types	Examples of financing types	Case examples
Grants, donations and philanthropy	Direct grants	External grants for NbS are available from a variety of sources, including public sector bodies and charitable or philanthropic organizations.	Rockefeller Foundation was a funding partner for Rebuild by Design, along with US government institutions. It included the Living Breakwaters project to reduce risk, revive ecologies and benefit residents in Staten Island (New York State [NYS], undated).
	Corporate sponsorship and advertising	These initiatives include initiatives set up by corporate entities to directly sponsor NbS activities.	The HSBC Water Programme funded the restoration of traditional cascading freshwater tanks (reservoirs) in Sri Lanka, to collect and utilize rainwater for agriculture and to build community resilience (IUCN 2015).
	Other types: Private donations and contributions, crowdfunding		
Market-based instruments	Payments for ecosystem services (PES)	PES occur when a beneficiary or user of an ecosystem service makes a direct or indirect payment to the provider of that service (UNDP, undated).	The watershed PES scheme in Colombia implemented in the Nima River region, where large-scale private water users and state agencies have paid private upstream landowners to implement ecosystem conservation measures (Rodríguez-de-Francisco and Budds 2015).
	Other types: Development of nature-based markets and products, user fees and service charges, biodiversity offsets		
Private investments and financial instruments	Debt instruments (e.g. bonds)	These are the transfer of capital from one entity to the borrowing party who is then under an obligation to pay the debt back at a later date, usually with interest (Meyers *et al.* 2020).	Milwaukee Metropolitan Sewerage District General Obligation Sewerage System Bonds propose US$80 million of funding with Certified Climate Bonds and includes green infrastructure (Kestrel Verifiers 2020).
	Other types: Capital markets, investment funds, direct investments (venture capital, angel investors, peer-to-peer, etc.)		
Risk management	Insurance products	Insurance products are financial mechanisms that are used to manage risks for governments, companies, households and individuals (Meyers *et al.* 2020).	Restoration Insurance Service Company, a planned pilot in the Philippines, will engage in mangrove conservation and restoration to provide flood reduction benefits. Insurance companies will pay an annual fee for these services (Conway and Mazza 2019).
	Pay for success	Pay for success is a mechanism by which the government repays the cost of service delivery if agreed-on outcomes are achieved (Urban Institute, undated).	The Forest Resilience Bond includes forest restoration and also a component whereby some of the beneficiaries will sign 'pay-for-success' cash flow contracts, which require payments based on measured improvement in certain benefits (Blue Forest Conservation, undated).

Sources: The authors, modified from IDB (2020); Meyers *et al.* (2020); Trinomics and International Union for Conservation of Nature (IUCN) (2019); European Investment Bank [EIB] (undated) and other sources cited

6.4.4 Addressing the finance gaps and improving the sustainability of NbS efforts

Several gaps have emerged in relation to NbS finance, which need to be addressed if the ambition to step up NbS action and reduce the NbS finance gap is to be met. These are:

- **Difficulty of gauging the current status and trends of NbS financing.** The nature of NbS financing means that financing statistics do not distinguish NbS as a distinct category. It remains hard to know the status of NbS financing or to track changes over time. There is also a need for outcome metrics to inform tracking of adaptation finance effectiveness.

- **Challenges related to NbS integration.** NbS are almost always blended or integrated with other approaches and solutions and sometimes not presented as climate adaptation activities in the first place (for example, environmental, social and governance financing). This means that it is often difficult to mobilize or allocate funding for NbS; in such cases, blending of financing mechanisms could help overcome this challenge.

- **Need for comprehensive assessment of NbS costs and funding needs.** A comprehensive assessment of NbS costs and funding needs remains a major gap. Not knowing how much, or what type of, finance is required, or by whom, makes identifying ways of generating sufficient funds challenging.

- **Identification of indirect and locally incurred costs.** In particular, the opportunity costs of NbS translate into an additional layer of funding needs, which are often indirect and are usually incurred by local populations. Not only does this result in underfunding, but it can also give rise to significant inequalities.

- **Inequities in access to financing.** Limited access to commercial financing mechanisms and global climate finance for subnational actors, including local communities, despite this being the scale at which many NbS are most effective. In particular, youth, women and indigenous peoples are often marginalized or excluded altogether from NbS funding. As above, this has implications for both funding security and equity.

- **Primary concern with public interest benefits.** Investments in NbS are often largely justified by their ability to generate public interest, non-market benefits. Only a limited range of NbS interventions and benefits lend themselves to commercial or return-generating investments, can be captured by the market or are capable of full cost recovery. This makes a strong case for combined public-private partnerships.

In order to address NbS financing needs and move NbS financing forward, all of these issues must be addressed. This requires the following steps:

Improve information and reporting. There is a need to routinely generate quantitative information on NbS costs, funding flows and gaps. These basic data can be used to identify what the financing needs are, who the cost-bearers are, and which opportunities exist to strengthen NbS financing solutions, and to track changes over time. Aligning financial flows to NbS with impact metrics enables full accounting, so that the incremental costs of establishing NbS can be compared with the benefits provided. For example, avoided recovery costs from repeated storm surges can far exceed one-time mangrove restoration costs.

Understand costs and cost-bearers. This important prerequisite for financing remains a complex task. Typically, both the costs and cost-bearers of NbS are diverse, spanning direct expenditures, indirect or opportunity costs, transactions costs, and broader institutional, policy, regulatory and even capacity and training requirements. It is important to ensure that, when NbS actions and funding needs are estimated, these indirect costs are also included, alongside the more obvious direct physical expenditures. There is a particular need to ensure that local opportunity costs are adequately recognized and compensated.

Diversify and expand the funding base. Traditional sources such as public budgets and international assistance remain critical, but they are unlikely to be able to meet future needs for NbS finance. There is also a need to deploy innovative mechanisms that draw on and blend different sources, and are tailored to creating broader enabling financial conditions for public and private investments in NbS (table 6.4). It is vital that these funding sources are accessible to marginalized groups, including indigenous communities and women. In many cases, this requires tailoring funding to local-level needs, capacities and scales and prioritizing particular recipients – for example, through mechanisms such as microcredit, savings and loans, business start-ups and small grants.

Harness the growing sources of funding and innovations. There is an increasing interest in, and acceptance of, nature-based and 'green' approaches among investors, the general public and public funding agencies. NbS can be explicitly included as eligible activities in innovation and technology funds, and in global adaptation financing facilities. There is a strong case for using public finance as leverage or using blended finance to stimulate greater private investment flows to NbS from growing sources of funding (table 6.4), which can be used alone or in combination.

Improve equity. There is a need to promote equity and effectiveness in the way in which funding is generated, allocated and spent. This means ensuring that financing mechanisms reach the full range of NbS cost-bearers and implementors, including youth, women, indigenous peoples and local communities. The role of these key groups as innovators and implementers of NbS should be fully considered when designing and implementing financing mechanisms.

Create enabling conditions for NbS financing and investment. It is not enough only to identify NbS costs, funding needs and potential financing mechanisms. It is also necessary to ensure that potential investors, donors and cost-bearers are enabled and encouraged to finance NbS. A wide range of factors constrain or act as barriers to NbS finance – or can act in its favour – including structural and regulatory frameworks, planning systems, market opportunities, fiscal and investment incentives, information and awareness.

Identify a convincing business case and bankable NbS projects. Defining a clear business case and bankable projects is essential to securing financing for NbS and needs to be clearly tailored to the target audience. Just as the needs for funding and financial support for NbS are diverse and wide-ranging, so are the interests and needs of the actors and stakeholders upon which they depend.

6.5 Implementation of NbS

Acknowledging the recent traction that NbS have gained worldwide to effectively adapt to current and, to some degree, future climate risks, there is a need to better comprehend the extent to which they are being used in different regions and contexts and to what ends. This section provides an overview of the current level of NbS implementation worldwide in relation to coastal hazards (mainly sea level rise and storm surge), intense precipitation, drought, and rising temperatures.

