Scaling Up the Use of Ecosystem-based Adaptation

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Ecosystem-based adaptation (EbA) has the potential to significantly enhance the resilience of society to climate change and could be a key part of national and global adaptation efforts. However, despite growing interest among policymakers, donors, scientists and practitioners, the current pace and scale of EbA implementation falls far short of its potential. The aim of this report is to highlight the opportunities for scaling up the use of EbA to help put the world on a more climate-resilient and nature-positive pathway.

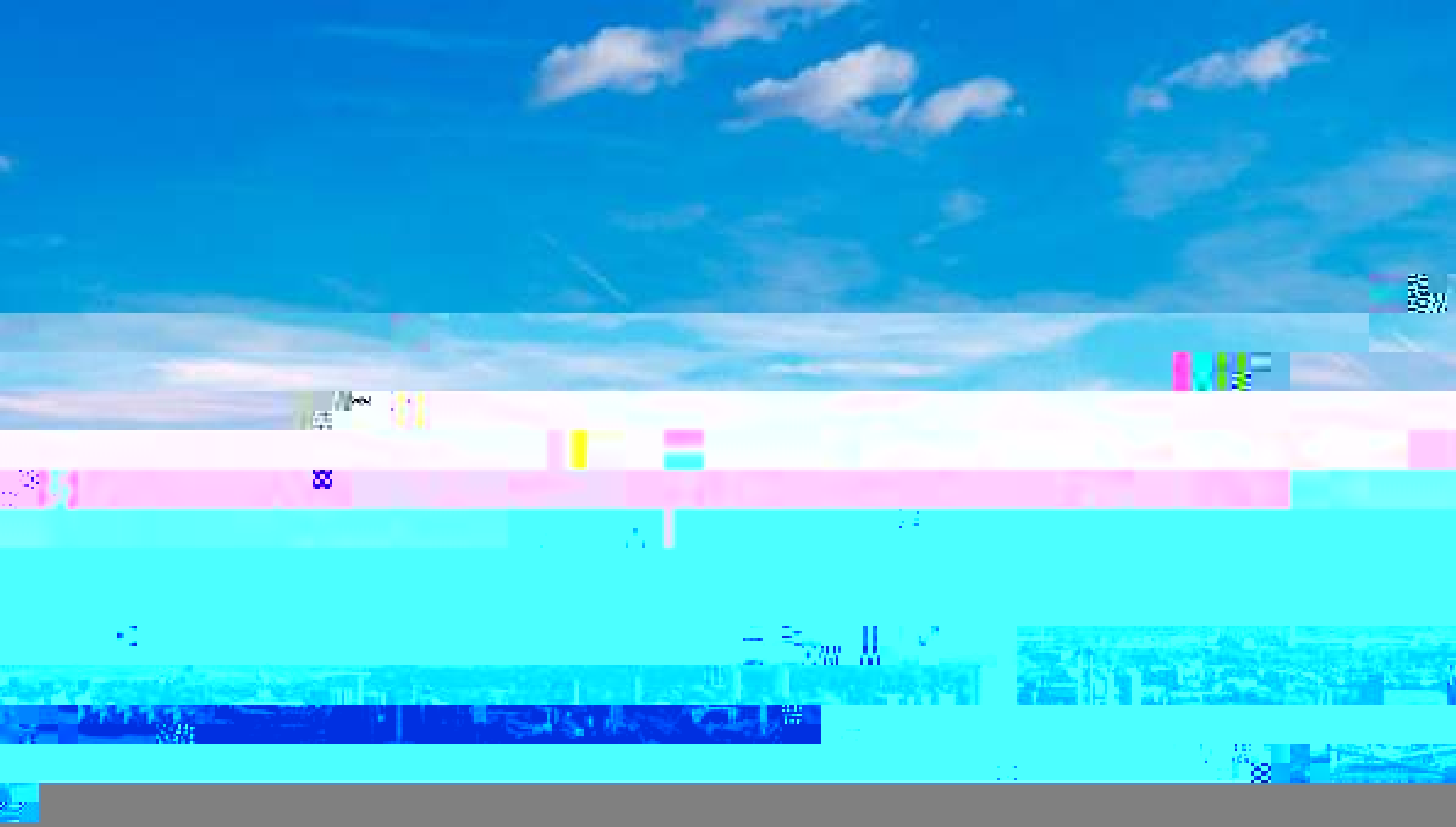
The report begins by examining the role of EbA in helping society adapt to climate change, while also contributing to biodiversity conservation, climate mitigation and sustainable development efforts. It assesses the current state and trends in EbA implementation. Next, it explores the barriers that are currently slowing the widespread application of EbA in policy and practice. Finally, the report provides a set of recommendations on how to enhance the scale and pace of EbA implementation to more fully harness the potential of ecosystems to deliver adaptation benefits. The report is based on a detailed review of over 750 documents (including scientific papers, technical publications, policy briefs and project reports) as well as input from 59 global EbA experts from 30 organizations. Throughout the report, the term "ecosystem-based adaptation" is treated as equivalent to nature-based solutions (NbS) for adaptation, in line with the recent definition of NbS by the United Nations (United Nations Environment Assembly [UNEA] 2022).

EbA can be defined as the use of ecosystems and biodiversity as part of a broader adaptation strategy to help people adapt to the adverse impacts of climate change. It involves the active conservation, restoration and management of ecosystems to foster climate resilience. EbA can help enhance the resilience of society to climate change by protecting communities from the effects of climate hazards such as strong storms, floods and heatwaves, and by ensuring that ecosystems continue to deliver key ecosystem services (such as food or access to water) that help people meet their diverse needs in a changing climate.

Common examples of EbA measures include the conservation or restoration of mangroves to protect coastal communities from storm surges and sea level rise, the establishment of green roofs, street trees and urban parks to reduce the risks of heatwaves and flooding in cities, and the conservation of upslope forests to prevent landslides and downstream flooding under extreme weather events.

EbA has many qualities which make it a potentially attractive approach for policymakers, donors, investors and practitioners. EbA measures can be applied in a wide range of socioecological settings (from coastal zones to cities to mountains) and can meet the adaptation needs of a diverse set of sectors and stakeholders. In addition to providing significant adaptation benefits, EbA can generate a large and diverse array of co-benefits to society, including biodiversity conservation, climate mitigation, food security, job creation, livelihood opportunities and economic development. As such, EbA can make a significant contribution to multiple international policy goals related to climate change, biodiversity conservation, ecosystem restoration and sustainable development.

While EbA is a versatile and widely applicable approach, there are some limitations to its use. For example, there may be some circumstances in which EbA cannot address the specific adaptation needs of targeted stakeholder groups. In addition, ecosystems are themselves vulnerable to climate change, so unless urgent action is taken to reduce greenhouse gases and slow the rate of climate change, the ability of ecosystems to protect communities and deliver essential ecosystem services will decline over time.



View of the london city dam. Thames flood barrier over river thames.
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limited awareness and understanding of EbA (especially among policymakers, private sector actors and the local authorities and technicians who are tasked with implementing EbA on the ground) can discourage or prevent its inclusion in relevant policies, regulations, budgets, adaptation plans and investments.

of ecosystems is critical for delivering adaptation services. It can also provide valuable information for government investment and budgeting decisions, for example, helping to ensure that public finance is directed towards activities that maintain or enhance ecosystems (and ecosystem services flows) and away from activities that undermine ecosystem functioning.

Governments, multilateral organizations, international development agencies, climate funds and other public funders could encourage the use of EbA by establishing green public procurement processes. “Green public procurement” refers to the public purchase of products and services which are less environmentally damaging than alternatives, when taking into account the whole life cycle of the product or service. Governments with existing green procurement procedures could review and update their technical standards and procedures to ensure that EbA options are always

Enhancing climate change resilience of rural communities
living in protected areas of Cambodia.
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the long-term resilience of communities, businesses and economies to climate change. In order to spur the use of EbA in economic recovery plans, governments, multilateral development banks, development agencies and other donors could directly provide grants, loans or other types of funding for priority EbA measures, such as investing in green infrastructure in cities to reduce heat exposure and urban flooding, or financing mangrove and wetland restoration to minimize coastal flooding.

Another way to accelerate action on EbA is to support the disclosure of risks to climate and nature among private sector actors, including businesses and financial institutions. There are currently two initiatives under way to promote greater transparency on climate- and nature-related risks to companies: the Task Force on Climate-related Financial Disclosures and the Task Force on Nature-related Financial Disclosures. The broad-scale adoption of these risk disclosure frameworks could spur greater use of EbA, as private sector actors become more aware of the risks they face from climate change and nature loss and the potential for ecosystem management to address these risks. Governments can support these risk disclosure efforts by creating national regulations that require companies to report their climate-related and nature-related financial risks and the actions they are taking to address these risks (including EbA).

There are opportunities to leverage more financial resources for EbA from the insurance sector. The insurance sector can incentivize the use of EbA among its clients by providing discounts for clients who use EbA to reduce their vulnerability, thereby reducing the cost of insurance. They could also support EbA by creating innovative insurance mechanisms that support the conservation, management and restoration of ecosystems that are important for adaptation. Finally, the insurance industry can invest directly in the restoration, conservation and sustainable management of ecosystems for climate resilience.

A fifth, and final, approach that holds promise for scaling up EbA is to prioritize EbA implementation in those contexts in which it will deliver the greatest and most significant adaptation benefits (i.e. where its implementation reduces the vulnerability or enhances the resilience of the greatest number of people). Decisions about whether, how, where and which EbA measures to include in adaptation initiatives for a given location should be based on a detailed, spatially explicit analysis of climate risks, stakeholder vulnerabilities and adaptation needs, potential adaptation measures, and numbers of potential beneficiaries. While the specific priority areas for EbA will differ from one country to the next, there are three contexts where EbA implementation holds particular promise for delivering adaptation benefits at scale.

Firstly, EbA should be prioritized in low-lying cities that are vulnerable to heat stress and flooding. As the world becomes urbanized, cities are increasingly at the forefront of climate change adaptation efforts. It is estimated that 55 per cent of the world's population (UNEP 2016) already lives in urban areas and the urban population continues to grow (United Nations 2018). Climate change poses significant risks to many cities because they are located in the floodplains of major rivers, on drained wetlands, along estuaries or along coastlines, and are therefore vulnerable to flooding and storm surges. An estimated 700 million people live in urban or peri-urban areas that are less than 10 m above sea level (Center for International Earth Science Information Network 2019). Flooding already causes an estimated US$ 120 billion of damage to urban property each year and this] я ꞯ]

As stronger storms, extreme rainfall events, record-breaking temperatures and historic climate-driven floods become more frequent and affect large parts of the world, governments, businesses and communities are increasingly calling for society to better prepare for and adapt to the negative impacts of climate change or face serious costs, damages and losses. Recent high-level reports, such as the United Nations Adaptation Gap Reports (UNEP 2021a; UNEP 2021e), the Adapt Now report (GCA 2019), and the latest report from the Intergovernmental Panel on Climate Change (IPCC 2022), have stressed the urgent need for much more ambitious policies, programmes and investments to build societal resilience to climate change. These reports have also highlighted the critical importance of ecosystems and ecosystem services in helping people to adapt to the adverse impacts of climate change. EbA can play a central role in enhancing the overall resilience of society to climate change, while also ensuring the conservation of ecosystems and ecosystem services on which society depends (GCA 2020).

In this chapter, we explore what ecosystem-based adaptation (EbA) is and how it can help put the world on a more climate-resilient and nature-positive pathway. The overall aim of this chapter is to ensure that readers have a clear understanding of what EbA entails and how it can make a significant contribution to both local and global adaptation efforts. We first briefly introduce the concept of climate change adaptation and the main adaptation approaches, so that the broader context in which EbA can be applied is clear. Next, we provide a detailed overview of the concept of EbA and clarify how EbA relates to other concepts such as NbS, green infrastructure and community-based adaptation. We then provide specific examples of how EbA can be applied in different socioeconomic contexts, in order to demonstrate the wide applicability and diversity of EbA measures. Finally, we highlight some of the reasons why EbA is rapidly gaining traction within policies, programmes, investments and research, as well as some of the physical limitations to its use. An overview of the current status and trends of EbA implementation is provided in chapter 2, while subsequent chapters examine the barriers (chapter 3) and opportunities (chapter 4) for scaling up the use of EbA globally.

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changes in society and ecosystems (such as farmers switching to non-agricultural livelihood activities or migrating to other regions – Kates, Travis and Wilbanks 2012; Fedele *et al*. 2019). Adaptation can be pursued by all constituents of society – individuals, households, communities, businesses and national governments – and involves actors in both public and private sectors. It can be based on traditional knowledge, local knowledge, scientific knowledge and technologies, or a combination thereof.

While there is a diverse array of measures that can be undertaken to help society adapt to climate change, adaptation actions can be broadly categorized into three main approaches: conventional hard approaches, soft approaches and EbA (Sovacool 2011; Jones, Hole and Zavaleta 2012).

- refer to the use of specific technologies, engineering solutions or human-built infrastructure to reduce the impacts of climate change on society. Examples include using sea walls to protect vulnerable coastlines from coastal erosion and storm damage, building dams, storm drains and canals to protect cities from the risk of flooding, establishing irrigation systems to tackle climate-induced water scarcity, building water treatment plants to ensure the provision of clean water during climate change, and installing air-conditioning to help households cope with rising temperatures and heat stress (Sovacool 2011; Jones, Hole and Zavaleta 2012). These hard adaptation approaches (which are often also referred to as "conventional" approaches, "engineered" solutions, "grey infrastructure" or simply "grey" approaches) are typically very effective at addressing specific climate hazards (Browder *et al*. 2019). However, they tend to be expensive to build and maintain, have a finite lifespan, and often involve large and irreversible disturbances to surrounding natural ecosystems (World Wildlife Fund [WWF] and World Bank 2013).

- refer to the use of information, finance, knowledge generation, policy, human resources development, policies, and planning processes to build societal resilience to a range of climate change impacts (Jones, Hole and Zavaleta 2012; Goldstein *et al*. 2019). Examples include enhancing awareness of climate risks, building capacity on climate adaptation, creating disaster risk reduction strategies to deal with climate hazards, developing social safety nets that can help communities affected by climate hazards, improving weather forecasts and climate modelling, and developing early warning systems for droughts, floods and other extreme weather events (Sovacool 2011; Jones, Hole and Zavaleta 2012). In most cases, soft approaches are used in combination with hard approaches and EbA.

- (EbA) is defined as "the use of biodiversity and ecosystem services as part of an overall adaptation plan strategy to help people adapt to the adverse effects of climate change" (CBD 2009). As detailed in the following section (section 1.2), EbA includes the targeted conservation, restoration and management of ecosystems to deliver services that help people adapt to climate change. In some cases, EbA measures are implemented as stand-alone, discrete adaptation initiatives that serve as alternatives to hard approaches. However, in most cases, EbA measures are implemented in tandem with hard and soft measures, as part of a broader adaptation plan (Bertram *et al*. 2017; Browder *et al.* 2019).

Adaptation planners and practitioners can use a mix of these different adaptation approaches to address the specific climate risks arising in a particular location and to respond to the differentiated vulnerability and adaptation needs of different stakeholder groups. In many cases, adaptation practitioners combine hard and EbA approaches in so-called "green-grey" or "hybrid" approaches (Browder *et al*. 2019, Green-Gray Community of Practice 2020).

While all types of adaptation are important, necessary and appropriate for certain contexts, our report focuses specifically on the opportunity to increase the implementation of EbA to help society become more resilient to climate change. Throughout this report, we use the term "EbA initiatives" to refer both to the use of initiatives that consist solely of EbA measures, as well as hybrid or green-gray approaches in which EbA is used in tandem with hard adaptation measures.

- is a broader umbrella concept that encompasses actions designed to address major social, economic and environmental challenges such as biodiversity loss, climate change, land degradation, deserti f cation, food security, disaster risks, urban development, water availability, poverty eradication, inequality and unemployment (Cohen-Shacham *et al.* 2016; Cohen-Shacham *et al*

There is a wide range of EbA measures that can be used to address different climate hazards and risks in different contexts, ecosystems and geographies (Ojea 2015, Swiderska, King-Okumu and Islam 2018). To demonstrate the diversity and wide applicability of EbA measures, here we provide a high-level overview of EbA measures that can be implemented in six socioecological settings, namely urban areas, agricultural landscapes, forested landscapes, mountainous regions, freshwater systems and coastal areas. Additional examples of EbA measures and case studies of their application in different settings can be found in Table 1. Since there are overlaps and interlinkages across these settings (e.g. urban areas may occur in coastal zones or in mountain areas), individual EbA measures are often relevant to multiple settings. In practice, EbA initiatives are often implemented across large spatial scales (landscapes, watersheds or even transboundary river basins) that include multiple socioecological settings, and therefore involve a suite of different EbA measures (Hutchins *et al*. 2021).

- There is a wide number of EbA measures that can help urban residents and businesses cope with rising temperatures, heat waves, urban flooding, greater water scarcity and other climate impacts (Gaffin, Rosenzweig and Kong 2012; Geneletti and Zardo 2016; Hobbie and Grimm 2020). For example, urban parks, street trees, green roofs, community gardens and other green spaces provide shade and evaporative cooling, reducing the impacts of rising temperatures on the health and well-being of urban residents (Norton *et al*. 2015; Hobbie and Grimm 2020; Koch *et al*. 2020). Other EbA measures, such as the restoration of ponds, urban wetlands, and green spaces, can help reduce the risks of urban flooding by increasing water infiltration into the soil and reducing the amount and speed of surface run-off (Chu *et al*. 2019; Hobbie and Grimm 2020). These measures can also capture and store water, allowing aquifer recharge and reducing the risks of water insecurity under changing rainfall patterns (Chu *et al*. 2019). The use of EbA measures in common in cities around the world, with well-documented examples from Europe (Gill *et al*. 2007; Naumann *et al*. 2011; Brink *et al*. 2016; Geneletti and Zardo 2016; Frantzeskaki 2019; Kabisch *et al*. 2017; McVittie *et al*. 2018; EEA 2021; Zölch, Wamsler and Pauleit 2021), the United States of America (Young 2011; Chu *et al*. 2019), Latin America (Tellman *et al*. 2018), Africa (Thorn *et al*. 2021) and China (Zevenbergen, Fu and Pathirana 2018; UNEP 2021a). Guidance on the implementation of EbA within cities is available from the World Bank (2021), UNEP (2021) and the Green-Gray Community of Practice (2020).

- EbA measures can help farmers, pastoralists and other rural residents adapt to the impacts of climate change on farm productivity, food security and rural livelihoods (Vignola *et al*. 2015; Miralles-Wilhelm 2021). For example, the establishment of diverse agroforestry systems can help buffer crops from the impacts of higher temperatures, heavy rains, droughts or strong winds, reduce soil erosion and modify the microclimate in ways that improve crop yields (Verchot *et al*. 2007; Harvey *et al*. 2014; Schoeneberger, Bentrup and Patel-Weynand 2017). Agroecological practices (such as cover crops, mulching, no till, crop rotation and soil and water conservation practices) can be used to help improve soil structure and fertility, increase water infiltration, reduce soil loss and protect crops from water scarcity (Sinclair *et al*. 2019; Miralles-Wilhelm 2021). Crop diversification and the conservation of agrobiodiversity can help reduce the risks of crop failure from high temperatures, heavy rainfall events, droughts, or climate-induced pest and disease outbreaks or invasive species (Burgiel and Muir 2010; Lin 2011; Snapp *et al*. 2021). Adopting silvopastoral practices and restoring degraded pastures can help to sustain the livelihoods of pastoralists and ranchers under climate change (International Fund for Agricultural Development [IFAD] 2020; Bah *et al*. 2021). At the broader landscape level, restoring forests, wetlands, riparian areas and degraded lands across the agricultural landscape can increase water infiltration and slow the flow of water, thereby ensuring the continued provision of water to agricultural areas and buffering against water scarcity and drought (Pramova *et al*. 2012). EbA measures can be easily incorporated into integrated landscape management, forest landscape restoration or climate-smart landscape initiatives which contribute to climate adaptation, climate mitigation, biodiversity conservation and food security efforts (Harvey *et al*. 2014; Reed *et al*. 2015; Stanturf *et al*. 2015; Reed *et al*. 2020). Guidance on the implementation of EbA in agricultural systems is available from Abdelmagied and Mphesha (2021), Wilhelm-Miralles (2021) and Sonneveld *et al*. (2018).

- EbA measures can also help communities living in forested landscapes adapt to higher temperatures, more severe heat waves, increased likelihood and severity of forest fires, longer fire seasons, changes in the availability of water, prolonged droughts, increased soil erosion, more frequent landslides, and climate-induced outbreaks of forest pests (Swiderska, King-Okumu and Islam 2018). Potential EbA measures for forested landscapes include the active protection of intact forests from deforestation, degradation and human-induced fires to ensure that forests are healthy and resilient to climate change, the restoration of degraded forest lands to restore hydrological services, and the use of sustainable forest management practices (e.g. thinning and/or selective logging) in natural forest stands to maintain forest health and productivity in a changing climate (Colls, Ash and Ikkala 2009; Chausson *et al*. 2020). Careful management of fires within forests can also help enhance their resilience to climate change and their ability to provide timber, firewood, non-timber forest products, water regulation and climate regulation services to society (Colls, Ash and Ikkala 2009). At the landscape level, the large-scale protection of intact forest through protected areas, conservation agreements, or community-managed forests can help to stabilize soils and prevent the incidence of landslides and flash floods under extreme weather events, while also providing valuable biodiversity and climate mitigation benefits (Dudley and Stolton 2003; MacKinnon, Dudley and Sandwith 2011; Lopoukhine *et al*. 2012; Martin and Watson 2016). Conserving and restoring forests at the landscape or watershed level can also improve water infiltration and storage, helping to preserve water in the face of changing precipitation regimes and rising temperatures. This regulatory function is particularly important in regions where large cities and towns lie downstream of forested areas (Dudley and Stolton 2003; Tellman *et al*. 2018; Ozment *et al*. 2021). Guidance for the use of EbA in forested landscapes can be found in Swiderska, King-Okumu and Islam (2018).

- The deliberate management of mountain ecosystems (including grasslands, páramos, wetlands, alpine ecosystems and montane forests) can play a key role in helping mountain communities to adapt to the impacts of rising temperatures, changing precipitation patterns and more intense extreme weather events (Lo 2016; Swiderska, King-Okumu and Islam (2018). Conserving, restoring and sustainably managing vegetation in the upper slopes of mountains can stabilize slopes and prevent landslides and avalanches during extreme storms or precipitation events (Forbes and Broadhead 2013). The use of ecosystem restoration practices, contour planting or agricultural terraces can help stabilize fragile mountain slopes and reduce water run-off, reducing erosion and the risk of climate-induced floods (UNDP 2015b). In dry mountainous areas, the adoption of rainwater harvesting techniques and other traditional water management practices can help farmers and herders manage the uneven spatial and temporal distribution of water in a changing climate (Sonneveld *et al*. 2018; Swiderska, King-Okumu and Islam 2018). Restoring mountain springs and riverbank vegetation can also help regulate water flows and ensure the continued provision of fresh water supplies downstream for domestic use, lowland irrigation and other needs under climate change (Price and Egan 2014; UNEP 2014). The management, conservation and restoration of healthy mountain ecosystems can also help build resilience against disasters by providing food, shelter and other goods to local mountain communities and sustaining their livelihoods (UNDP 2015b). Guidance on the use of EbA in mountainous regions is available from UNDP (UNDP 2015b) and from Swiderska, King-Okumu and Islam (2018).

- Communities living adjacent to freshwater systems (such as rivers, streams and inland wetlands) are threatened by increased temperatures, changes in rainfall, and more intense droughts, flash floods and storms, which may reduce agricultural production in river floodplains, damage houses and community infrastructure, reduce domestic water supply and negatively affect fishing and other livelihoods. EbA measures can play an important role in providing resilience to these climate hazards. For example, conserving and restoring habitats along streams and rivers in upper catchments can protect downstream communities and infrastructure from flooding and erosion, while also improving water security and maintaining livelihoods (De Vriend *et al*. 2014; Seddon *et al*. 2020a). The restoration or renaturalization of stream and river structures can help enhance

Chausson *et al*. 2020). In the energy sector, for example, future (Imbert 2018). In contrast, if sea walls or levees are destroyed by heavy storms or rising sea levels, they no longer deliver their intended protective function and become stranded assets that need to be replaced (OECD 2021).

A final reason why EbA is an attractive approach is that it allows policymakers, donors and practitioners to pursue multiple policy agendas simultaneously. Due to its ability to generate multiple societal benefits, EbA can help governments not only to meet their commitments under the United Nations Framework Convention on Climate Change (UNFCCC)[7], but also to achieve related policy goals under the Convention on Biological Diversity[8], the United Nations Convention to Combat Desertification (UNCCD)[9], the Sendai Framework for Disaster Risk Reduction[10], the United Nations Sustainable Development Agenda[11], the Bonn Challenge[12], the UN Decade on Ecological Restoration[13] and related policy initiatives (Ojea 2015; Seddon *et al*. 2020b). For instance, EbA implementation contributes to countries' national development strategies and sustainable development agenda by enhancing food, water and energy security, providing opportunities for training and empowerment, creating jobs, enhancing health outcomes, reducing disaster risks and generating local economic development (Vijtpan *et al*. 2018; Raes *et al*. 2021; Roe *et al*. 2021). In addition, EbA initiatives (particularly those involving the active restoration of degraded ecosystems) can play a potentially important role in helping countries recover from the current COVID-19 pandemic by providing a source of jobs and economic activity, and by enhancing the resilience of communities to both current and future climate shocks (Edwards, Sutton-Grier and Coyle 2013; OECD 2020; Beyer and Vandermosten 2021). Finally, if designed and implemented appropriately, EbA can also contribute to

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	• Establishment and management of urban parks, street trees, green roofs, green façades, community gardens and other green spaces to provide shade and cool cities, mitigating the negative impacts of high temperatures and heat stress. • Conservation, management and restoration of parks, green roofs, rain gardens, bioswales, rivers, ponds and urban wetlands to increase water infiltration, reduce surface run-off, manage storm water and reduce flooding risks. • Renaturalization and restoration of riparian areas, rivers and floodplains in urban areas to improve water management and reduce flooding from extreme rainfall and severe storms. • Rainwater harvesting through urban gardens, rain gardens and other green spaces to capture and store water, allow aquifer recharge, and ensure water supply during climate-induced droughts. • Creation and management of parks and protected areas within and adjacent to cities to ameliorate heat stress and attenuate flood risks.	• China is promoting the widespread uptake of “sponge cities” in which open green spaces, green roofs, bioswales, ponds and urban wetlands are intentionally conserved to enhance water infiltration and reduce flooding risks under extreme rainfall events (Zevenbergen *et al*. 2018; Griffiths *et al*. 2020). Since 2014, more than 30 different pilot sponge cities have been implemented across China. • In Europe, the integration of street trees, green roofs and walls, parks, and other green spaces has been widely used to combat rising temperatures, heat stress and climate-induced flooding (Geneletti and Zardo 2016). The Urban Nature Atlas[14] contains more than one thousand case studies of the use of NbS for urban resilience, most of which come from Europe. • The CityAdapt project[15] is using EbA measures to build the resilience of urban systems in three Latin American and Caribbean countries (El Salvador, Jamaica and Mexico) and four Asian countries (Bhutan, Cambodia, the Lao People's Democratic Republic and Myanmar). EbA measures include using urban agriculture with drought-resistant seeds, restoring wetlands and mangroves to reduce the risk of flooding and saline intrusion and establishing urban forests, parks and gardens, as well as watershed management to increase water infiltration and storage.

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- Planting trees in crop fields and pastures in diverse agroforestry systems to buffer the impacts of high temperatures, heavy rains, droughts and extreme weather events on crops and livestock.
- Use of agroecological practices (e.g. cover crops, intercropping, mulching, reduced tillage, crop rotation or soil and water conservation practices) to increase water infiltration, reduce soil erosion and protect crops from climate-induced water scarcity.
- Conservation of agrobiodiversity and crop diversification to reduce the risk of crop failure in a changing climate.
- Adoption of sustainable livestock management practices (e.g. rotational grazing, transhumance, silvopastoral systems) to enhance the resilience of grazing lands and livestock production to climate change.
- Restoration of degraded cropland and pastures through natural regeneration or active replanting to improve water infiltration and reduce soil erosion.
- Use of traditional water harvesting practices to maximize water capture and to recharge groundwater for domestic and agricultural use during dry periods and droughts.
- Conservation or restoration of forests and wetlands in the broader agricultural landscape to regulate water flows, prevent flooding and minimize potential water scarcity.