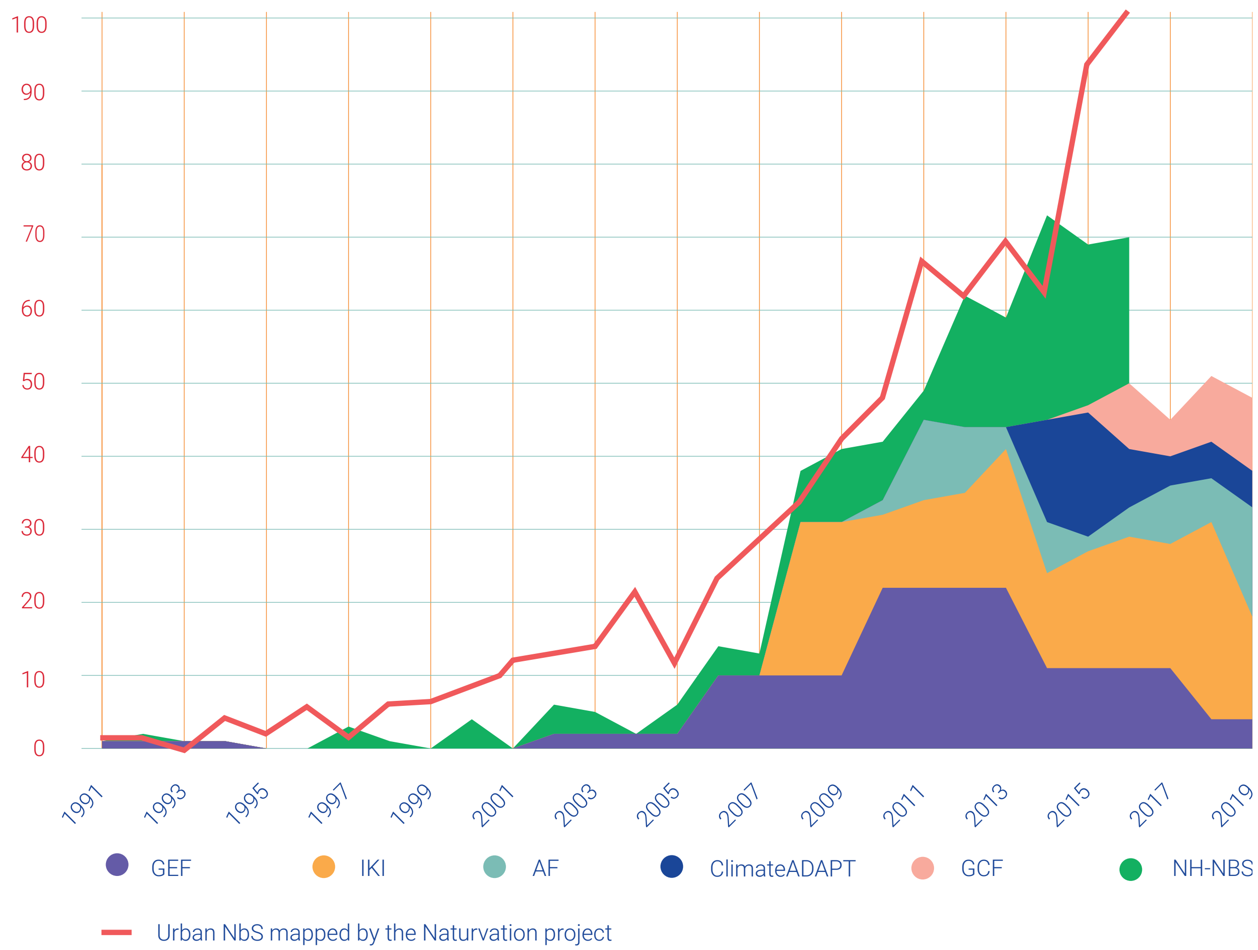
Publicly available project-related information from global financing facilities, such as the GEF,[5] GCF,[6] the AF[7] and IKI,[8] has been collected and assessed to understand levels of NbS implementation and types of solutions used to address the climate hazards in low- and middle-income countries. Similar information has also been extracted from the Natural Hazards – Nature-based Solutions platform[9] (NH-NbS), which was hosted by the World Bank and covered a broader range of geographies and countries, as well as additional funding sources. For NbS projects in Europe, information was retrieved from the ClimateADAPT database.[10] Information accessible via the CDP[11] was analysed to identify NbS-related adaptation actions in urban areas and cities.

As the latter three databases rely on self-reporting, they do not provide a full picture of ongoing activities. Unlike the GEF, GCF, AF and IKI, they do not allow the level of NbS implementation to be assessed in relation to the implementation of other climate-related initiatives. While the focus of the data collected is on adaptation, initiatives pursuing other objectives that have clear adaptation co-benefits are also included in the analysis. Harmonizing the information across these seven data sources, the analysis is based on a total of 942 projects across all world regions that have NbS for adaptation either as the main focus (green) or as one element among others (hybrid).

Despite this probably being the most comprehensive assessment of NbS implementation to date, it is not possible to provide a full overview of NbS implementation, either because many initiatives are not recorded or because documented information about them is not readily accessible. For example, owing to a lack of available information, high-income regions outside Europe are not well covered in this analysis, apart from initiatives being implemented at the city level. Furthermore, initiatives presented on a number of project-based platforms, such as Oppla,[12] Naturvation,[13] Panorama[14] and the Urban Climate Change Research Network,[15] were not included in the analysis because the necessary data could not be retrieved. Despite providing a formidable repository of the peer-reviewed literature on the topic, the Nature-based Solutions Initiative[16] was not included due to resource constraints. Therefore, while providing a good overview of the scale, regional distribution and types of NbS implementation to address climate hazards, the results presented in this chapter possibly reflect only a fraction of the full picture. The analysis thus complements assessments, building primarily on case studies and illustrative findings with regard to synergies and trade-offs, costs

5 https://www.thegef.org/projects
6 https://www.greenclimate.fund/projects
7 https://www.adaptation-fund.org/projects-programmes/
8 https://www.international-climate-initiative.com/en/projects
9 The NH-NbS platform information was downloaded from https://naturebasedsolutions.org, but as of January 2021 a modified website is accessible at https://documents.worldbank.org/en/publication/documents-reports/documentlist?qterm=P162684.
10 https://climate-adapt.eea.europa.eu/
11 https://www.cdp.net/en/data
12 https://oppla.eu/case-study-finder?combine=
13 https://naturvation.eu/atlas
14 https://panorama.solutions/en/portal/ecosystem-based-adaptation?page=2
15 https://uccrn.ei.columbia.edu/case-study-docking-station
16 https://www.naturebasedsolutionsinitiative.org/

Figure 6.6. Evolution of NbS initiatives over time, based on the total number of projects reported in the data sources



Note: NbS projects presented include both green and hybrid initiatives. Years refer to the start date of the initiatives.[1] NH-NBS data collection was discontinued after 2016. The red line depicts the evolution of NbS activities in European cities tracked within the Naturvation project.
Sources: Authors' analysis; Almassy *et al.* (2018)

1 Data provided by the GEF does not include specific start dates for the initiatives it supports. Instead, it provides information about which funding cycle initiatives were included in. As such, GEF data presented in this figure represent a yearly average of the total number of NbS projects supported during each funding cycle.

and benefits, and challenges related to scaling-up (for example, Cohen-Shacham *et al.* 2016; Kapos *et al.* 2019; Organisation for Economic Co-operation and Development [OECD] 2020a; Seddon *et al.* 2020; Donatti *et al.* 2020; Chausson *et al.* 2020).