- In El Salvador, efforts are under way to restore coffee farms and ecosystems in the watershed of San Salvador in order to increase water infiltration, prevent flooding downstream and reduce the risks of landslides.[16]
- In Humbo, Ethiopia, farmers have adopted the use of farmer-managed natural regeneration to regenerate trees on degraded agricultural and forest land to recharge groundwater, reduce flash flooding and soil erosion, and safeguard agricultural livelihoods (Hou-Jones, Roe and Holland 2021).
- In Bangladesh, the Climate-Resilient Ecosystems and Livelihoods project helped rural farming communities to adopt EbA measures (including the use of agroforestry, integrated pest management and the preservation of natural vegetation adjacent to farming plots) to strengthen the resilience of agricultural production and local livelihoods to climate change (USAID 2017a).
- The Great Green Wall Initiative[17] aims to build the resilience of vulnerable smallholder farmers and ecosystems to climate change across the African Sahel by scaling up land restoration with native species and supporting sustainable agricultural production (Goffner, Sinare and Gordon 2019; Green Climate Fund [GCF] 2021).
- In Uganda, smallholder farmers are being encouraged to diversify their cropping systems to increase their household income and food security under changing climatic conditions (Nanfuka, Mfitumukiza and Egeru 2020).

For more information, please visit https://cityadapt.com.
For more information, please visit https://www.greatgreenwall.org/about-great-green-wall.

• Conservation, management and restoration of native vegetation to stabilize slopes and prevent the risks of landslides and avalanches during extreme rainfall events. • Restoration of degraded areas (through natural regeneration, active planting, terracing or contour planting) to stabilize slopes and reduce run-off, erosion and landslides due to extreme weather events. • Restoration and management of highland pastures to reduce soil erosion and maintain livestock productivity in a	

- Protection and restoration of native ecosystems along streams and rivers in upper attachment bars to reduce downstream fooding.
- Restoration and renaturalization of stream and river structures to enhance food reduction, improve water quality, regulate water temperatures and support inland fsheries amid climate change.
- Restoration of degraded foodplains to regulate water availability, reduce fooding and provide livelihood opportunities.
- Conservation of intact wetlands to limit run-off from water catchments and increase water availability for agriculture and domestic use.
- Reduction of pressure on freshwater ecosystems by targeting issues such as overfshing, contamination and pollution from agricultural run-off and industries, and unsustainable development on food plains.
- Reforestation and restoration of riparian vegetation along riverbanks to slow run-off and reduce downstream damage to communities, properties and livelihoods.

- In The Gambia, an ongoing project aims to restore and rehabilitate at least 10,000 ha of agricultural land and degraded ecosystems (including forest, mangroves and savanna) along the River Gambia to improve the health, food security and water security of communities and reduce the risk of climate-induced fooding (UNEP 2017).
- In the Philippines, the Ministry of Environment and local communities are using EbA measures along the Ilog-Hilabangan river basin and the Tagum-Libuganon river basin to protect biodiversity, improve water availability for local communities and reduce the risks of climate-driven fooding (GIZ 2020).
- The water component of the Thai-German Climate Programme[1 er basin and the Tagum-]

as part of larger biodiversity conservation or sustainable development initiatives and are not distinguished

examples of EbA planning and implementation in urban areas. Another relevant initiative is the Nature-Based Infrastructure Global Resource Centre[29]

- An online survey by the Global Adaptation Network (GAN) obtained information from 90 EbA practitioners from around the world, with 53 per cent of the projects occurring in Africa, 34 per cent in Asia and the Pacific, 3 per cent in Latin America and the Caribbean, 3 per cent in North America, 2 per cent in Europe and the remainder occurring in multiple regions (UNEP unpublished data). The projects occurred in a wide variety of settings, of which the most common were agricultural lands (18 per cent), forests (14 per cent), coastal zones (10 per cent), wetlands (8 per cent), urban areas (8 per cent) and freshwater systems (8 per cent; UNEP unpublished data).

- A study of 190 small-scale adaptation projects in the South Pacific from 1995 to 2006 by the GEF Small Grants Programme found that 115 projects were ecosystem-based, while an additional six projects combined ecosystem-based approaches with engineered structures (Hasan *et al*. 2021).

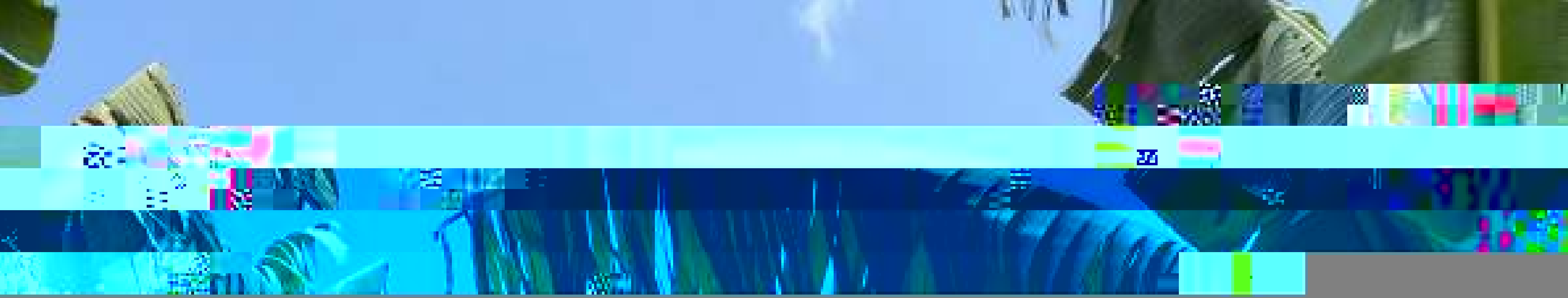
- Finally, a review of more than 26,000 scientific publications found that the term “ecosystem-based adaptation” appeared among the top 50 key words used in climate change adaptation publications published between 2016 and 2020, indicating the growing profile of this research area (Nalau and Verrall 2021).

In addition to the growing number of scientific papers, there has also been a dramatic increase in the number of guidelines, references and tools for EbA. The EbA Tools Navigator[33], developed by the International Institute for Environment and Development (IIED), UNEP-WCMC, IUCN and GIZ, contains more than 240 tools and publications that are suitable for helping practitioners, planners and decision makers design and implement EbA (Bjerre *et al*. 2021).

Key documents for EbA implementation include guidance on:

- assessing stakeholder vulnerability and climate risks for EbA (Munroe *et al*. 2015; Hagenlocher *et al*. 2018)

- selecting, designing and implementing EbA initiatives (Travers *et al*. 2012; SCBD 2019; Garstecki *et al*. 2020; Donatti *et al*. 2021)



Trees surrounding coffee crop.

In summary, the large body of scientific publications, analyses and technical guidance suggests growing interest and use of EbA but does not directly provide information on the overall status of EbA implementation. The detailed analysis of EbA implementation by UNEP (2021a) which recorded more than 900 initiatives is probably the most comprehensive analysis of EbA action to date, but is still an underestimation of the number of global EbA activities, given that it only focused on a handful of data sources and did not contain information on initiatives funded by national governments, development organizations, international and national NGOs or the private sector.

Another way to get a sense of how much EbA is being implemented is to look at its reported use in particular socioecological contexts. While EbA is applicable to a wide number of contexts, the best documented examples of EbA are in cities and coastal areas.

In cities, numerous studies suggest that the conservation, restoration and management of ecosystems for climate resilience is widespread:

- A study by Brink *et al*. (2016) documented 139 case studies of EbA being used in 112 different urban areas. The case studies came predominantly from eastern Asia, Europe and North America, with the most studied cities being Beijing, Manchester, London and Toronto, but cases were also reported in Africa and South America. Commonly used EbA measures included green space (mentioned by 36 per cent of the articles), trees and shrubs (26 per cent), wetlands (24 per cent) and parks and gardens (15 per cent).

- A study by the Carbon Disclosure Project found that of the 210 cities around the world that disclosed their adaptation actions, just under half (101 cities) reported planting trees and creating green spaces to adapt to climate change (Kapos *et al*. 2019). Data from the Carbon Disclosure Project suggest that the implementation of NbS (including EbA) has grown significantly in recent years, increasing from 7 per cent of the cities in 2017 to nearly 12 per cent in 2019 (UNEP 2021a).

- A review of the urban adaptation plans of 14 cities in Europe found that there was general awareness and incorporation of EbA measures in all these plans, with 85 per cent of the plans including maintaining and enhancing urban green spaces for flood retention and water storage, 57 per cent promoting green walls and roofs, and 29 per cent of plans including the renaturalization of river systems (Geneletti and Zardo 2016), although the authors emphasized that it is not clear if the high prevalence of EbA in these cities is representative of adoption levels across European cities.

- The new, previously mentioned, Urban Nature Atlas

For more information, please visit https://una.city/.

under improved management for adaptation benefits (as at Oct 2020).

Other United Nations organizations that are featuring EbA in their strategies and initiatives include FAO[37] and the World Food Programme (WFP) (Kapos *et al*. 2019). For example, as part of its efforts to build the resilience of vulnerable communities to climate change, the WFP promotes the restoration of degraded ecosystems as natural buffers against climate change impacts (WFP 2022). From 2016–2020, WFP worked with governments, partners and communities to restore more than 900,000 ha of degraded land and forests (WFP 2022).

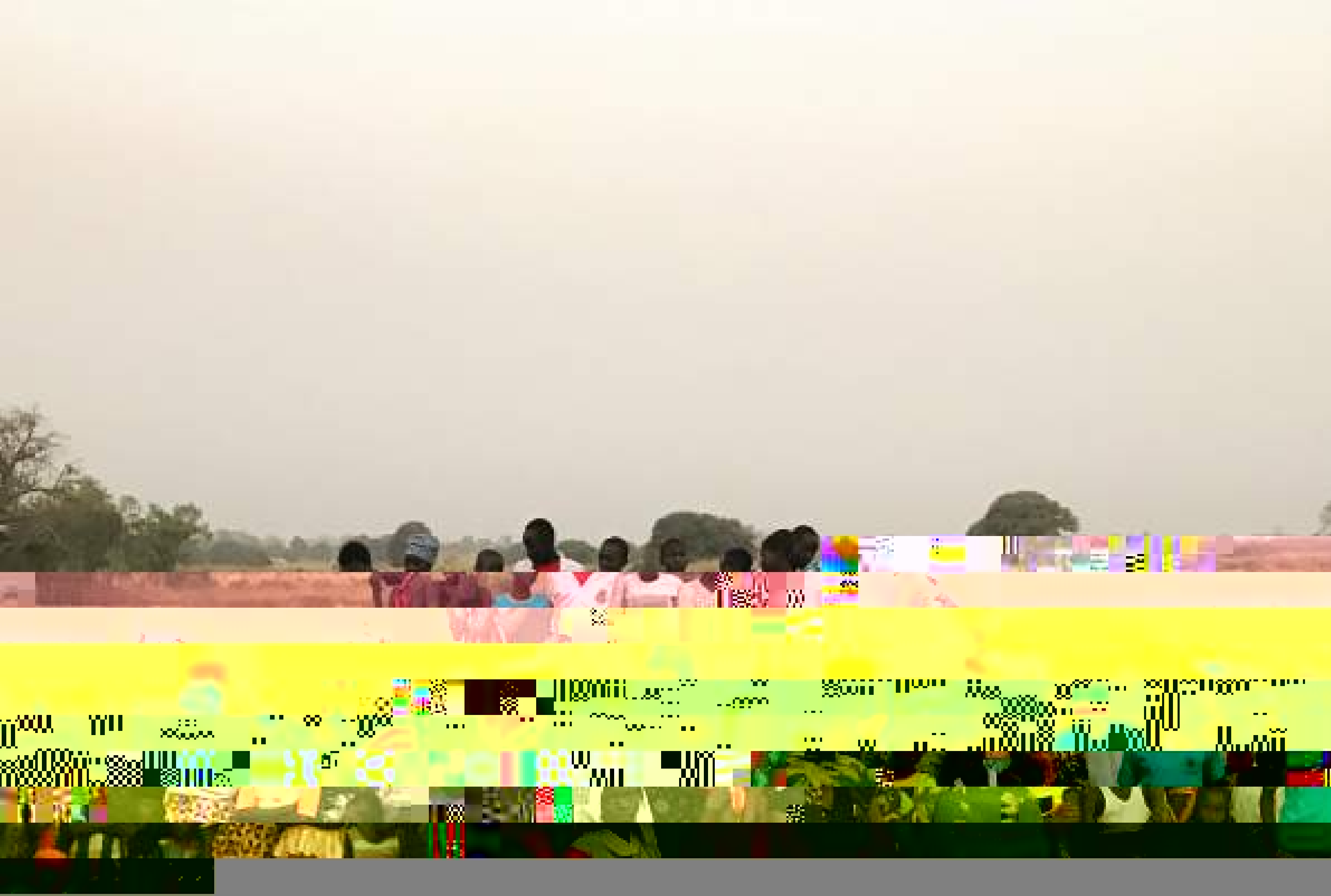
EbA is also receiving significant support from a handful of key bilateral and multilateral donors.

Of the bilateral donors, the most prominent champion of EbA is the German Government. A report by the World Resources Institute (WRI) estimates that the German Government invested between US$ 920 million and US$ 1,510 million in NbS for adaptation in 2018 through its official development assistance (Swann *et al*. 2021). Within the German Government, the International Climate Initiative (IKI), funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), has been a particularly strong proponent for EbA. From 2008 to July 2021, IKI funded 56 EbA projects globally, investing approximately €299.5 million in total (E. Philipp pers. comm). These projects include implementing EbA in diverse ecosystems and sectors (e.g. water, agriculture, land use and finance), integrating EbA into NAPs, and promoting private sector engagement in EbA. Many of the more recent IKI projects are designed to promote the use of EbA at large spatial scales and have longer durations and higher funding levels (E. Philipp pers. comm.). IKI has also been providing long-term support for networks (such as FEBA and the EbA Community of Practice) and knowledge platforms and tools such as the EbA Tools Navigator and the EbA Support are progressively becoming much more important EbA actors and committing more of their funds towards this approach.

One multilateral development bank that is actively promoting nature-based initiatives for climate change adaptation is the Inter-American Development Bank (IDB; Ozment *et al*. 2021). A recent review of the IDB's investments found that the bank had invested in 28 nature-based initiatives (including EbA) in 15 countries within the Latin America and the Caribbean region from 2015 to mid-2020 (Ozment *et al*. 2021). These investments represented a total value of nearly US$ 1.25 billion (of which US$ 813.12 million came from IDB funds and US$ 436.77 million was leveraged from external donors and counterpart governments; Ozment *et al*. 2021); however, the exact amount that was targeted towards NbS is not known, as these figures represent the funds for the entire project, including non-ecosystem-based interventions. IDB projects included investments in multiple EbA practices such as adopting best management practices for farmland, establishing urban parks, and conserving and restoring intact wetlands, grasslands, riverbeds, riparian areas and forests, as well as investments in coastal habitats (e.g. coral and oyster reefs, coastal wetlands, sandy beaches and dunes, mangroves and forests).

The World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR, a grant-funding mechanism managed by the World Bank) are similarly supporting the use of natural ecosystems for climate and 1 per cent at the global level (GEF Secretariat pers. comm.). The high number of projects in Africa reflects the fact that many of the EbA projects were funded by

One of the most important networks is FEBA[50], a collaborative network that aims to share experiences and knowledge, improve implementation of EbA activities on the ground and influence the development of EbA polices. To date, FEBA has more than 90 members, including government ministries and subagencies (e.g. KfW, the UK Department for



Large scale ecosystem-based adaptation in the Gambia: developing a climate-resilient natural resource-based economy.

adaptation, but also climate change mitigation, biodiversity conservation and sustainable development (Epple *et al*. 2016). Within the UNFCCC, EbA has been promoted in numerous workstreams, decisions and mechanisms, including the Cancun Adaptation Framework[58], the Nairobi Work Programme[59], the AF, REDD+ planning, NAPs and NDCs (Reid *et al*. 2016; Seddon *et al*. 2019; 2020b). NbS (including EbA) were also prominently featured at UNFCCC COP26, with numerous announcements and commitments related to the use of ecosystem restoration and conservation to help society adapt to and mitigate climate change (United Nations Economic and Social Commission for Asia and the Pacific [ESCAP] 2021). EbA and other NbS are also likely to become an important component of the CBD post-2020 global biodiversity framework[60] that is currently under discussion. There is also increasing political interest in and commitment to investing in ecosystem conservation, restoration and management to achieve the goals of the Sendai Framework for Disaster Risk Reduction[61], the Global Mangrove Alliance[62], the Sustainable Development Agenda, the Ramsar Convention on Wetlands[63], the New Urban Agenda[64], the UNCCD[65]. the Bonn Challenge[66], the UN Decade on Ecosystem Restoration[67] and related international agreements and initiatives (Epple *et al*. 2016; Seddon *et al*. 2021; Sudmeier-Rieux *et al*. 2021).

Another indication of the growing political traction of EbA is the large number of high-level policy reports, declarations and initiatives that have highlighted the importance of EbA and other NbS for addressing global challenges. The following are some key examples of key EbA-related policy initiatives:

- NbS (including EbA) were included as one of the nine action tracks of the 2019 United Nations Climate Action Summit, convened by the United Nations Secretary-General.

- The Nature-based Solutions for Climate Manifesto[68], which was launched at the 2019 United Nations Climate Action Summit, calls for countries to mainstream NbS within national governance, climate action and climate policies and scale up the conservation and restoration of forests and other terrestrial ecosystems, freshwater systems, marine and coastal systems in support of climate change adaptation and mitigation. This manifesto was signed by 32 countries, the European Commission, 21 civil society organizations and 8 private sector groups (Seddon *et al*. 2021).

- The Least Developed Countries 2050 Vision (LDC 2050 Vision) highlights the importance of ecosystems for climate resilience. One of the three overarching goals of the LDC 2050 Vision is that "climate-resilient landscapes and ecosystems are sustainably managed, less vulnerable to shocks and stresses, and use NbS" (LDC Initiative for Effective Adaptation and Resilience 2019).

- The Leaders' Pledge for Nature[69], agreed at the United Nations Summit on Biodiversity in September 2020, calls for countries to "step up global ambition for biodiversity and to commit to matching our collective ambition for nature, climate and people with the scale of the crisis at hand" and to "put nature at the heart of national and international development strategies" (Leaders' Pledge for Nature 2020; Roe *et al*. 2021). It was signed by leaders from 92 countries from all world regions, and the President of the European Commission on the behalf of the European Union.

For more information, please visit https://unfccc.int/process/conferences/pastconferences/cancun-climate-change-conference-november-2010/statements-and-resources/Agreements.
For more information, please visit https://unfccc.int/topics/adaptation-and-resilience/workstreams/the-nairobi-work-programme-the-unfccc-knowledge-to-action-hub-for-climate-adaptation-and-resilience.
For more information, please visit https://www.cbd.int/conferences/post2020/wg2020-03/documents.
For more information, please visit https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030.
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For more information, please visit https://www.leaderspledgefornature.org/.

A final way to understand the extent to which EbA is being adopted globally is to track the investment in EbA. Finance for EbA can come from different sources including international public sources (such as multilateral climate and environmental funds, multilateral development funds, bilateral financial cooperation), domestic public sources (such as national funds and budgets) and private sources (including non-profit organizations, market debt and business investments; Hunzai *et al*. 2018). However, as noted in section 2.1, it is difficult to estimate the total finance that is being allocated to EbA due to the lack of centralized data on EbA projects, the large number and diversity of actors involved, the lack of a standard way of tagging and reporting finance and funding sources, and the fact that EbA activities are often blended or integrated with other adaptation activities. Some information on the levels of investment in EbA investments by MDBs, multilateral climate funds, bilateral funders, and other individual organizations has already been provided in section 2.3. Here we provide additional information on the overall level of international public funding for EbA using information from two key synthesis reports.

First, a study led by the WRI and the GCA estimated the amount of public international funding flowing towards NbSA (Swann *et al*. 2021). Using publicly available data from the OECD, the authors estimated that US$ 3.8 billion to US$ 8.7 billion were provided to EbA in 2018, up from an estimated US$ 2.1 billion to US$ 4.1 billion in 2012 (Swann *et al*. 2021). This funding represents approximately 0.6 to 1.4 per cent of total climate finance flows and 1.5–3.4 per cent of public finance flows in this area (Swann *et al*. 2021). Most of this funding was provided by a handful of bilateral donors (Germany, Japan, Sweden, the UK and the USA) and by multilateral donors, the biggest of which were the Asian Development Bank, the European Union, the GCF, IFAD, the GEF and the AF (Swann *et al*. 2021). Most of this funding was provided in the form of grants, which accounted for as much as 85 per cent of funds deployed to developing countries (Swann *et al*. 2021). Funding for EbA was mainly directed towards activities in countries in sub-Saharan Africa and South and Central Asia, which together have received approximately 50 per cent of total public EbA funding. However, the authors note that their results likely underestimate the total flows for EbA because their available for this approach: according to this report, current investment in NbS (including but not limited to EbA) is estimated to be US$ 133 billion annually (of which 86 per cent stems from public funds and 14 per cent from private funds), but investment needs by 2050 are estimated to reach more than US$ 536 billion per year. The recent “State of the Finance for Nature in the G20” report concluded that current investments in nature by G20 are insufficient and called for the G20 to increase their annual spending on NbS from US$ 120 billion per year to US$ 285 billion by 2050 to tackle the intertwined climate, nature and land degradation challenges (UNEP 2022). The United Nations Secretary-General has also called for multilateral donors to channel more of their funds towards NbS, including EbA (UNFCCC 2021b).

There are also numerous reports that have stressed the large gap in adaptation finance more generally. For example, the Adaptation Gap Report 2021 (UNEP 2021e) estimated that adaptation costs in developing countries were five to 10 times greater than the available public adaptation finance and called for urgent, more ambitious action to fill this widening funding gap. The lack of sufficient funding for climate adaptation (including EbA) was a major point of discussion at the UNFCCC COP26 (November 2021), as developing country leaders emphasized the need for greater funding to enable more ambitious and rapid action on climate adaptation. To address this challenge, the Glasgow Climate Pact includes a goal for developed countries to double the adaptation funding provided to developing countries by 2025, which could lead to greater funding for EbA initiatives (ESCAP 2021; UNFCCC 2021a).

In summary, while the extent of funding available for EbA is not known, there is general agreement that the amount of money being invested in EbA is low and insufficient to fully harness the adaptation potential of nature and foster resilience at scale (Bapna and Fuller 2021).

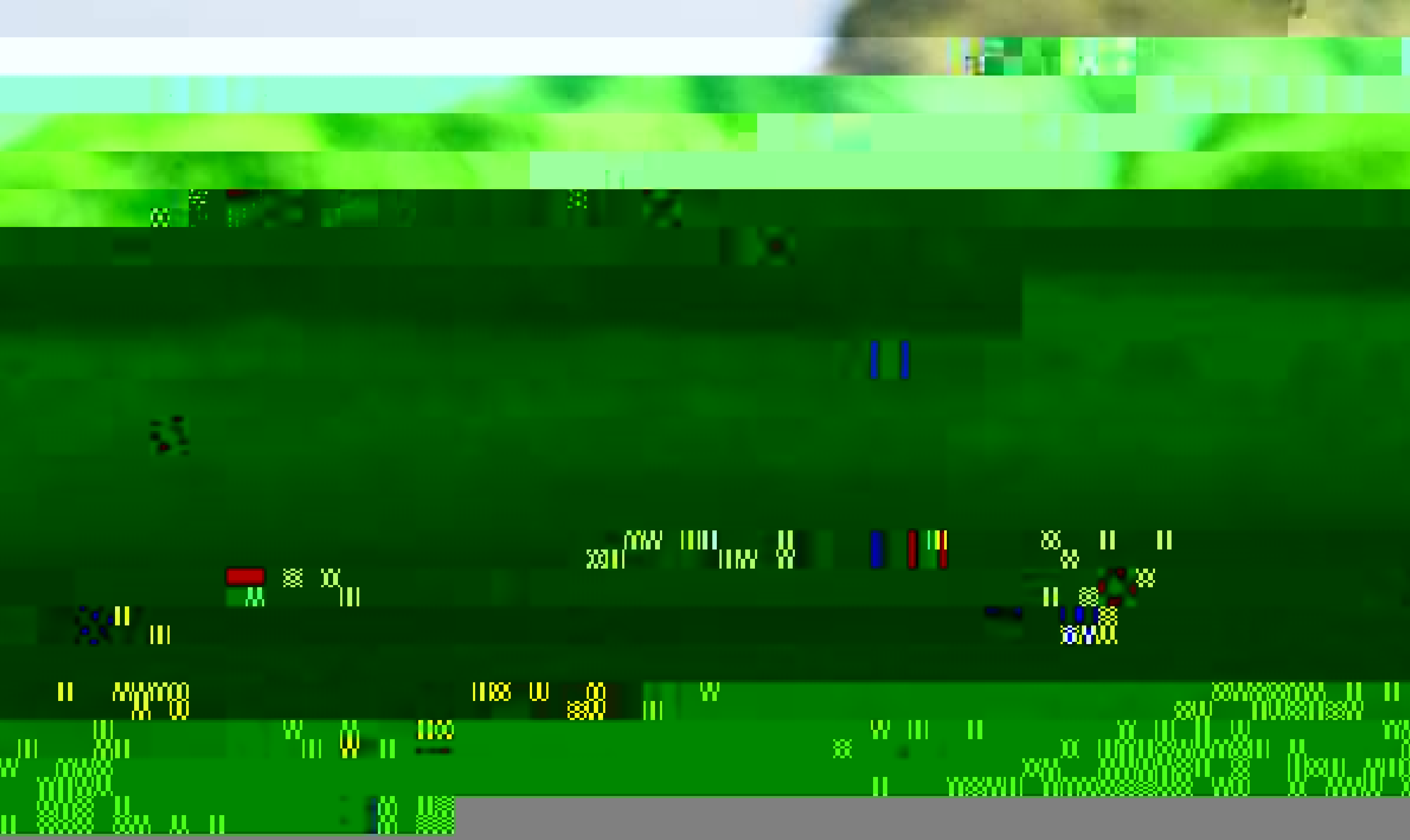
As highlighted in this chapter, it is difficult to provide a comprehensive assessment of the current extent of and trends in EbA implementation because the data on EbA are incomplete, insufficiently detailed and scattered across multiple institutions, geographies and sectors. In addition, since most EbA initiatives are in early stages of implementation, it is too early to determine clear trends in implementation. Nevertheless, our analysis provides some key insights into the current state and trends of EbA action.

First, our analysis suggests that there is already substantial action on EbA practice, policy and finance at the global scale. EbA initiatives are being implemented across the world with support from a diverse suite of actors, including United Nations organizations, bilateral and multilateral development agencies, MDBs and multilateral development funds, national and local governments, international NGOs and academia, among others. Several thousand EbA initiatives have been documented in databases, scientific publications, case studies and reports, with examples from various countries, socioecological settings and sectors, and in both developing and developed contexts. Since many initiatives are not labelled as such or are not included in the existing database, the total number of EbA initiatives under way is likely somewhat higher. EbA also has significant traction in the international policy arena. EbA features prominently in the NAPs and NDCs of many (but not all) countries (Seddon *et al*. 2019; 2020b). Numerous high-level policy initiatives, reports and declarations call for greater uptake and finance of EbA and other NbS, signalling high-level support. In addition, EbA is currently being funded by a small number of key bilateral donors, multilateral donors and climate and environment funds, with an estimated US$ 3.8 billion to US$ 8.7 billion of public finance provided to EbA in 2018 (Swann *et al*. 2021).