6.5.1 Evolution of NbS implementation

The fact that NbS for adaptation is a relatively recent concept is reflected in the limited number of projects that implicitly or explicitly build on it (figure 6.6). Prior to the early 2000s, NbS were only considered in the context of mitigation – if at all – and are therefore not represented here. Between 2005 and 2015, there was an exponential increase in activities when integrating across the entire data set. However, from then on, the rate of increase seems to have plateaued at around 70 new initiatives per year, despite the emergence of new funding sources, foremost among them GCF. This mainly results from the fact that GEF-funded NbS initiatives peaked in the fifth funding cycle, both in the absolute number of projects and as a proportion of total climate-related investment, which dropped from 20 per cent in GEF-5 to 13 per cent in GEF-6.[17] It is not yet possible to fully assess the trajectory after 2016, pending updates to data from the NH-NbS platform, which has been discontinued (B. Jongman, personal communication, 29.11.2020; World Bank 2017).

Data on NbS initiatives in urban areas from CDP are not presented in figure 6.6 because the database does not

17 Since its establishment on the eve of the Rio Earth Summit in 1992, the GEF has had eight four-year funding cycles. These are: Pilot phase, 1991–1994; GEF-1, 1994–1998; GEF-2, 1998–2002; GEF-3, 2002–2006; GEF-4, 2006–2010; GEF-5, 2010–2014; GEF-6, 2014–2018; and GEF-7, 2018–2022.

Box 6.9 Using nature-based solutions to address coastal climate hazards, including storms, coastal erosion and flooding

As climate change intensifies, coastal areas are anticipated to be increasingly impacted by rising sea levels and increased frequency of extreme weather events. For coastal communities and ecosystems, these changes in climate conditions could result in increased exposure to storm surges and coastal flooding, increased rates of coastal erosion, and increased risk of groundwater salinization. While there are a number of interventions available to address coastal climate hazards (such as hard infrastructure), in recent decades the relative merits of implementing NbS have been increasingly recognized.

Increasing recognition of the benefits of NbS is facilitated through projects such as 'EbA: Strengthening the Evidence and Informing Policy', which was implemented by the IUCN and its partners – the International Institute for Environment and Development (IIED) and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (International Union for Conservation of Nature [IUCN], undated a). The project aimed to demonstrate to policymakers from developing countries why and when EbA represents an effective option for addressing climate hazards – discussing the conditions under which it works, and the benefits, costs and limitations of natural systems in relation to other available options – and to promote the integration of EbA principles into policy and planning processes. Over its lifespan, the project worked with the governments of 12 developing countries to develop clear country-specific policy recommendations and explore opportunities for, and barriers against, uptake.[1]

Another project raising awareness of NbS, this time among both government and community actors, is the Neotropical Mangrove Conservation Alliance – a collaborative project between BirdLife partners that aims to conserve, restore and manage mangrove forests sustainably throughout the American tropics. The project facilitates knowledge-sharing and capacity-building among local stakeholders, while also raising awareness of the importance of mangroves and the need for on-the-ground conservation. In Samoa, where 74 per cent of people and infrastructure are situated in low-lying coastal areas, the project is working with the Matafaa indigenous village community to protect their coastal mangroves and help them to sustainably exploit the natural resources they provide (such as herbal medicine, fuel, fibre and fish). It is expected that protecting these coastal mangroves will reduce the vulnerability of the island's agricultural land to flooding and erosion caused by extreme weather events.

Exemplifying NbS for addressing coastal climate hazards in a developed country context, the UK Environment Agency – in collaboration with the Royal Society for the Protection of Birds (RSPB), engineers and the local community – created a new coastal wetland at Medmerry, a low-lying area on the south coast of England. This intertidal habitat acts as a buffer to sea level rise and storm surges. While the local community did not implement the project, they were engaged in the design process in order to ensure that the wetland enhanced recreational opportunities and contributed to the area's sense of place. Completed in 2013, the new wetland reduces flood risk for 348 homes. Aside from the scheme's biodiversity benefits, it has directly resulted in several major economic benefits, namely through significantly reducing ongoing maintenance costs of the area's flood defences, increasing tourism to the area and providing a natural fish nursery that is helping sustain the area's local fishing fleet (Royal Society for the Protection of Birds, undated).

Even as governments and other actors are increasingly addressing coastal climate hazards through applying nature-based approaches, it is often found that interventions are designed to address the impacts of coastal hazards on a single sector or stakeholder group, without properly consulting other stakeholders. As such, many NbS interventions can be seen to be lacking a truly common goal that benefits all of the area's stakeholders. Moving away from closed and/or silo-oriented design and implementation processes towards more comprehensive approaches will be the first step towards achieving truly effective and sustainable NbS. In particular, design and implementation processes for NbS need to find a greater role for local people and ensure that they are able to receive a share of the benefits provided by the intervention.

1 The 12 countries were: Bangladesh, China, Nepal, Burkina Faso, Kenya, Senegal, South Africa, Uganda, Chile, Costa Rica, El Salvador and Peru.

Table 6.5. Number of NbS initiatives in relation to the total adaptation or climate-related portfolio, average funding including direct and co-finance, and ratio between green and hybrid interventions

Data source	Climate change portfolio (n)	NbS initiatives of climate change portfolio (n)	Funding volume (US$ million)	Green initiatives/ hybrid initiatives (%/%)
GEF[1]	1,724	192	5.8 + 39.0	46/54
GCF[1]	139	37	27.3 + 27.4	19/81
AF[2]	107	70	7.2	13/87
IKI[1]	766	207	4.4	55/45
ClimateADAPT[2,3]	160	53	-	42/58
CDP[2]	730	202	-	59/41
NH-NBS[2]	-	181	-	54/46

1 The climate change portfolio includes mitigation and other objectives besides adaptation.
2 The climate change portfolio includes only adaptation.
3 Only case studies and adaptation options were analysed.

Source: Authors' analysis

provide information about the start dates of initiatives, making it impossible to assess the timeline. However, data from NbS initiatives in European cities collected in the context of the Naturvation project (Almassy *et al.* 2018) also show a strong upward trajectory after 2000, although it is not possible to say whether the trend will continue unabated after 2016. Reassessment of the available data within the next three to five years will therefore be important if we are to establish a better sense of longer-term trends across the whole spectrum of NbS activities.

6.5.2 Investments in NbS for adaptation

In this section, investment in NbS for adaptation is discussed from three perspectives based on the information assessed: first, in the context of the contribution of NbS for adaptation compared with the overall portfolio of adaptation or, where not clearly distinguishable, climate-related initiatives; second, in relation to the project-level funding volume of NbS interventions; and third, as a ratio of green versus hybrid NbS interventions.

In relation to the total number of climate-related initiatives, the proportion of NbS projects across the four climate and development funds ranges from 11 per cent (GEF) to 65 per cent (AF), with GCF and IKI both standing at 27 per cent (table 6.5). These figures are comparable to the levels of funding described in section 6.4, except for GCF with only 9 per cent of financial investment (table 6.3). The discrepancy is mainly explained by higher levels of co-finance directed towards other targets, primarily mitigation, and suggests that NbS currently does not receive private sector support on a par with other climate-related interventions.

Adaptation employing NbS makes up some 33 per cent of all adaptation actions for ClimateADAPT, but for reasons that are unclear, the number of new interventions shows a fairly linear decline from 48 per cent in 2014 to 15 per cent in 2019. The proportion of cities reporting NbS in the CDP database is very consistent at around 28 per cent, despite the number of cities reporting adaptation actions having risen by over 50 per cent between 2017 and 2019. This indicates that one in three cities uses NbS to address climate hazards. However, most cities implementing NbS also report a number of engineering or grey infrastructure solutions which, taken together, reduce the actual level of NbS implementation to circa 10 per cent of the overall adaptation portfolio. Nonetheless, the implementation of NbS is showing clear signs of growth, increasing from just 7 per cent in 2017 to nearly 12 per cent in 2019. Overall, considering the annual variations of implementation across the programmes, available time frames are still too short to determine clear trends in NbS implementation.