Second, there are some signs that the pace of EbA activity is slowly increasing. The overall amount of international public finance being allocated to EbA grew from estimated US$ 2.1 billion to US$ 4.1 billion in 2012 to between US$ 3.8 billion and US$ 8.7 billion EbA in 2018 (Swann *et al*. 2021), but it is not yet clear if this trend will continue. The World Bank increased the number of its NbS projects by 35 per cent from 2018 to 2020 (World Bank 2021a), though it is not clear how many of these projects were specifically EbA activities. The UK has committed to spending £3 billion from 2021 to 2026 to protect and restore nature as part of its ICF (United Kingdom 2021). IUCN has more than doubled the number of its EbA projects from 2015 to 2020 (Bjerre *et al*. 2021). There have also been a growing number of policy declarations and commitments by multilateral development banks (such as the "MDB Joint Statement on Nature, People and Planet" and the Glasgow Climate Pact) that aim to increase the amount of finance directed towards NbS and climate change adaptation, which could lead to greater finance for EbA in the future. Finally, the burgeoning number of publications, case studies and guidelines likely reflects both greater implementation and rising interest in EbA (Chausson *et al*. 2020; Nalau and Verrell 2021).

However, while there is clearly significant action on the ground and a trend of growing support, it is also clear that the level of EbA activity, finance and policy implementation falls far short of its potential (Kapos *et al*. 2019; Seddon *et al*. 2020a; United Nations 2021a). The number of EbA initiatives under way, while significant, is far fewer than what could be achieved (Roberts *et al*. 2012; Dorst *et al*. 2019; UNEP 2021a). Even if the actual number of EbA initiatives is in the tens of thousands (which is likely a high estimate), rather than the several thousand currently documented, this is still too little to have a meaningful impact on the hundreds of millions of people who are threatened by climate change. In addition, many of these initiatives are small, short-term and stand-alone projects, rather than being integral components of long-term development policies (Roberts *et al*. 2012; Cohen-Shacham *et al*. 2019; Bhattarai *et al*. 2021). EbA is not yet systematically integrated into all national climate change policies, national development plans, sectoral plans and local regulations where it is relevant, and EbA measures are often o 9.5 51.0236 723.528 Tm[(gr)8.9(ew fr)4;lookn t

EbA is increasingly recognized by governments, civil society, the scienti f c community and the private sector as being an important means of increasing societal resilience to climate change. However, despite its potential to deliver signi f cant adaptation and socioeconomic bene f ts, EbA remains underused and falls far below its potential (Ojea 2015; Kapos *et al*. 2019; Sarabi *et al*. 2019). In this chapter, we explore the barriers that are currently hindering the widespread adoption and scaling up of EbA, using a detailed review of more than 750 scienti f c and technical documents. The overall aim of the chapter is to provide a better understanding to policymakers, practitioners, donors and other interested stakeholders of the types and diversity of barriers facing EbA initiatives, so that they can anticipate potential barriers that may impede or delay EbA implementg636sTm[ted s3 rodundin023, civil



Enhancing capacity, knowledge and technology support to build climate resilience of vulnerable developing countries.

of EbA and therefore turn to grey infrastructure as the default option for preventing flooding, reducing heat risks or addressing other climate risks (Browder *et al*. 2019). A study of multiple European cities, for example, Chausson *et al*. 2020; UNEP 2021a). In order to design successful adaptation initiatives, policymakers, planners and practitioners require detailed information on the costs and benefits of different EbA measures (including not only adaptation benefits, but also co-benefits such as climate mitigation, biodiversity conservation and economic development), how the costs and benefits compare to alternative, infrastructure-based measures, and the distribution of these costs and benefits across different stakeholder groups (Travers *et al*. 2012; Emerton 2017; Richerzhagen *et al*. 2019). Although the evidence base for EbA is rapidly growing, more information is needed on which EbA measures (or combination of measures) will be the most cost-effective and deliver the greater level of adaptation and co-benefits for a particular context (Doswald *et al*. 2014; Ojea 2015; Reid *et al*. 2018; Seddon *et al*. 2020a). Multiple studies have highlighted the need for a more robust evidence base, standardized metrics and agreed-upon methodologies for measuring the costs, benefits and effectiveness of EbA in different contexts, including in cities, agricultural landscapes, coastal environments, mountain ecosystems and urban areas in order to better inform the design of EbA investments, policies and programmes (e.g. Colls, Ash and Ikkala 2009; Harvey *et al*. 2017; Milman and Jagannathan 2017; Swiderska, King-Okumu and Islam 2018; Keeler *et al*. 2019; Sarabi *et al*. 2020). Another major knowledge gap that constrains the use of EbA is the lack of information on how the costs, benefits and effectiveness of EbA measures compares to alternative grey infrastructure measures (Narayan *et al*. 2016; Keeler *et al*. 2019). Other studies have emphasized the importance of having more information on the distribution of EbA costs and benefits across different social groups (particularly among women and men) or across time (i.e. across different generations) in order to facilitate the design of more inclusive and gender-responsive initiatives (Brink *et al*. 2016; Angula *et al*. 2021; Hagedoorn *et al*. 2021). In addition, there is a need to ensure that these analyses of costs, benefits and effectiveness take into account both the adaptation benefits (e.g. reduced flood risks or reduced property damage) as well as co-benefits (such as food security, water security, carbon sequestration), and account for potential trade-offs between interventions, ecosystem services and stakeholder groups (Seddon *et al*. 2020a).

A third critical knowledge gap is the limited knowledge and technical guidance on how to most effectively integrate EbA approaches with conventional, engineering solutions and other adaptation measures. Ecosystem-based measures are often used in combination with hard infrastructure and other adaptation strategies, yet there is still limited understanding of how these hybrid approaches should be designed to deliver the desired adaptation outcomes (Browder *et al*. 2019; Green-Gray Community of Practice 2020). For example, in smallholder farming systems, researchers have noted the need to have more information on how to most effectively integrate the use of EbA approaches (such as agroforestry systems and soil and water conservation practices) with other adaptation strategies such as the use of irrigation systems, agricultural technology (e.g. improved seeds), climate information systems and insurance (Harvey *et al*. 2017). In coastal systems, there is a need for better information on how to most effectively combine EbA measures such as the restoration of coral reefs with the more conventional construction of sea walls or embankments (Narayan *et al*. 2016). Guidance on how to integrate EbA with hard infrastructure approaches is also a common challenge in urban development and infrastructure initiatives (e.g. Browder *et al*. 2019; Green-Gray Community of Practice 2021).

A final knowledge gap is the need for a better understanding of how ecosystems provide adaptation services and the extent to which ecosystems will continue to provide these services under climate change (Jones, Hole and Zavaleta 2012; Buckwell *et al*. 2020). Despite significant advances in ecosystem science, there is still some uncertainty about how the extent, location and condition of different ecosystems impact their ability to provide the ecosystem services that help society adapt to climate change, and the limits and thresholds under which ecosystems might no longer be able to deliver adaptation benefits (Nalau *et al*. 2018a; Buckwell *et al*. 2020). For example, researchers have noted that it is critical to understand whether coral reefs will continue to provide significant protection to coastal communities if they are affected by climate-driven bleaching events, or whether mangroves will continue to buffer the impacts of storm waves under increasingly strong storm events and rapidly rising sea levels (Jones, Hole and Zavaleta 2012). More information is also needed on how quickly the restoration of degraded land or the planting of trees in cities can result in the provision of flood protection or heat stress benefits, how much of an area will need to restored, how many and which tree species need to be planted, how these areas should be managed, how quickly the cooling benefits will be provided, and how long these benefits will last in a changing climate (Milman and Jagannathan 2017; Seddon *et al*. 2020a). Uncertainties around how climate change will impact ecosystems and how the continued degradation of ecosystems will affect their ability to provide adaptation services has been shown to dampen enthusiasm for the use of ecosystems as part of adaptation strategies. For example, a study in Bangladesh highlighted the need for better information on how both climate and non-climatic stressors will affect coastal ecosystems in the future, so that this information can inform the design of adaptations strategies for improving the resilience of coastal communities (Mustafa Saroar *et al*. 2019). A review of EbA literature by Nalau *et al*. (2018a) also highlighted significant knowledge gaps regarding the capacity of ecosystems to continue to provide ecosystem services and adaptation in a changing climate.

A third broad set of barriers that is frequently mentioned in the literature is the lack of adequate technical capacity to successfully design and implement EbA measures at scale (Travers *et al*. 2012; Kapos *et al*. 2019). The planning, implementation and management of EbA initiatives requires significant technical expertise and know-how, including skills in climate change modelling, vulnerability analyses, assessment of the costs and benefits of different adaptation measures, participatory stakeholder engagement processes, project design, finance and adaptive management, among others (Lo 2016; Swiderska, King-Okumu and Islam 2018; Kapos *et al*. 2019). If this technical capacity is not available, this can slow down or even impede EbA action.

The literature suggests that two types of capacity gap play a particularly important role in preventing the adoption and scaling up of EbA. First, in many countries (especially in developing countries), governments lack staff with the diverse set of scientific skills and knowledge needed to effectively plan and implement EbA policies and initiatives. To be successful, government ministries, departments and agencies need staff who can understand climate scenarios and vulnerability assessments, rigorously assess the advantages or disadvantages of different adaptation options, bring together stakeholders to prioritize adaptation actions and manage the rollout of existing policies and initiatives (Lo 2016; Knowles and Bragg 2018; Kapos *et al*. 2019). They also need staff who can develop fundable projects and identify and secure finance to support EbA (Ilieva 2018; Swann *et al*. 2021). Finally, it is helpful for governments to have staff or partners who are "knowledge brokers" who can relay EbA-relevant information and analyses to decision makers and end users, and who can bring together stakeholders across different disciplines and departments and facilitate collaboration among policymakers, scientists and practitioners (Brink *et al*. 2016; Bednerek *et al*. 2018; Sarabi *et al*. 2020). However, in many cases, this technical expertise is often either missing, incomplete or unevenly distributed across different government departments, slowing EbA action. For example, the limited technical capacity and know-how of governments and national institutions was identified as a major constraint to the implementation of EbA initiatives in Nepal (Bhattarai *et al*. 2021), Peru (Ilieva 2018), South Africa (Knowles and Bragg 2018) and Sweden (Wamsler *et al*. 2020), among others. The lack of technical capacity and skilled knowledge brokers has also been identified as a key barrier to the implementation of urban EbA initiatives (Brink *et al*. 2016; Sarabi *et al*. 2020).

A second key capacity gap is the lack of adequate technical knowledge and know-how among the professionals and technicians involved in implementing and monitoring EbA interventions. To ensure success, it is critical that engineers, contractors, planners and regulators working in key sectors (e.g. agriculture, forestry, water and sanitation, infrastructure, urban development and planning) have the appropriate skills for designing and implementing EbA measures. However, in many cases, these technical staff lack EbA-relevant knowledge and skills because EbA are not included in their formal training or certification programmes (Browder *et al*. 2019; Kapos *et al*. 2019; OECD 2021; Terton and Greenwalt 2021). A global review of 139 EbA case studies in urban areas, for example, found that the lack of technical skills and know-how was one of the most common barriers to implementation (Brink *et al*. 2016). Other studies have similarly noted the urgent need to provide specialized training on how to effectively implement NbS to the engineers, contractors and other technical staff in charge of designing, implementing and regulating adaptation measures (WBCSD 2017; Sarabi *et al*. 2020). Another key consideration is that many technical professionals lack experience of the complex and

initially delayed the projects' design and implementation (Carro *et al*. 2018). In Europe, negative stakeholder perceptions were a major obstacle to implementing EbA in coastal zones, as local communities were concerned about the effectiveness of nature-based approaches (compared to hard structures) and angry at potentially losing land for ecosystem restoration and conservation (Doswald and Osti 2011). A lack of citizen awareness and interest in EbA was also reported as an obstacle to the mainstreaming of EbA in municipal plans in Sweden (Wamsler *et al*. 2020). Negative public perceptions of EbA have also been reported to delay the realization of large-scale, ecosystem-based flood defence programmes, as local stakeholders are often opposed to allowing reclaimed land to be returned to wetlands (Temmerman *et al*. 2013).

The lack of wide public support for EbA is linked to limited public awareness and understanding of EbA, cultural preferences for certain land uses and landscape types, and, in some cases, entrenched preferences for hard infrastructure, especially among urban and coastal stakeholders who are accustomed to using grey infrastructure to address climate challenges and using construction to stimulate economic growth and job creation (Sarabi *et al*. 2019). For example, in Samoa, local stakeholders preferred the use of hard infrastructure (such as groynes and seawalls) as solutions to sea level rise, flood and coastal erosion over EbA solutions because they were more familiar with engineered approaches and were confident in their ability to protect them from climate risks (Nalau *et al*. 2018b). There may also be trade-offs involved with the use of EbA which may dampen enthusiasm for this approach: for example, setting aside land for EbA in cities may conflict with urban development plans (Lo 2016).

The fifth category of barriers – governance challenges – are one of the most frequently reported barriers to achieving the efficient and successful use of EbA at scale (Ojea 2015; Nalau and Becken 2018; Amend 2019). In the context of EbA, governance refers to the norms, institutions and processes that determine how society distributes the power, responsibilities and decision-making processes to protect, restore and sustainable manage ecosystems as part of an overall strategy for climate change adaptation (Iza 2021).

As EbA involves multiple sectors, governance levels, institutions and stakeholders and is often implemented at broad geographic scales that cross political or administrative boundaries, the potential challenges of successfully planning and governing EbA interventions are significant.

The literature has identified three governance factors that are of particular relevance. First, in many places, there is a lack of clear institutional arrangements, decision-making structures or procedures for EbA that lay out who has the authority or mandate to advance this approach. Because of its multisectoral and multidisciplinary nature, EbA lies at the interface of multiple departments and policy sectors and does not easily fit into the existing decision-making structures and procedures. Often, it is not clear which government departments or institutions are responsible for planning, leading or funding EbA interventions, especially in cases where interventions cover several sectoral, geographic or administrative boundaries (Ojea 2015; Reid *et al*. 2019). The lack of clear institutional arrangements (within institutions, across institutions and across municipalities) and streamlined decision-making procedures has been found to complicate the delivery of EbA in multiple locations (Kabish *et al*. 2016; Nalau and Becken 2018; Amend 2019). For example, a study of adaptation initiatives in E grentions3il [illegible]

2018a; Kapos *et al*. 2019). EbA measures cut across different government departments, institutions and sectors, as well as across different spatial scales, and therefore require both significant horizontal (i.e. across government departments and sectors) and vertical collaboration (e.g. from local to national levels) within governments (Lo 2016; Amend 2019). Ensuring the successful collaboration across these different entities and scales is often tricky because government departments and institutions tend to work as silos, with each focusing on its own set of goals, priorities and resources (Brink *et al*. 2016; Sarabi *et al*

assessments, zoning ordinances or building codes for developing new infrastructure (housing, roads, bridges, ports, energy systems, hydropower) or retrofitting and upgrading existing infrastructure can prevent or prohibit the application of EbA measures by both public and private sector actors (Watkins *et al*. 2019). For example, a study of Swedish municipalities found that the lack of supportive legislation for incorporating green roofs and other EbA measures into building requirements hindered their broad adoption (Wamsler *et al*. 2016). Landscape planning and zoning across urban, rural and coastal areas can also undermine EbA efforts, if it permits the construction of new infrastructure on coastal areas, wetlands or river floodplains where the vegetation is critical for protection from storms, or if it fails to protect natural ecosystems that provide critical adaptation benefits (Kabish *et al*. 2016; Browder *et al*. 2019; Kapos *et al*. 2019). A related issue is that even in cases where regulations and laws are designed to support EbA, the lack of compliance or enforcement of these regulations may limit EbA application (Chong 2014; Pasquini and Cowling 2015; Sarabi *et al*. 2019).

Finally, the lack of coherence across policies, laws and regulations (at both national and lower levels) that affect ecosystem conservation, restoration and use is often a major challenge for EbA implementation (Ilieva and Amend 2019). In essence, any policy that affects natural resource use, land use, forests, agriculture, coastal areas, watershed management or urban landscapes, or that involves sectors where EbA could be applied, is potentially of relevance to EbA and could either promote or hinder its uptake. In Europe, for example, the lack of consistency in both the intention and implementation of different policy areas, such as agriculture, biodiversity, fisheries and transport, is often an important detriment to the use of EbA (Naumann *et al*. 2011). In Sweden, efforts to increase the extent of green areas in cities to manage stormwater often run counter to policy initiatives that promote urban densification (Wamsler *et al*. 2016). The lack of coherence across policies at different levels or in different sectors has also been noted as a major challenge to the mainstreaming of EbA in Peru (Ilieva *et al*. 2018). In addition, the lack of coherent policy and regulatory frameworks is also a major constraint to private sector investment in adaptation, as it sends mixed signals to the private sector about the importance of considering ecosystems in business decisions (Dougherty-Choux *et al*. 2015).

Many of the most common and most important barriers to the implementation and scaling up of EbA are financial in nature (Nalau *et al*. 2018a; Kapos *et al*. 2019; Swann *et al*. 2021). Like other adaptation measures, EbA requires significant financial resources for planning, implementation and management, as well as for related capacity-building and stakeholder engagement efforts (Hunzai *et al*. 2018; Swann *et al*. 2021). Domestic funding for EbA is often limited because national and/or local governments are underresourced, have constrained budgets and need to balance EbA with competing priorities, as is the case in Nepal (Bhattarais the of multiple actors (potentially including both private and public actors), or if acquiring this space incurs high opportunity costs, this can significantly delay or prevent progress (Colls, Ash and Ikkala 2009). Only in cases where EbA focuses on changing the management of existing ecosystems (e.g. changing agricultural practices on farms or rewetting peatlands to foster greater resiliency) is space not necessarily a limiting factor.

There are many documented examples of the difficulty of securing land for EbA implementation, including cases in Australia (Lukasiewicz, Pittock and Finlayson 2016), Mauritania (Mills *et al*. 2020), Nepal (Mills *et al*. 2020), Peru (Ilieva *et al*. 2018) and Thailand (GIZ-ECOSWat 2017). In some landscapes, there is limited land available for EbA because most of the land has already been urbanized or used for other activities. For example, efforts to provide storm and coastal flood protection by restoring or conserving mangroves, tidal wetlands and other coastal vegetation are often constrained by the lack of remaining undeveloped land (Temmerman *et al*. 2013). Similarly, efforts to restore rivers and floodplains are often stymied by the presence of housing and infrastructure within the floodplains. In other landscapes, project proponents may encounter difficulties in obtaining permission to implement adaptation measures because much of the land is privately owned and landowners are not willing to participate, or because municipal governments have limited abilities to act on or influence private land. For example, a study in the Murray-Darling catchment in southeastern Australia highlighted the difficulties of implementing catchment-scale programmes on private property as a major constraint to the implementation of EbA measures (Lukasiewicz, Pittock and Finlayson 2016). Private landownership is a particular challenge for EbA uptake in urban contexts, given that most land and real estate in cities belongs to private owners and acquiring this land is prohibitively expensive (Sarabi *et al*. 2020). In some countries, customary landownership practices can also limit the opportunities for women to implement EbA practices; Nigeria is an example (Oloukoi *et al*. 2014). A final reason why it can be difficult to obtain space for implementing EbA measures is that most land is already being used by local communities for agriculture, fishing or other productive uses, and communities are often sceptical of proposals to replace their current land use with ecosystem-based activities. For example, one study found that in Mauritania, local community members preferred to continue their traditional livelihoods on degraded lands, rather than restoring the ecosystems to provide adaptation benefits (Mills *et al*. 2020).

Our review of the scientific and technical literature indicates that there are many barriers that can potentially slow down or prevent the implementation of EbA. The major types of barriers identified in the literature include limited awareness and understanding of EbA, knowledge and evidence gaps, technical capacity constraints, insufficient political and public support, governance challenges, policy and regulatory challenges, finance challenges and limited space for EbA implementation.

However, beyond identifying potential obstacles to EbA implementation, the literature does not yet provide a comprehensive understanding of how, where and when different barriers emerge or how these barriers can be overcome (Davies *et al*. 2020; Ishtiaque *et al*. 2020). The evidence base is still too incomplete to enable the identification of which specific barriers – or combinations of barriers – are most likely to arise in a particular type of intervention, in a particular context, or at a particular stage of an EbA intervention (e.g. planning, design, implementation, management; Sarabi *et al*. 2021). In addition, while most initiatives face multiple barriers (either simultaneously or sequentially), the relationships between different types of barriers and the relative importance of individual barriers are not yet well understood. This makes it hard for adaptation practitioners to know which barriers are the most critical to address, or which strategies are likely to be most effective at overcoming these challenges. However, as more EbA initiatives get under way and existing initiatives evolve and mature, our understanding of the barriers that EbA interventions face in different contexts is likely to become more sophisticated and nuanced. Over time, there will also be more examples of how initiatives have successfully overcome different sets of barriers in different contexts, as well as guidance on how to best anticipate, plan for and address potential challenges.

Yet, even with our current, incomplete knowledge, it is already clear that there are numerous aspects and dimensions that EbA planners and practitioners must consider as they design and implement EbA interventions, in order to improve their chance of success. The evidence to date suggests that, like conservation and sustainable development initiatives more broadly, the successful implementation of EbA depends on having supportive policies, an enabling governance context, appropriate knowledge and technical capacity, increased awareness and understanding, strong public and political support, sufficient and sustainable finance, and available space. In the next chapter (chapter 4), we explore potential actions that we think could help address many of the current barriers to EbA and thereby spur greater uptake of EbA globally.

EbA has the potential to play a central and crucial role in putting the world on a climate-resilient and nature-positive pathway. However, as highlighted in the previous chapters, the current use of EbA falls short of its potential and remains far below the scale necessary to respond to the impacts of both existing and future climate change. The number and size of EbA initiatives is still small, many national and local policies do not yet effectively integrate EbA, and the availability of public and private finance for EbA falls far below what is needed (Roberts *et al*. 2012; Ojea 2015; Swann *et al*. 2021). A wide range of factors (including policy and regulatory constraints, knowledge and awareness gaps, capacity gaps and lack of finance) has been shown to potentially slow or impede the implementation of EbA measures (see chapter 3). These potential barriers will need to be quickly addressed, circumvented or overcome in order to harness the full potential of ecosystems for climate resilience.

In this chapter, we examine opportunities for rapidly scaling up the use of EbA across all regions of the world, in support of climate adaptation and other policy goals. By "scaling up", we refer both to increasing the number of EbA initiatives[76] globally (i.e. replicating successful EbA approaches in new locations) as well as significantly enhancing the spatial scale and coverage of existing and future initiatives, making them bigger, more sustainable and more impactful.

Although there are no silver bullets for harnessing the full potential of ecosystems for climate resilience, there are many promising avenues for scaling up EbA action and overcoming the barriers which often restrict its widespread use. In this chapter, we provide a broad list of recommendations which, if implemented, could help tip the scales in favour of EbA and accelerate its implementation at scale. These recommendations are based on an extensive review of more than 750 documents, as well as discussions and input from 59 EbA experts from 30 organizations with experience in EbA policy, implementation and finance (see the acknowledgements section for experts' names and affiliations). Rather than attempting to provide an exhaustive list of all potential actions that could help advance EbA, or a systematic plan for scaling up, we suggest a set of recommendations which, in our judgment, hold the greatest potential for success. These include actions which already have some support or momentum from policymakers, investors or practitioners, actions which address specific barriers to the use of EbA, and actions that build on existing opportunities. Some of these actions will directly spur the use of EbA (e.g. creating regulations that mandate its use), while others may advance EbA more indirectly by creating larger constituencies of support and greater momentum for action. The list of recommendations is intended to be a starting point for more detailed consideration, rather than a prescriptive list of actions that must be followed. It is likely that some of these recommendations will only apply to certain contexts or initiatives, while others may be more broadly applicable. Indeed, we anticipate that these recommendations will evolve over time as more information and experiences on EbA are shared.

Our recommendations are organized into five broad categories: 1) developing a supportive policy and regulatory framework for EbA; 2) using innovative policy instruments and approaches; 3) working with key groups that can spur greater uptake of EbA; 4) using innovative approaches to increase EbA finance; and 5) targeting EbA to the contexts where the greatest adaptation benefits will accrue. For each of these broad categories, we provide a set of specific recommendations (see Table 3 for the full list of recommendations). For each of the recommendations, we highlight why this action is important, explain what specific steps can be undertaken and specify the role of different actors. Where possible, we also provide successful examples of EbA implementation that could be built on or replicated in other locations. While the

As in the rest of the report, we use the term "EbA initiatives" to refer broadly to initiatives that include actions to actively conserve, manage or restore ecosystems with the intent of helping people adapt to climate change. This includes both initiatives that consist solely of EbA measures, as well as initiatives in which ecosystem-based approaches are used in combination with hard infrastructure or engineering approaches (e.g. green-grey or hybrid approaches).

recommendations are presented individually, almost all these recommendations are closely linked. Action on many fronts – and by many actors – will be needed if we are to harness the full adaptive benefits of nature and achieve impact at scale.

	Raise the profile of EbA in national-level commitments for climate, biodiversity and sustainable development Mainstream EbA in policy, planning and budgeting processes
	Encourage the use of natural capital accounting Use green public procurement processes to increase the use of EbA Promote the integration of green and blue infrastructure in infrastructure projects Use building codes and zoning regulations to support EbA
	Support EbA action by Indigenous Peoples, local communities and women Promote greater involvement by private businesses Stimulate greater investment by the financial sector
	Use green, blue and resilience bonds to secure finance for EbA Support the use of debt-for-nature and debt-for-climate swaps Use COVID-19 stimulus and recovery funds to support EbA action Support risk disclosure by businesses in the private sector Create innovative insurance mechanisms to protect and restore ecosystems

Prioritize the use of EbA in low-lying cities that are vulnerable to flooding and heat stress

Prioritize the use of EbA in coastal areas that are vulnerable to sea level rise, storm surges and erosion

Prioritize the use of EbA in agricultural landscapes that are critical for food and water security had included EbA actions to reduce the threats of climate change to people (Terton and Greenwalt 2020), while another report found that a total of 91 countries (out of 114 countries which had submitted NDCs by October 2021) had included EbA within their NDCs (Bakhtary, Haupt and Elbrecht 2021). There is, however, scope for more ambitious action. For example, in both existing and future rounds of NDCs, governments could set more ambitious, measurable and time-bound targets for how, when and where EbA will be deployed and how many people will benefit from EbA initiatives. They could also ensure that NDCs cover all relevant ecosystem types (not only forests, but also grasslands, wetlands, coral reefs, mangroves, etc., depending on national circumstances) and create more specific plans for how they will design, implement and fund EbA implementation (Seddon *et al*. 2020b; Martin, Bartlett and Marcella 2020). Detailed guidance is available on how to integrate EbA into the formulation, implementation and review of NAPs (UNEP 2021d) and NDCs (Martin, Bartlett and Marcella 2020; Bakhtary, Haupt and Elbrecht 2021; Terton and Greenwalt 2021).

In addition to raising the profile of EbA within the climate agenda, governments should also seek to integrate EbA into their national-level commitments for biodiversity, sustainable development and related policy initiatives, and foster linkages across these commitments. For example, governments could highlight the role of ecosystems in fostering climate adaptation in their National Biodiversity Strategies and Action Plans and prioritize the conservation and restoration of healthy, intact ecosystems that are critical for both current and future adaptation efforts (SCBD 2019). Such a commitment would help protect healthy, intact ecosystems that are critical for both current and future adaptation (Martin and Watson 2016). Similarly, national governments could integrate EbA actions into their national plans for sustainable development, Land Degradation Neutrality and disaster risk reduction, as well as into their commitments to large-scale environmental initiatives such as the United Nations Decade on Ecosystem Restoration[77] (UNEP 2020), the Bonn Challenge[78] (Dave *et al*. 2018) and the Global Mangrove Alliance,[79] all of which have the potential to have impact at a meaningful scale. Raising the profile of EbA within these interlinked policy agendas and demonstrating the synergies across these agendas should help to catalyse greater investment and implementation of EbA on the ground.