Based on the available information, the average funding volume for NbS-relevant projects varies considerably across funding sources, showing significant differences between funds with and without co-financing (table 6.5). With the exception of GCF, direct funding is typically between US$4 and US$7 million. Average co-funding levels are almost 1:7 for the GEF and 1:1 for GCF; in the absence of further information, however, it is unclear how to interpret the figures. The ClimateADAPT, CDP and NH-NbS databases are not analysed in this context as they either provide no information, or incoherent

Box 6.10. Using nature-based solutions to address intense precipitation, including flooding, erosion and landslides

Flooding, erosion and landslides induced by heavy rains pose risks to, among other things, human life, crops, livestock and infrastructure. In certain areas, climate change is projected to lead to increased precipitation, which will inevitably heighten the risk of these hazards occurring. The risks of flooding, erosion and landslides, however, has also been aggravated by human-driven processes that lead to long-term degradation of ecosystems and landscapes, such as the expansion of urban and agricultural areas and the exploitation of natural resources (for example, deforestation and mineral extraction). NbS are increasingly being recognized for their ability to reduce the risks of precipitation-induced hazards, as well as their potential to contribute to related societal challenges. In particular, ecosystem-based adaptation (EbA) – a subcomponent of NbS – is recognized for its ability to harnesses biodiversity and other ecosystem services at a scale that reduces the vulnerability of communities and ecosystems to climate change across a variety of landscapes.

For example, the Scaling Up Mountain Ecosystem-Based Adaptation project has implemented EbA measures across mountain ecosystems in Nepal, Uganda and Peru (International Union for Conservation of Nature [IUCN], undated b). In all cases, the project has implemented best-suited EbA measures, selected through participatory processes and evidence-based policy advocacy at the local and national levels. In Nepal, this led to the implementation of natural infrastructure such as bamboo check dams, and the planting of grass and tree species that help restore agricultural lands damaged by landslides and flooding. In Uganda, the project implemented EbA measures such as agroforestry and the re-vegetation of riverbanks alongside hard structural measures such as roadside drainage bunds and run-off retention drains, in order to reduce the risk of flooding, landslides and erosion occurring on Mt. Elgon's degraded landscape. Meanwhile in Peru, wetland conservation and communal native grassland management implemented by the project now contribute to, among other things, reduced erosion rates.

In Europe, the Lower Danube Green Corridor provides an ambitious example of EbA being implemented to reduce climate risks in a floodplain landscape (European Environment Agency, European Climate Adaptation Platform [ClimateADAPT], undated). The initiative aims to restore the Danube's floodplains across Bulgaria, Romania, Ukraine and Moldova, to reduce the risk of flooding and to enhance the landscape's ability to provide other ecosystem services (such as fishing, eco-tourism and grazing land). Over the last century, the river's capacity to provide these ecosystem services has been severely reduced due to human-driven processes that have reduced the river's floodplains, increased riverbed erosion and led to an 80 per cent loss of the river's wetlands. To combat this, the initiative aims to protect 1 million ha of land surrounding the river, restore 224,000 ha of natural floodplains and promote sustainable use and development within the river catchment. The first target has already been exceeded, with 1.4 million ha of wetland areas under some form of formal protection, while to date 60,000 ha of wetland has been restored.

The Building Climate Resilience through Rehabilitated Watersheds, Forests and Adaptive Livelihoods project being implemented in Comoros is aiming to increase the climate resilience of 15 villages across Comoros' three islands (UNEP, undated b). In these locations, increasingly erratic and decreasing rainfall are threatening the country's already tenuous water security (presently, less than 13 per cent of the population has access to good quality water supplies). Meanwhile, widespread deforestation has led to significant decreases in the water storage capacity of soil on the islands, leading to flooding and soil erosion. To combat these hazards, the project is promoting an integrated watershed management approach that includes implementing a number of EbA practices such as reforestation and restoring and sustainably managing 7,500 ha of watersheds, alongside small structural measures such as building rainwater-harvesting devices, constructing anti-erosion structures on farmland and developing sustainable livelihoods. To date, the project has reforested 170 ha of land and provided training on climate-resilient land management practices to the owners/leaseholders of 214 ha of land (UNEP, undated c).

Despite the growing number of EbA initiatives, ensuring that they are sustainable in the long-term, or that there is an incentive to upscale them in the future, remains a key challenge for implementers. To overcome this challenge, NbS – and in particular EbA – require that immediate responses be complemented by long-term strategies to ensure that they are able to enhance socioecological resilience in the longer term. Part of this long-term approach should be to integrate NbS and EbA into national and subnational policies and strategies and to mainstream these approaches into sectoral planning.

information, in relation to funding levels. Despite this, it is apparent that the reported initiatives range from very small investments (such as greening a roof) to very large investments (such as thousands of hectares of floodplain restoration).

For the entire data set, the ratio between green initiatives (i.e. initiatives in which NbS are implemented on their own) and hybrid initiatives (i.e. initiatives in which NbS are combined with engineered solutions) is around 1:1. However, there are large differences across the platforms. For example, green initiatives constitute between 13 and 59 per cent of NbS-related initiatives, depending on the platform analysed (table 6.5). The relatively low proportions of green initiatives for the AF and GCF probably reflect their greater focus on traditional rural development in comparison with the GEF and IKI, which dedicate more attention to environmental protection and biodiversity while simultaneously pursuing development outcomes.

Irrespective of the ratio between green and hybrid NbS across the four funds, given their development focus, all projects allocate considerable resources towards other activities, namely capacity-building and training, awareness-raising, development of institutional and regulatory frameworks for scaling up pilots, innovative business and livelihood opportunities, and monitoring frameworks, such as climate information or early warning systems. While an in-depth assessment of the within-project distribution of funds was only possible for AF, the descriptions of envisaged benefits for the GEF, GCF and IKI portfolios suggest that they dedicate similar levels of project funds to development-related activities.

Average funding for green initiatives directly related to NbS ranges from 61 to 67 per cent of total budgets, while it is merely 12 to 20 per cent for hybrid projects. This indicates that AF projects addressing climate hazards, whether employing NbS, infrastructure-based/engineered solutions, or a combination of the two, typically integrate development components in order to raise system resilience in the context of sustainable development and livelihood enhancement. In addition, while the NbS components of projects in more rural settings typically constitute between 19 and 27 per cent of available budgets, this is only 7 to 14 per cent for projects focusing on urban climate risks, potentially reflecting the greater need for engineered or grey infrastructure solutions in urban contexts.

However, OECD (2020a) suggests that regulatory frameworks might also be hampering stronger investment in NbS. Qualitative comparisons with the ClimateADAPT database suggest that most European NbS projects lack this strong connection to development, instead focusing more on the technical, financial and sometimes legal aspects of NbS implementation.18 In view of the close correlation between positive development outcomes and climate resilience, the tendency of the four funds under consideration to allocate similar levels of funding to development-related activities is justified since improving livelihoods, capacity-building and governance are as necessary as technology transfer and implementation (UNEP 2018).

6.5.3 Regional distribution and focus of NbS for adaptation

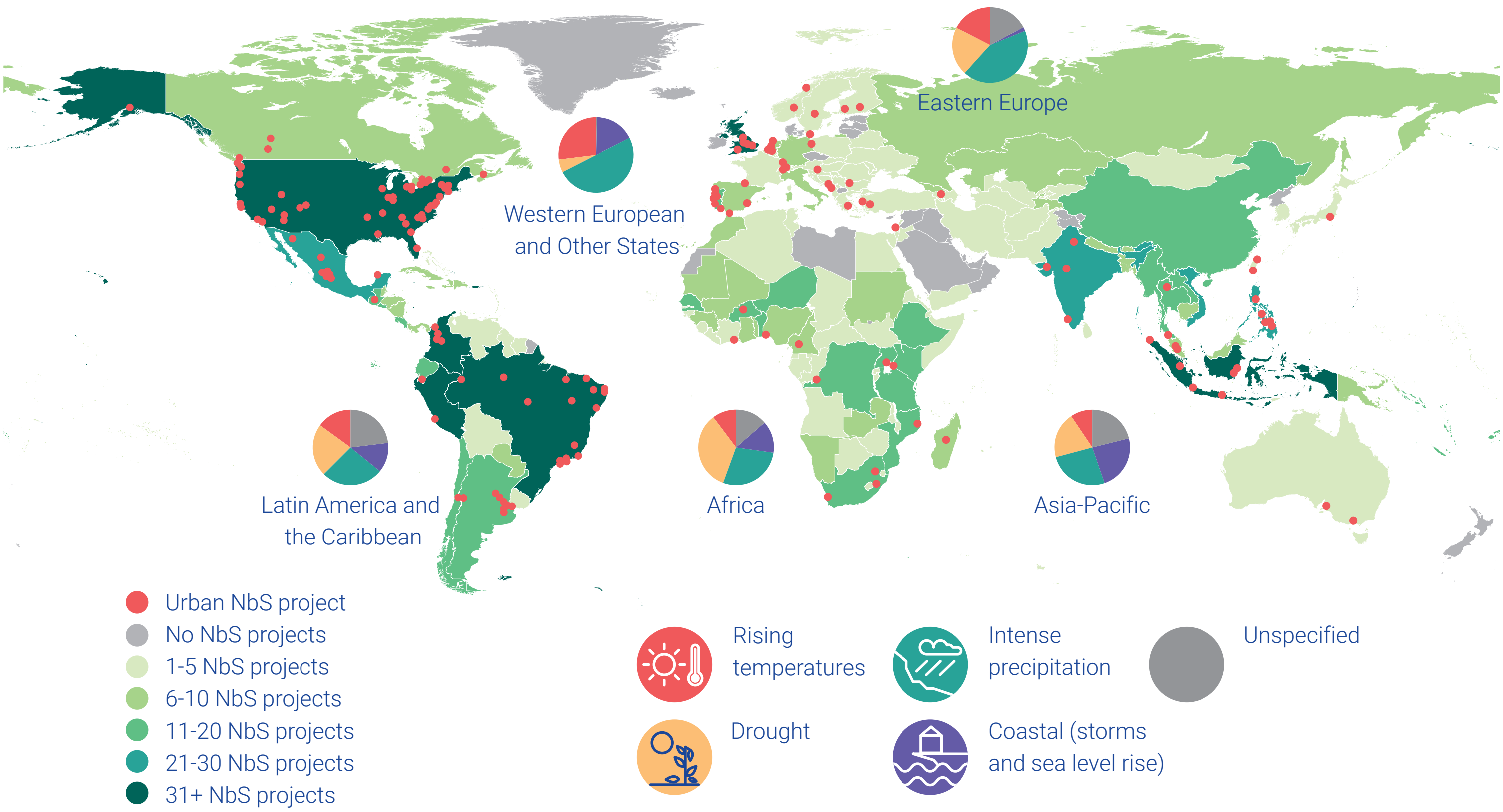
Adaptation with NbS is recorded for all continents except Antarctica. While a few countries stand out with more than 30 initiatives (Brazil, Colombia, Indonesia, Peru, UK and USA), and 40 countries worldwide have no recorded initiatives, by far the largest group of countries (91 of 207) has between one and five projects (figure 6.7). Whereas 39 countries still record six to 10 projects, the number of projects per country then declines dramatically, to the extent that only five countries have 21–30 projects. The distribution across regions is rather balanced with Africa, Asia-Pacific, Latin America and the Caribbean, and Western Europe and Other States all covering between 21 per cent and 25 per cent of initiatives. Only Eastern Europe is underrepresented with 4 per cent, while 3 per cent of projects were designed for multiple regions. Taking a closer look, it is also apparent that several countries in Central Asia and the Middle East have low levels of NbS implementation, warranting more focus on these regions in the future.

With the exception of projects described on the ClimateADAPT and NH-NbS databases, developed countries are primarily represented via urban NbS initiatives documented on the CDP platform, on which more than half the entries are located in Western Europe, North America and other high-income countries (figure 6.7). In addition, one in four cities reporting NbS are from Latin America and the Caribbean, whereas cities in Africa, Asia-Pacific and Eastern Europe are strongly underrepresented. This suggests that urban NbS are in need of stronger recognition in most developing regions. Language barriers, access to information and/or cultural and political reasons may also limit cities in these regions from disclosing information on CDP.

Globally, across the entire data set, intense precipitation is the climate hazard most frequently addressed (31 per cent), followed by drought (23 per cent). Coastal hazards, primarily sea level rise and storm surge, are covered in 16 per cent of cases, and rising temperatures is represented in 14 per cent of cases (figure 6.7). While 16 per cent of the data set does not mention specific climate hazards, in many cases more than one hazard is addressed. At the regional level, the picture is somewhat different:

18 A lack of information on funding in the ClimateADAPT database means that quantitative comparisons are not possible.

Figure 6.7. Global map of NbS initiatives for adaptation, showing the number of initiatives per country, the geographic distribution of cities reporting on NbS activities, and the regional distribution of hazards being addressed by NbS initiative



Note: Red dots represent the geographic location of cities reporting NbS activities via the CDP. Pie charts show the regional distribution of the hazards being addressed by NbS initiatives across UN Regional Groups

Source: Authors' analysis based on data sourced from the GEF, GCF, AF, IKI, ClimateADAPT, CDP and NH-NbS databases

- **Coastal hazards:** With 23 per cent of initiatives addressing coastal hazards in the Asia-Pacific region, coastal hazards are second only to intense precipitation. This is due in part to the region's large number of small island states and great exposure to tropical storms. At the other extreme, coastal hazards are mentioned in only 2 per cent of Eastern European cases, while for all other regions they are relevant in 13–17 per cent of initiatives.

- **Intense precipitation:** Western Europe and Other States and Eastern Europe stand out, with 50 per cent and 43 per cent of projects respectively addressing this hazard, compared with between 26 per cent and 28 per cent in all other regions. This might be explained by increasingly restricted waterways in Europe and other developed countries leading to more flooding downstream.

- **Drought:** For Africa, this is the most important hazard addressed, at 34 per cent, which is reflective of the region's greater exposure to drought risk in comparison with most other regions. While it is only reported in 6 per cent of initiatives in Western Europe and Other States, in all other regions drought represents 20–22 per cent of hazards addressed.

- **Rising temperatures:** Perhaps surprisingly, for Western Europe and Other States rising temperatures represent the second most common hazard (at 27 per cent) and can largely be attributed to urban heat. Despite being exposed to typically higher temperatures, rising temperatures are only mentioned for 9–10 per cent of initiatives in the Asia-Pacific and Africa regions and in 15 per cent and 17 per cent of projects in Latin America and the Caribbean and Eastern Europe respectively, suggesting that there is a certain level of pre-existing adaptation to current levels of heat in more tropical regions.

Table 6.6. Geographical distribution of NbS initiatives

	Africa	Asia-Pacific	Eastern Europe	Latin America and the Caribbean	Western Europe and Other States	Multiple regions	World
Rural	73%	51%	64%	51%	27%	93%	52%
Coastal	16%	28%	3%	19%	18%	0%	19%
Urban (incl. coastal)	11%	21%	33%	31%	54%	7%	29%

Source: Authors' analysis based on data sourced from the GEF, GCF, AF, IKI, ClimateADAPT, CDP and NH-NbS databases

It will be important to track the regional distribution and hazard focus of future NbS projects to start understanding whether increasing climate change results in diverging trends.

Analysis of the available data indicates that over half of all NbS initiatives are carried out in rural geographies, while just under 20 per cent and 30 per cent of initiatives are located in coastal and urban environments, respectively. Four per cent of initiatives are located in coastal cities (table 6.6). In Africa and, to a lesser extent, in Eastern Europe, rural initiatives are significantly more prevalent, whereas in Western Europe and Other States the implementation of NbS within urban environments is much more prevalent than in rural areas.