While the development and implementation of national policy commitments is the responsibility of policymakers and requires strong political leadership, other actors can also support these efforts. Academic institutions, research organizations and think tanks can ensure that EbA targets are robust and based on the best available knowledge from science and practice (Seddon *et al*. 2020b). They can also develop and apply methods for documenting EbA implementation, policy integration and budget allocations, and for tracking progress towards national-level commitments. Local government agencies, NGOs, civil society organizations, Indigenous Peoples, local communities and other practitioners can share their knowledge and experiences with EbA implementation, helping to identify the most promising interventions for a given location or context and prioritizing ecosystems for adaptation action (Nalau *et al*. 2018; Swiderska, King-Okumu and Islam 2018). Organizations that provide international public funding (e.g. bilateral donors, multilateral organizations and climate and environmental funds) can support governments in developing ambitious national-level commitments, by providing technical expertise for the design and implementation of national commitments and related policies; helping to strengthen institutional capacity on EbA; funding research, demonstration and monitoring efforts to further strengthen the EbA evidence base; and funding EbA knowledge exchange and information hubs (Ng'etich 2021). Perhaps most importantly, international public funders need to significantly step up the level of finance they provide for EbA, so that developing governments can access the necessary funds to deliver on their national commitments and implement EbA at scale (Murphy and Parry 2020; United Nations 2021). The recent commitment by the world's major multilateral development banks (MDB Joint Statement on Nature, People and Planet, endorsed in November 2021 at COP26[80]) to help countries to secure high ambition

For more information, please visit https://www.decadeonrestoration.org/about-un-decade.
For more information, please visit https://www.bonnchallenge.org.
For more information, please visit https://www.mangrovealliance.org.
For more information, please visit https://thedocs.worldbank.org/en/doc/e523c9386dd95f2ec59613310611e1de-0020012021/mdb-joint-statement-on-nature.

in implementing NbS across their relevant plans and strategies, and to allocate more funds towards NbS, could be an important step for accelerating EbA action (Bennet 2021). The Glasgow Pact from COP26 similarly calls on developed countries to double their 2019 level of funding for climate change adaptation by 2025, in order to help developing countries quickly ramp up their adaptation efforts. Securing more international funding for adaptation and NbS is essential for helping countries to deliver on the EbA actions they have outlined in their NAPs and NDCs.

While national-level policy commitments signal the intent of countries to conserve, manage and restore ecosystems for adaptation goals, the goals and visions of these national policy commitments will only be achieved if EbA is systematically embedded into all relevant policy, planning and budgeting processes (Ilieva and Amend 2019; Terton and Greenwalt 2020). Mainstreaming includes revising, updating and developing policies, regulations and incentives so that they promote the use of EbA, allocating funds for EbA in national and local budgets, and ensuring alignment between national, local and sectoral policies that affect ecosystem management and conservation (UNEP 2021d). Mainstreaming the consideration of EbA into all levels and stages of decision-making (from policy formulation to implementation to evaluation) will help align policies and decision-making within governments, facilitate planning and implementation of ecosystem-based initiatives, promote cross-sectoral collaboration across different ministries, departments and institutions, and reduce the cost of adaptation planning, ultimately resulting in the greater use of EbA (Ilieva and Amend 2019; SCBD 2019). Strong political leadership will be needed to mobilize action and synergize efforts across different governance and sectoral levels.

To achieve impact at scale, EbA must become a standard feature of government decision-making (Huq *et al*

2020; Tall *et al*. 2021). At both national and local levels, governments can put in place financial instruments to generate public funding for EbA, including allocating revenue from targeted taxes (e.g. property taxes, carbon taxes), tradable permits, development rights, water-use fees, payments for environmental services, and national climate and development funds, among other possible sources (Dougherty-Choux *et al*. 2015; GCA 2020). National governments can also issue green bonds (see section 4.4.1), green credit lines and insurance schemes to channel funding towards EbA actives (Hunzai *et al*. 2018). Since mainstreaming is an iterative and often multi-year process, a high level of political support and long-term budgeting are critical for success.

Other actors can also play a role in mainstreaming EbA. MDBs, climate funds, bilateral donors and other funders can provide valuable technical expertise and funding to support mainstreaming efforts. In addition, public funding agencies can themselves commit to mainstreaming the use of EbA in their investments and operations or include EbA considerations as criteria in their public funding allocations, thereby creating additional impetus for national governments to embrace the use of EbA (Ng'etich 2021). Civil society organizations, communities and the general public can work with policymakers to mainstream the use of EbA and actively engage with governments in the planning, implementation and monitoring of EbA initiatives (Kapos *et al*. 2019; Wamsler *et al*. 2020). EbA practitioners and researchers can build the capacity of policymakers and technical staff to design and implement EbA initiatives, through training programmes, workshops, site visits and peer exchanges with other policymakers who are already leading the way on EbA (Kapos *et al*. 2019). EbA practitioners can also drive greater mainstreaming of EbA by documenting and disseminating information

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For more information, please visit https://www.adaptationcommunity.net/ecosystem-based-adaptation/international-eba-community-of-practice/.
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For more information, please visit https://iclei.org.
For more information, please visit https://www.c40.org.

delivering key adaptation services (e.g. which areas of forest may be important for ensuring the water security of downstream cities during periods of climate-induced drought; United Nations 2020). It can also help countries more carefully manage the potential trade-offs between different economic activities (e.g. intensive agriculture, bioenergy production, industrial production) and ecosystem services like flood protection, or between different development trajectories (Bagstad *et al*. 2021). In addition, information generated by natural capital accounting can be a valuable input for government investment and budgeting decisions and can potentially help guide public finance towards activities that maintain or enhance natural capital (and ensure the continued delivery of ecosystem services) and away from activities that undermine ecosystem functioning (Bagstad *et al*. 2021).

In order for natural capital accounting to help move forward action on EbA, however, it is critical that governments commit to implementing natural capital accounting over the long term and using the results to inform decision-making in key policy areas (e.g. agriculture, environment, economy, trade). In addition, governments need to dedicate the necessary technical and financial resources and set up mechanisms for incorporating the results of accounting exercises into relevant policy and investment decisions. To ensure that natural capital accounting informs adaptation planning, governments could also include natural capital accounting as part of climate vulnerability assessments and adaptation planning processes. Research organizations, academic institutions and think tanks can provide valuable technical and scientific support to natural capital accounting efforts, helping with data collection, analysis, interpretation and application. International public donors can provide critical financial support to cover the costs of natural capital accounting, encourage its use by national governments, and also facilitate valuable networking and learning opportunities. One prominent example of such support is the World Bank-led Wealth Accounting and Valuation of Ecosystem Services (WAVES) partnership,[89] which brings together United Nations organizations, governments, international institutes,

change, while ensuring the provision of other critical services (Green-Gray Community of Practice 2020). The careful integration and management of green infrastructure (e.g. green roofs, street trees, parks and urban gardens) and blue infrastructure (e.g. rivers, ponds, floodplains and wetlands) into infrastructure planning can provide a range of benefits to society (Thiele *et al*. 2020; Liberalesso *et al*. 2020; TNC 2021a). These benefits can include climate adaptation benefits such as protection from flooding, reduced heat stress, and reduced risks from sea level rise and landslides, but also potentially other benefits such as biodiversity conservation, reduced energy consumption in buildings, improved air quality, carbon storage, health benefits and recreational opportunities (Zuniga-Terran *et al*. 2020; Green-Gray Community of Practice 2021). The use of green and blue infrastructure has rapidly gained traction among national decision makers, urban professionals, city leaders and MDBs who recognize its ability to deliver multiple benefits (Quintero 2012). Prominent examples of the broad uptake of green and blue infrastructure include the EU Strategy on Green Infrastructure (European Commission 2021), the Netherlands Government's "Building with Nature" approach that incorporates the use of ecosystems for managing flood risks (de Vriend *et al*. 2014), the Chinese Government's Sponge City programme (Zevenbergen *et al*. 2018), the IDB's support for green infrastructure programmes in Latin America (Watkins 2014; Watkins *et al*. 2019; Ozment *et al*. 2021), and the World Bank's work on green infrastructure (Hallegate *et al*. 2019), among others. The recent creation of the Coalition for Climate Resilient Infrastructure (CCRI), a private sector-led coalition of institutional investors, banks, insurers, rating agencies and governments representing over US$ 20 trillion in assets, also highlights the growing momentum and interest in enhancing the climate resilience of infrastructure and could result in greater investment in blue and green infrastructure in the future (Carmody and Chavarot 2021).

There are multiple potential avenues for scaling up the use of green and blue infrastructure and making this the default option for infrastructure development. National and local governments can include green and blue infrastructure in national guidelines, standards or regulations (e.g. for stormwater management, flood control, wastewater treatment, urban development or infrastructure development) and require that key service providers (e.g. water and7ties , unitcipl gtsmater a] TJETBT/C2_1 1 Tf9.5 0 0 9.5 537.529 465.528 Tm[(0480049005000450057624

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tnfrastructure

by giving them discounted bank home loans, among other preferential treatment (Liberalesso *et al*. 2020). The private sector can also play a role in promoting green and blue infrastructure, by providing both technical expertise and capital to design and structure infrastructure investments that incorporate green and blue infrastructure in support of adaptation goals (Carmody and Chavarot 2021). MDBs, development agencies and other public investors can encourage the use of green and blue infrastructure by requiring that proposals for major infrastructure development carefully identify climate risks to infrastructure investments, assess the importance of ecosystems in providing risk protection, and integrate green and blue infrastructure. They can also provide loans wa Jlue iv1 gs/TT1 155T9.5 0 0 04546005300084.86053000624 Tm[6>5631.0236

consider the important role of ecosystems in enhancing societal resilience to climate change (Dougherty-Choux *et al*. 2015; Chu *et al*. 2019). For example, regulations can be updated to prohibit new developments in ecosystems that are critical for coastal protection or require that new developments are set back a certain distance from the coastline or from critical coastal ecosystems. Where possible, the development (or revision) of zoning regulations and/or land-use plans should be based on a spatially explicit analysis of the extent and condition of the region's ecosystems and the ecosystem services (e.g. food protection, food provision) they provide, so that the regulations can be of the world's land and seas, have livelihoods that are dependent on ecosystems, and stand to directly benefit from effective EbA action (Mfitumukiza *et al*. 2020; Townsend and Craig 2020). As much as 65 per cent of the world's land is thought to be under customary, community-based tenure systems, though precise data are lacking (Rights and Resources Initiative 2015). The amount of land that is owned managed or occupied by Indigenous Peoples is enormous: although Indigenous Peoples represent less than 5 per cent (approximately 370 million) of the world's population, they manage or have rights to an estimated 37.9 million km^2 (or 28.1 per cent) of the world's land area, including 7.8 million km^2 within protected areas (Garnett *et al*. 2018). Much of this indigenous land is ecologically intact and of higher conservation and adaptation value than surrounding non-indigenous lands (Fa *et al*. 2020). In addition, indigenous lands generally experience lower levels of deforestation and degradation than non-indigenous lands (Sze *et al*. 2022). While Indigenous Peoples and local communities have a wide range of political, cultural and economic aspirations, many depend on terrestrial, freshwater and marine ecosystems for their livelihoods (e.g. for agriculture, hunting or fishing), have a long history of managing climate variability and changes in the environment, and have valuable local and traditional knowledge of ecosystems and natural resource management that can be incorporated into the design of EbA initiatives (Nalau *et al*. 2018b; Schlingmann *et al*. 2021). Local communities are often uniquely positioned to understand the particular climate-related vulnerabilities and risks they face and can help guide the development of EbA initiatives that are culturally appropriate and tailored to the local context. For example, in many developing countries where communities lack access to potable water, women are responsible for securing water for household consumption and have valuable knowledge of which springs or streams are the first to run dry under drought conditions (Ali and Grobicki 2016). In addition, many local communities have knowledge of indigenous plant species, seed collection and planting methods that are crucial for ecosystem restoration efforts (Reyes-Garcia *et al*. 2019; Hosen, Nakamura and

Other actors can also support greater leadership on EbA by Indigenous Peoples, local communities and women. For example, researchers and practitioners can work closely with Indigenous Peoples, local communities and women to codesign more holistic EbA projects that build on local, traditional and scientific knowledge and are carefully tailored to local contexts and needs (Nalau and Becken 2018). International public funders (including MDBs, multilateral and bilateral organizations, and climate funds) can significantly increase the amount of finance they provide to locally led action and make these funds more flexible and accessible to local actors, by simplifying onerous application processes and requirements (Soanes *et al*. 2017; Soanes *et al*. 2020). They can also set targets for how much funding will be delivered to local communities and how much will go towards EbA. The group of Least Developed Countries, for example, has made a commitment to dedicate 70 per cent of their climate fund to locally led climate action by 2030 (Soanes *et al*. 2020) which, if achieved, could significantly enhance the implementation of adaptation measures – including EbA – by local stakeholders. The recent announcement by global leaders at COP26 that they would mobilize US$ 450 million[90] for initiatives and programmes to enhance locally led approaches is another important step for elevating EbA and other local adaptation solutions.

As governments, donors and other organizations engage with Indigenous Peoples, local communities and women on EbA, it is critical that they apply the “Principles for Locally Led Adaptation Action” that were designed to ensure local actors have greater power and resources to build resilience to climate change (GCA 2020).[91] These principles were developed by the GCA and have already been endorsed by more than 70 organizations, governments and funders (Coger 2021). All actors that that are developing, funding or implementing EbA actions should also adopt a gender-responsive approach to EbA that recognizes gender differences in adaptation needs and capacities, promotes gender-equitable participation and influence in decision-making processes, and ensures gender-equitable access to finance and other benefits (Angula *et al*. 2021; Dazé and Terton 2021). The GCF is already effectively address both climate change and biodiversity risks (Goldstein *et al*. 2019).

There is an urgent need to rapidly scale up the use of EbA by businesses to improve the resilience of businesses and national economies to climate change, while conserving the natural ecosystems and services on which society depends (Stoll *et al*. 2021). Research suggests that businesses are likely to be willing to invest in EbA under three circumstances. First, businesses will invest in EbA if it is in their interest to do so, that is, if the actions reduce the risks and costs of climate change impacts on their operations, corporate supply chains, employees and customers, and if these actions improve their bottom line (Stoll *et al*. 2021; Tall *et al*. 2021). For example, agrobusinesses may be willing to invest in EbA measures (such as soil and water conservation practices) if these measures help to ensure the continued provision of agricultural commodities in a changing climate, supporting business continuity and pro f tability. Second, businesses may be x ˜ я y ḫ] γ öo f ta δ

Ecosystem-based adaptation in Tanzania.

scale (Swann *et al*. 2020; UNEP 2021a). In order to significantly increase the amount of funding for EbA, it will be necessary to do a much better job of unlocking and enabling private capital from the financial sector, including investments from banks, pension funds, microfinance institutions, impact investors, insurance companies, hedge funds and private equity funds (Fayolle *et al*. 2019; Miller and Swann 2019; Tall *et al*. 2021).