6.5.4 Using NbS to manage climate hazards

This section describes the relationship between the distribution of primary climate hazards, presented above, and their expression in different contexts, referred to here as 'proximate climate hazards' for clarity. It also examines the NbS utilized to address them by reducing either vulnerability or exposure and thereby managing risk (figure 6.8). Descriptions of the relationships between the different primary and proximate climate hazards are followed by a summary of the connections between proximate climate hazards and the NbS used to manage them:

- **Coastal hazards**, mainly sea level rise and storm surge, are relevant for 16 per cent of NbS projects. These are primarily concerned with addressing coastal flooding and erosion, but can also have implications on urban and river flooding when in the vicinity of the coast.

- **Intense precipitation** is addressed by nearly a third of all initiatives. These initiatives are primarily connected to river flooding, but urban flooding and erosion and landslides are also important. While the links between intense precipitation and these proximate hazards are immediately apparent, the fairly strong relationship between intense precipitation and drought illustrated in figure 6.8 is explained by the fact that floods and droughts often occur in the same rural landscapes due to increasing climate variability. They therefore need to be managed together.

- **Drought** is addressed by 23 per cent of initiatives, which focus primarily on droughts affecting agricultural and livestock production and constraining water availability. River flooding and erosion and landslides are also important for the same reason described under intense precipitation. While erosion is more commonly related to intense precipitation events, wind can also be a major driver of soil erosion in dry landscapes.

- **Rising temperatures** are the primary climate hazard in 14 per cent of cases analysed and shows strong links to temperature-related proximate hazards, including heat and fires. There is also an important connection to drought, which often occurs together with extended periods of extreme heat, and this can explain the minor connections to flood- and erosion-related hazards.

Although the relevance of specific NbS to addressing proximate climate hazards is complicated by the seemingly countless possibilities, there are a few clear trends:

- **Coastal flooding and erosion** make up 11 per cent of all analysed climate hazards and relate primarily to coastal NbS, namely restoration or protection of coral reefs, seagrass meadows, coastal wetlands (such as salt marshes), mangrove forests, and dunes and beach vegetation, all of which reduce wave and wind energy, thereby limiting their impacts.

Box 6.10. Using nature-based solutions to address drought and rising temperatures, including heat, fires and desertification

In many parts of the world, climate change will lead to warmer, drier conditions, increased frequency of drought and longer fire seasons. These conditions will directly result in increased frequency of wildfires and accelerated rates of desertification (Center for Climate and Energy Solutions 2020). With increases in the frequency and magnitude of these impacts already being observed in certain regions, NbS are increasingly being recognized as an effective approach to addressing these climate risks.

For example, to combat the increasing risk of forest fires in Gambia, the national government (with support from UNEP) has developed a project to restore degraded forests and farmland, establish ecologically sustainable businesses to stimulate investments in environmental services, and integrate adaptation measures into sectoral policies that encourage/support the maintenance of healthy ecosystems that enhance resilience to climate impacts (UNEP, undated a).

Meanwhile in Paraguay, UNEP and the national government are working to reduce the vulnerability to drought events of the food systems of seven communities in the dry forests of the Chaco region by implementing cost-effective, on-the-ground EbA measures determined via community consultation (Adaptation Fund, undated b).

Finally, in Kazakhstan, UNDP and the Kazakh Government have expanded protected areas in the Altai-Sayan region by 328,000 ha and created a 'green corridor' to link up previously separated protected areas within the region. In parallel, to reduce the region's increasing vulnerability to wildfires, as part of the project a regional fire management system was established and training in wildfire management was provided to local firefighters (International Climate Initiative 2020b).

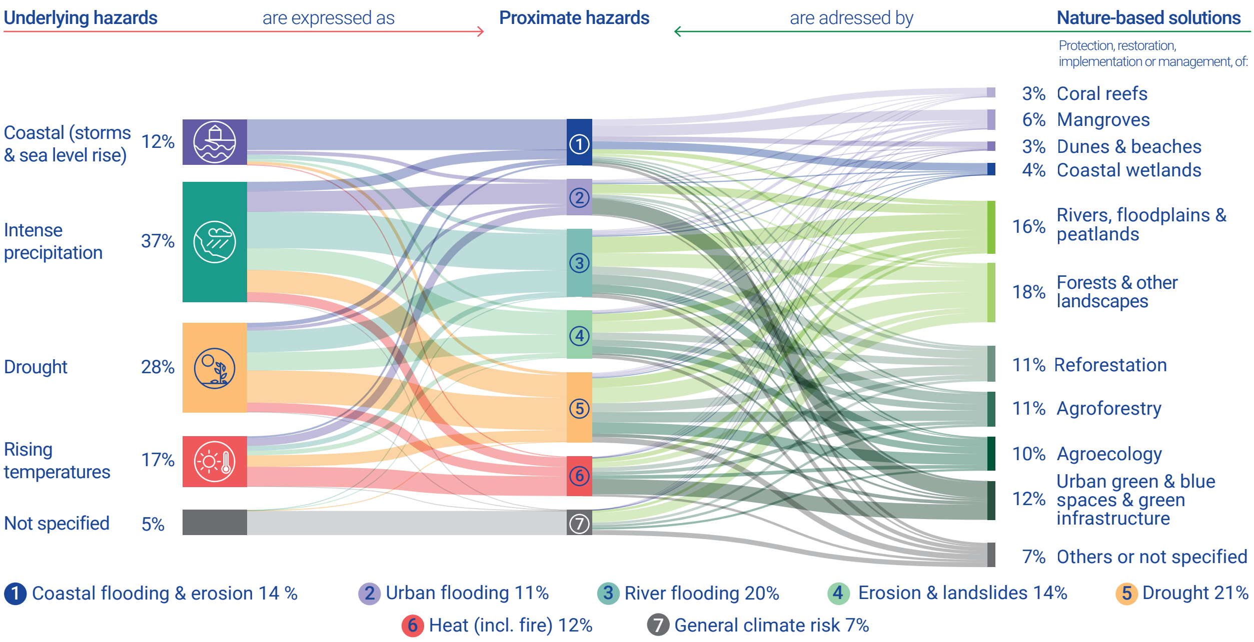
In these three case studies, the ecosystems involved are forested plains that are subject to periodic droughts and wildfires. In each case, these hazards threaten the sustainability of the ecosystem in question and degrade its capacity to deliver valuable ecosystem services. In response, all three interventions have adopted a landscape-approach to adaptation that involves maintaining viable natural habitats, restoring degraded land, expanding conservation areas and implementing sustainable production practices tailored to the ecosystem in question. In all of these projects, this has resulted in the rehabilitation of degraded forest, wildlife and agricultural areas.

While the primary objective has been to restore degraded landscapes and make them resilient to climate change, in each case securing and maximizing tangible societal benefits has also been an overarching goal. This is reflected in the fact that all three projects use metrics based on societal units – such as number of communities, businesses, families, people or women who benefit from the project's outputs – to quantify certain objectives and measure some parts of their success. Meanwhile, to ensure that success is achieved equitably, all three projects have taken measures during their planning and implementation phases to ensure that the project is gender sensitive.

A common challenge facing the successful implementation of these projects has been a lack of institutional capacity within communities and government actors to effectively implement and manage NbS. As such, all three projects incorporated capacity-building elements targeting relevant stakeholders to enable them to understand concepts, manage risks and implement best practices associated with NbS.

Finally, these projects demonstrate the importance of holistic approaches to nature-based adaptation. For example, while each project clearly leverages the restoration or protection of landscapes as a means of enhancing the resilience of the ecosystem and its local populous to drought and wildfires, each project also utilizes other means to ensure further effectiveness and sustainability. For instance, in Kazakhstan the training of firefighters and installation of a fire management system in the Altai-Sayan region means that when wildfires inevitably occur, the extent of the damage sustained should be significantly reduced. Meanwhile, in Gambia the co-development of policies for the agriculture, environment and energy sectors with relevant government institutions could prove crucial in protecting gains made by the restoration of ecosystems and preventing a return to a business-as-usual scenario in which ecosystem degradation continues.

Figure 6.8. Sankey diagram connecting underlying hazards to their impacts on the ground (proximate hazards) and how different NbS are being used to address them



Note: The thickness of the ribbons is determined by the number of projects referring to each of the categories. Projects often mention multiple underlying and proximate hazards and can refer to several NbS to address them. (Example how to read the figure: temperature rise can lead to increased heat in urban areas that is effectively ameliorated with green and blue spaces as well as green infrastructure. Many other NbS are sometimes also used in the context of heat-related hazards). Percentage values presented in the figure are rounded to the nearest integer.

Source: Authors' analysis based on data sourced from the AF, GCF, ClimateADAPT, CDP, IKI and NH-NbS databases

- **Urban flooding** constitutes 11 per cent of examined cases and is addressed primarily via the implementation of urban green spaces, including urban watersheds, to enhance water infiltration and retention. Upstream nature-based watershed management also contributes to reducing peak run-off and thus flood risk.

- **River flooding** accounts for 21 per cent of reported hazards and is mainly mitigated by restoring or protecting floodplains and peatlands and by enhancing riparian vegetation to act as a buffer to fluctuations in water flux. To smaller degrees, forest and landscape restoration or protection, reforestation, agroforestry, and agroecological practices also contribute to managing surface run-off.

- **Landslides and erosion** represent 13 per cent of analysed cases. Similar to river flooding, watershed management options are primarily utilized to manage the resulting risks. Forest and landscape restoration and protection, reforestation, agroforestry and agroecology also play significant, though minor, roles.

- **Droughts** constitute 23 per cent of proximate hazards, which are most frequently addressed via integrated watershed and landscape management to enhance available water resources. Reforestation and more climate-smart agricultural practices (for example, agroforestry, agroecology) are also important measures to lower drought-related income losses through diversification and better water management.

- **Rising temperatures** play a role in 16 per cent of examined projects. The majority of temperature-related risks relate to urban cases, which are mitigated through green spaces, trees, and green and blue infrastructure, all of which have cooling effects. Where heat and droughts occur together, a similar range of NbS are utilized to manage the hazards.

- **A general climate risk** was attributed to 5 per cent of cases because no explicit climate hazard could be identified. This was often the case in earlier projects and those focusing on other goals (such as carbon sequestration or biodiversity) while providing important resilience co-benefits, primarily through forest and landscape restoration or protection.

While drawing upon a greater evidence base in terms of the number and scope of NbS activities analysed, the results of this assessment largely confirm the findings of recent literature describing how NbS approaches are being used to address climate hazards (for example, Kapos *et al.* 2019; Chausson *et al.* 2020; Seddon *et al.* 2020, Almassey *et al.* 2018). However, whereas a large meta-analysis of empirical studies suggests that NbS lead to clear positive outcomes

Box 6.12. Using nature-based solutions to address urban climate risks, including to sea level rise, flooding and heat

As cities confront a range of increasing climate change hazards, from floods to heat to sea level rise, they must address how these affect businesses, infrastructure, delivery of services, biodiversity, the natural environments and residents. As recognition grows around how NbS can provide increased resilience alongside health and well-being co-benefits, NbS approaches are increasing in popularity in cities of all sizes, across developed and developing countries.

In Lao People's Democratic Republic (PDR), climate change is increasing the frequency and intensity of extreme rainfall, resulting in more frequent and more severe flooding in vulnerable and rapidly growing cities along the Mekong River. Flood management in the country has traditionally used a hard infrastructure approach; however, building on and scaling up previous successful interventions in wetland rehabilitation, UNEP and the national government (with GCF funding) have initiated a new project for integrated climate-resilient flood management utilizing NbS. Interventions include increasing green spaces and permeable surfaces within cities to reduce run-off and rehabilitating and protecting urban streams and wetlands. The results are expected to greatly reduce the economic burden of flooding, which is estimated to cost each household approximately US$1,000 after each heavy rainfall event (Lao People's Democratic Republic and United Nations Environment Programme 2019).

Singapore, a much denser and more populous city than those found in Lao PDR, is also dealing with flood risk. The city is also concerned about accelerated coastal erosion and the increasing vulnerability of ecosystems to climate change. To better understand these hazards, the Government has undertaken an extensive assessment of the vulnerability of ecosystems and plant species from i) forests and wetlands that are vulnerable due to fragmentation compounded by changes in rainfall patterns, ii) mangroves that are at risk from sea level rise and iii) corals that are threatened by higher temperatures. As a result of this assessment, Singapore's response targets the restoration of forests and mangroves through both planting and minimization of other pressures, diversification of roadside tree species, and long-term planning approaches to address coastal vulnerability to flood and erosion. This comprehensive and interdisciplinary approach has consequently improved climate resilience for the population as well as ecosystems and biodiversity.

New York City has also focused on trees and urban forests with its MillionTreesNYC project for heat and flood reduction benefits. The project is notable for its public-private partnership approach that brings together city departments, academia, research institutes, community organizations, homeowners and local businesses to plant 1 million trees. In addition to the adaptation benefits, the project also prioritizes CO_2 sequestration and air quality co-benefits. The project has a strong emphasis on cost-benefit analysis, emphasizing the economic benefits associated with the capacity of trees to reduce storm water and air pollutants – estimated to equate to a return of US$5.60 in benefits for every dollar spent (Quinn 2018). The goal of 1 million trees was reached in 2015, expanding the city's urban forest by 20 per cent (NYC Parks 2015).

Lao PDR, Singapore and New York are just a few examples of the many cities and countries pursuing urban NbS to build resilience and provide co-benefits for growing and changing populations. Each case highlights some effective strategies for expanding and enhancing NbS actions, whether by building on previous knowledge, experiences and projects or mobilizing interdisciplinary and multi-stakeholder partnerships. There are also several commonalities across the cases. One common challenge is that full results, especially in terms of building resilience and/or reducing risks, may not yet be apparent – either because the project has just started or because the results reflect the implementation of the NbS approach and not necessarily when it is 'tested'. The cases in Singapore and New York also hint at some of the limitations of NbS in urban environments where ecosystem fragmentation or remaining physical space for interventions is limited. Nevertheless, all three cases demonstrate the potential for NbS to improve resilience, especially to flooding-related risks, for people while improving urban ecosystems and biodiversity.

in relation to food production, landscape restoration, flood management, and erosion control (Chausson *et al.* 2020), whether the activities described here achieve their goals cannot be assessed using the approach applied. Determining this would require a far more in-depth assessment, which is presently not feasible given the small number of cases that are at the point at which they could be analysed through an ex-post impact assessment. Furthermore, even for NbS projects that have been fully implemented, there is presently no information available about these initiatives that would allow their outcomes to be assessed. This information gap represents a major barrier that urgently needs addressing in order to allow for independent and transparent analyses of the outcomes of NbS projects and a more systematic reflection on the pros and cons of future NbS investments.

6.5.5 Benefits and co-benefits of NbS

In contrast to engineered solutions to mitigate climate hazards, NbS can provide a wide range of additional direct and indirect benefits, which are frequently not sufficiently taken into account when making investment decisions (OECD 2020a). Besides the benefits mentioned in table 6.1, the analysis of available data sources shows several other benefits of NbS that are relevant for future decision-making (table 6.7). Some of the benefits listed in table 6.7 arise in the context of projects focusing primarily on rural development in a changing climate and are therefore much less relevant for projects that are situated in high-income regions or employed to manage urban climate risks. That is because NbS are often better positioned than their engineering-based counterparts to building adaptive capacity while also managing climate risks due to their important contributions to enhancing environmental governance, building capacity, raising awareness, developing innovative business models and offering alternative income streams to improve livelihoods.

NbS are also often favoured as solutions when it comes to simultaneously addressing several environmental challenges because of their capacity to provide multiple ecosystem benefits, such as enhancing or maintaining important ecosystem services, biodiversity, carbon storage and landscape restoration. For example, NbS were implemented in only 8 per cent of GEF projects focusing exclusively on climate change (GEF-1 to GEF-7), whereas they were selected in between 50 per cent and 70 per cent of projects that combined climate change with land degradation, biodiversity or transboundary water management. This suggests that NbS-related projects are being viewed as integrated solutions to a range of development challenges, rather than merely as a direct substitute to engineering solutions.

Several of the projects assessed explicitly mention gender equity as an important goal and some even focus on using NbS to improve women's livelihoods by enhancing incomes, health, or local governance and institutional capacity. Other initiatives highlight improvements in indigenous or local community rights and land tenure arrangements in the context of developing NbS to manage land sustainably, with clear benefits in terms of climate resilience. In addition, NbS are frequently mentioned as means of enhancing transboundary collaboration and conflict resolution where landscape-level interventions are being pursued. Furthermore, many interventions specifically envision developing blueprints and frameworks for scaling up pilot projects to larger scales as well as mainstreaming NbS into national planning processes.

While there is sufficient evidence supporting the effectiveness of NbS under current climatic conditions, NbS are subject to the impacts of climate change and may lose some or all of their capacity to reduce or manage climate risks in the future. For example, warm-water corals are already threatened by the impacts of climate change and are unlikely to survive a 2°C increase in global temperatures above pre-industrial levels (IPCC 2018). It is therefore important to consider ecological thresholds when devising new NbS initiatives to ensure that, despite unavoidable climate change, they can continue to provide their environmental and other benefits.

6.5.6 Challenges and recommendations for scaling up NbS implementation

NbS are increasingly being discussed as effective and cost-efficient solutions to climate-related risks (Costanza *et al.* 2008; Kapos *et al.* 2019; OECD 2020a). Chausson *et al.* (2020) evaluated a large number of cases from the peer-reviewed literature, concluding that 59 per cent of the cases analysed had positive effects on the climate hazard addressed, with improvements in soil erosion, freshwater flooding and reversal of degradation, but only limited information was available on coastal hazards, wildfire, and slope stability. Similarly, Seddon *et al.* (2020) report on multiple cases in which NbS contributed to reducing exposure to climate hazards in relation to soil erosion, inland and urban flooding, coastal hazards and sea level rise, urban heat waves and heat island effects, and to reducing the impacts of drought. They also describe cases of positive effects on vulnerability reduction via enhancing and diversifying ecosystem services and through governance reform, empowerment and improved access to natural resources established in the context of NbS interventions.

However, for most NbS initiatives analyzed in this context, it is too early to assess their effects on reducing climate risks, as work is often still ongoing. Further, where NbS projects have been fully implemented, there is surprisingly little information available on the effectiveness and efficiency of the intervention. Only AF provides easily accessible final project evaluations, but none of these discuss the longer-term results. Improving the availability of ex-post evaluations of NbS interventions and initiatives is therefore of utmost importance in order to shed more light on their effectiveness, efficiency and environmental, socioeconomic, and financial sustainability, all of which are critical to their long-term success and scalability.

Table 6.7. Examples of environmental, social, economic, policy-related and other benefits related to interventions with NbS

Scale	Environmental	Social
• Local • Subnational • National • Regional • Global	• Improved water quality and availability • Biodiversity protection • Carbon storage • Reversal of degradation • Lower air and noise pollution • Protected area development (e.g. park zonation) • Nature corridors	• Human capacity and training • Greater opportunities for women • Awareness-raising and knowledge-sharing • Grass-roots mobilization • Building adaptive capacity at local levels
Economic	**Policy-related**	**Risk management / Other**
• Income, livelihoods, and food security • Increased crop, livestock and forestry productivity • Creation of new jobs (e.g. tourism, aquaculture, non-timber forest products) • Water security • Health (e.g. water, sanitation and hygiene) • Energy security • Regional development • Market access • Value and supply chain development • Innovative business models • Enterprise development • Public-private partnerships • Microfinance and loans • Benefit-sharing mechanisms (e.g. PES, REDD+) • Water councils, water funds	• Improved indigenous and community rights and land tenure arrangements • Local governance and institutional capacity • Urban planning • Dialogue platforms • Policy frameworks, including national strategies to mainstream and scale up NbS • Strategies for biosphere preservation and wildlife habitats • Subnational and national governance structures for watershed and forest management • Transboundary collaborations • Peace processes	• Infrastructure against coastal erosion • Flood control • Soil protection against landslides and erosion control • Disaster risk reduction • Development of early warning and climate information systems • Adaptation M&E • Measurement, reporting and verification of greenhouse gas emissions • Centres of excellence • Insurance (e.g. against crop loss or flooding) and other risk transfer mechanisms

Source: Summarized from stated benefits from the AF, GCF, IKI and NH-NbS databases

Despite the absence of more systematic assessments of project outcomes, there is encouraging evidence that, across the entire spectrum of information available, implementation of NbS for adaptation has been growing strongly since the early 2000s. However, there are also indications that this expansion may be slowing. It will therefore be important to continue monitoring both the rate of NbS implementation and the proportion of funding allocated to NbS across accessible donor and implementer platforms to assess whether the implementation of NbS for adaptation is indeed being scaled up.

This assessment suggests that the ratio between green and hybrid solutions is fairly balanced across the entire data set. However, whether green, hybrid or grey solutions are preferred often depends on local contexts. For example, in urban settings interventions are more commonly a mix of nature-based and engineered or infrastructure solutions. While this partially reflects context-specific constraints, giving greater prominence to NbS is often also limited by the existing policy, regulatory and financial frameworks which, for a number of reasons, tend to favour traditional planning and engineering solutions (OECD 2020a). In particular, NbS often require considerable time to reach their potential benefits but will then appreciate over time. On the other hand, while grey infrastructure may provide services immediately after implementation, it will depreciate thereafter and thus often requires more costly maintenance. Improving regulatory frameworks to ensure that benefits and costs are accounted for to address short- and long-term needs may enhance decision-making in favour of NbS.

Moreover, in comparison with conventional engineered solutions, NbS provide a wide range of co-benefits, including securing a broad range of ecosystem services on which the livelihoods of local communities depend, generating diversified income revenues, and improving food security, water availability and health (Losada *et al.* 2018; Kapos *et al.* 2019; Seddon *et al.* 2019; Buckley *et al.* 2019, Chausson *et al.* 2020). However, due to challenges in evaluating and valuing these benefits, they are often not sufficiently taken into account in decision-making processes. Fully accounting for additional benefits of NbS, which can outweigh their direct climate-risk reduction and environmental benefits (for example, Buckley *et al.* 2019), would likely enhance acceptance and levels of implementation.

6.6 Scaling up and moving forward

This chapter has highlighted several key gaps that need to be filled in order to scale up the use of NbS for adaptation, as called for in a number of high-profile contexts (for example, GCA 2019), and to realize their many potential socioeconomic and environmental benefits. Progress in application and scaling-up of NbS is likely to depend on:

- Expansion and consolidation of currently limited and scattered evidence on the effectiveness and cost-effectiveness of NbS for adaptation that takes account of the full range of benefits they provide (including avoided costs).
- Improved and long-term monitoring and evaluation of ongoing and completed initiatives to further expand the evidence base and link impacts to financial flows.
- Effective communication of that evidence base in forms appropriate for, and accessible to, investors and decision makers.
- Effective tracking of investment of finance and effort in NbS implementation to help identify gaps.
- More concrete incorporation of NbS into planning for adaptation across scales and sectors, through the NAP process and beyond, including recognition of, and explicit planning for, the links and co-benefits between NbS for mitigation and NbS for adaptation.
- Diversification and innovation in financing for NbS, blending different sources and ensuring that aspects of the enabling environment such as structural and regulatory frameworks and fiscal incentives are conducive to investment in NbS
- Critically, NbS planning and implementation need to account for climate risks to ecosystems and include measures to address them in order to avoid investment in solutions that may be ineffective or short-lived.

The potential of NbS for adaptation can best be fully realized by limiting the risks of dangerous levels of global warming and by scaling up ambition and action on protecting, conserving and restoring nature.