To date, leveraging private sector finance for EbA and other resilience-building projects has proven to be challenging (Fayolle *et al*. 2019; Stoll *et al*. 2021; Tall *et al*. 2021). Many EbA actions have high transaction and development costs, require long-term investments, and often deliver benefits over time frames that are much longer than typical investment cycles (UNEP 2021a). The lack of predictable and quantifiable revenue flows from EbA initiatives often makes them unappealing to investors who are looking for “bankable” projects with attractive returns on their investments (WWF 2020; Tall *et al*. 2021). Investors are often deterred from investing in EbA because of the considerable uncertainty about future climatic conditions, how climate change will impact their business operations and assets, and how EbA could help address these risks (WWF 2020). In addition, because most investors focus primarily on short-term results and profits, they are often averse to

A fourth broad set of actions that can help accelerate EbA action is the use of innovative finance mechanisms to generate funding at the scale that is needed. While most funding for EbA continues to stem from public budgets and international assistance, there are increasing opportunities to use new innovative mechanisms to attract greater public and private investment. These innovative finance mechanisms may tap into new sources of funds, blend different sources of funds, de-risk private sector investments or develop novel ways to unlock funds for the conservation, management and restoration of ecosystems for climate resilience (Deutz *et al*. 2018; Louman *et al*. 2020). The design of innovative finance mechanisms for climate change adaptation, nature conservation, and sustainable management of landscapes and seascapes is a rapidly emerging field (Deutz *et al*. 2018; Louman *et al*. 2020). Here we highlight five innovations that we think hold particular promise for quickly increasing the pace and scale of EbA finance: 1) using green bonds to secure finance for EbA, 2) supporting the use of debt-for-nature or debt-for-climate swaps, 3) leveraging COVID-19 stimulus and recovery funds towards EbA action, 4) supporting climate and nature risk disclosure by businesses, and 5) creating innovative insurance programmes.

One finance approach that holds significant potential to attract and leverage finance for EbA is the development of “green bonds”. These are debt instruments that can be used by governments, organizations and companies to generate capital to finance projects that have positive environmental and climate impacts (Tuhkanen 2020). In these bonds, some or all of the proceeds of the bonds are allocated to investments that support specific environmental or climate change goals, such as energy efficiency, green infrastructure, low-carbon development or climate resilience. “Blue bonds” are a subset of green bonds which are used to finance environmental projects in marine and coastal environments, while “resilience bonds” or “green bonds for climate resilience” are a subset of green bonds in which the proceeds are specifically designed to help manage the financial risk from climate change impacts or catastrophes (Deutz *et al*. 2018; Bascuñan, Molloy and Sauer 2020a; Qadir and Pillay 2021). Here we use the term green bonds broadly to include both blue bonds and resilience bonds.

The first green bond was issued by the European Investment Bank in 2007 (Qadir and Pillay 2021). Since then, the green bond market has grown rapidly, with an estimated cumulative total of US$ 1.002 trillion in green bonds being issued from 2007 to 2020 (Jones 2020). Across the world, green bonds are now being issued by multilateral organizations, sovereign countries, municipalities, national development banks, financial institutions and corporations. Demand for green bonds continues to grow as investors aim to fulfil their green mandates (Qadir and Pillay 2021).

While green bonds hold tremendous promise for channelling private finance towards environmental and climate action, their application to EbA initiatives is only now beginning to be explored. To date, most of the proceeds from green bonds have been directed towards climate mitigation projects (rather than to climate adaptation efforts), with 95 per cent of the current green bond funding supporting projects in renewable energy, low-carbon buildings, energy efficiency and low-carbon transportation (Tuhkanen 2020; Mejía-Escobar, González-Ruiz and Franco-Sepúlveda 2021). However, there is growing momentum to use green bonds to finance climate adaptation and resilience initiatives that can protect communities from climate hazards while also generating returns for investors (Chahine and Liagre 2020; Louman *et al*. 2020). One example comes from Fiji. In 2017, Fiji was the first developing country to issue a sovereign green bond (the Fiji Sovereign Green Bond) to mobilize funding to help build climate resilience, with over 90 per cent of its proceeds allocated to adaptation projects, including reforestation and conservation activities (IFC 2017; Ng’etich 2021). Another example is the Netherlands’ €5.98 billion green bond (issued in 2019) which will fund coastal and river

or nature conservation (McDonnell 2021; Shalal and Lawder 2021; Singh and Widge 2021). In these "debt-for-climate" or "debt-for-nature" swaps, instead of continuing to make external debt payments to the creditor in a foreign currency, the debtor nation makes payments in a local currency to finance climate projects or nature conservation actions based on terms agreed upon with the creditor (Essers, Cassimon and Prowse 2021; Singh and Widge 2021). As part of these green debt swaps, countries can commit to using the debt relief to finance the conservation, restoration and sustainable management of ecosystems that provide protection against climate hazards. One example of this approach is an innovative climate debt swap for the Seychelles in which the country agreed (among other things) to use debt relief funds to restore coral reefs, improve management of mangroves and protect marine conservation areas in order to provide key climate adaptation and biodiversity benefits (Deutz helping to spur economic recovery (Edwards et al. 2013; WWF and International Labour Organization 2020; Raes et al. 2021). A recent report, for example, found that every dollar spent on ecological restoration KIRIVEXIH EX PIEWX RMRI HSPPEVW SJ IGSRSQMG FIRI¼XW (UNEP and Food and Agriculture Organization of the United Nations [FAO] 2020). Public works programmes that have a strong focus on ecosystem restoration, land and water management and soil conservation (such as the Working for Water[95] and Working for Wetlands[96] programmes in South Africa, the Mahatma Gandhi National Rural Employment Guarantee Act[97] in India, and the Productive Safety Net Programme[98] in Ethiopia) have been shown to provide important employment and training opportunities to local communities, while also stimulating local economies (Pasquini and Cowling 2015; Norton et al. 2020). Second, the implementation of EbA initiatives by governments as part of their economic recovery plan can help to improve the long-term resilience of communities, businesses and economies to climate change, while also providing valuable climate mitigation, biodiversity and sustainable HIZIPSTQIRX FIRI¼XW et al. 2021; Murti and Sheikholeslami 2021; Tall et al. 2021). Investing in the active conservation, management and restoration of ecosystems now could enhance community resilience XS JYXYVI GPMQEXI ERH SXLIV WLSGOW ERH WMKRM¼GERXP] reduce the cost of future adaptation action (FEBA 2020; WRI 2020). At the same time, investments in NbS could help countries make progress on their biodiversity and sustainable development commitments (Murti and Sheikholeslami 2021).

In order to place EbA at the heart of COVID-19 recovery plans, governments, MDBs, development agencies and other donors could directly provide grants, loans and other types of funding for priority EbA measures, for I\EQTPI ¼RERGMRK QERKVSZI ERH [IXPERH VIWXSVEXMSR XS QMRMQM^I GSEWXEP ½SSHMRK ERH TVSXIGX XLI PMZIPMLSSHW SJ ¼WLMRK GSQQYRMXMIW MQTVSZMRK [EXIVWLIH management to ensure continued availability of water to communities and businesses, restoring degraded agricultural land to enhance the resilience of food systems and rural livelihoods, and investing in green infrastructure in cities to reduce heat exposure and

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Building resilience of communities living in degraded forests, savannahs and wetlands of Rwanda.
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growing concern over the unprecedented loss and degradation of ecosystems is also leading to calls for businesses to disclose their dependencies on nature and the risk that nature loss or degradation pose to their operations (IPBES 2021; Task Force on Nature-related Financial Disclosure [TNFD] 2021). Investors, lenders, insurers and other market participants are increasingly demanding robust and comparable information on how companies will be affected by climate change and the loss of nature, and how they are preparing to deal with these risks, so that they can make informed investment decisions about which companies will be most resilient into the future (Tall *et al*. 2021).

There are two related initiatives under way to require greater transparency on the climate-related and nature-related risks to companies, both of which could spur greater action on EbA. First, the Task Force on Climate-related Financial Disclosure (TCFD),[99] created by the G20's Financial Stability Board, has developed voluntary recommendations for business to disclose their climate-related risks. The TCFD recommendations (TCFD 2017) require that organizations disclose the actual and potential impacts of climate-related risks and opportunities on their business strategy, explain how they assess and manage climate-related risks, and identify the metrics and targets they use to assess and manage these risks (Hallston 2018; TCFD 2021). Already, more than 1,500 organizations have supported the TCFD guidelines, including 1,340 companies with a market capitalization of US$ 12.5 trillion and financial institutions responsible for assets of US$ 150 trillion (TCFD 2021). In addition, more than 110 regulatory and government entities, including the governments of Belgium, Canada, Chile, France, Japan, New Zealand, Sweden and the UK, have encouraged the use of TCFD, and a number of national governments (e.g. New Zealand) have announced government plans to make these climate-related disclosures mandatory for certain publicly listed companies and large financial institutions (TCFD 2021).

The second, more nascent, initiative is to get businesses to disclose their dependencies on nature and the risks that nature loss or degradation pose to them. Launched in June 2021, the new Task Force on Nature-related Financial Disclosures (TNFD) aims to create a risk management and disclosure framework for organizations to report and act on evolving nature-related risks. Specifically, this new initiative aims to get companies to disclose their dependences on nature, their impacts on nature and how the loss or degradation of ecosystems and their services could affect their businesses, so that this information can be incorporated into strategic planning, risk management and asset allocation decisions, and ultimately shift global financial flows away from nature-negative to nature-positive

For more information, please visit https://www.fsb-tcfd.org.

Another important opportunity for accelerating the use of EbA is to encourage greater action by the insurance industry (Beck *et al*. 2019; Bascuñan, Molloy and Sauer 2020b; Máñez-Costa *et al*. 2020). Although interest in EbA is still nascent in the insurance sector, insurance providers are very aware of the growing risks that climate change poses to homes, businesses and other assets and the associated rise in the costs of providing insurance, and are interested in finding ways to reduce these risks and thereby reduce the cost of payouts for climate hazards (Beschaf 2020; Máñez-Costa *et al*. 2020). In 2017 alone, private insurers paid out more than US$ 133 billion for weather-related damages, mainly from coastal storms, and this amount is expected to grow significantly unless comprehensive adaptation measures are put in place (Beck *et al*. 2019).

The insurance sector could potentially support action on EbA in three ways (Beck *et al*. 2019). First, the insurance sector can incentivize the use of EbA among its clients by providing discounts for clients who use EbA to reduce their vulnerability, thereby reducing the cost of insurance (Beck *et al*. 2019; Máñez-Costa *et al*. 2020; Reguero *et al*. 2020). For example, the National Flood Insurance Program of the Federal Emergency Management Agency (FEMA) in the United States of America uses a voluntary community rating scheme in which communities that restore or conserve natural features that reduce flood risk such as wetlands, green spaces or living shorelines are rewarded in the global capital market as it needs to invest its premium payments to earn revenue for later payouts (Beck 2019). In 2020, the global insurance community collected an estimated US$ 6.3 trillion in premiums.[101] If even a fraction of this capital were channelled towards the restoration, conservation and sustainable management of ecosystems for climate adaptation, this would greatly increase both the financial and physical resilience of communities globally.

EbA practitioners (whether in the government, private sector or civil society) can help the insurance sector to become more familiar with EbA and its risk reduction benefits by sharing information and evidence on its effectiveness and highlighting successful examples where insurance payouts have been reduced due to the use of EbA measures. Governments can develop policies, laws and regulations that encourage the insurance sector to look more closely at the ways in which they can support EbA, and conservation

For more information, please visit iuuqt;00xxx/jjj/psh0qvcmjdbujpot0jotvsbodf.iboecppl0fdpopnjd.boe.gjobodjbm.ebub0xpsme.jotvsbodf. marketplace.

already lives in urban areas and that more than two-thirds will live in cities by 2050, with 90 per cent of this urban growth occurring in low- and middle-income countries that already have large vulnerable populations (United Nations 2018; Chu *et al*. 2019). Many cities are at significant risk from climate change because they are located in the floodplains of major rivers, on drained wetlands, or along estuaries or coastlines, and are therefore vulnerable to flooding, storm surges and sea level rise (McGranahan, Balk and Anderson 2012; Hobbs and Grimm 2020). An estimated 700 million people live in urban or peri-urban areas that are less than 10 m above sea level (Center for International Earth Science Information Network 2019). Flooding already causes an estimated US$ 120 billion of damage to urban property each year and this is expected to increase significantly in coming years (Browder *et al*. 2019). Many low-lying cities are also especially vulnerable to the impacts of rising temperatures and heat waves because the of the large amounts of concrete, asphalt and metal in urban structures which readily absorb and re-radiate heat, making urban areas significantly warmer than surrounding areas and leading to adverse health outcomes (Koch *et al*. 2020). Urban residents who are poor and lack access to basic social services and resources, such as secure housing, energy, water and sanitation, education, health care and employment, are particularly vulnerable to climate change impacts (Chu *et al*. 2019). Adaptation action is urgently needed not only to enhance the climate resilience and well-being of rapidly growing urban populations, but also to protect critical assets such as infrastructure, and facilities used for manufacturing and financial services which are concentrated in cities (Chu *et al*. 2019).

EbA has the potential to significantly enhance the climate resilience of low-lying cities. There is a robust (and rapidly growing) evidence base on the successful use of EbA practices to manage heat and flooding risks in cities (e.g. Chu *et al*. 2019; Hobbs and Grimm 2020; Koch *et al*. 2020). The establishment and management of green roofs, street trees, urban parks and other green spaces can significantly lower temperatures and reduce the threat of heat stress through shading and evapotranspiration (Norton *et al*. 2015; Koch *et al*. 2020). For cities threatened by flooding, the integration of EbA practices such as street trees, green roofs and walls, urban parks, rain gardens, bioswales, urban ponds and impervious surfaces can help increase the infiltration of water into the soil and reduce run-off during heavy rain events, thereby reducing the risk of flooding while also providing important energy savings, recreational and health benefits (Hobbs and Grimm 2020; McDonald *et al*. 2020). At the larger watershed scale, the targeted conservation, restoration and management of upland forests and other native vegetation can significantly reduce the risks of urban flooding downstream and also prevent landslides from occurring during extreme weather events (Reid *et al*. 2016; GCA 2019). EbA options to prevent the flooding of coastal cities are discussed in the following section (section 4.5.2).

In order to encourage the widespread implementation of EbA in low-lying cities, a mix of policy, regulatory and financial incentives is needed. As highlighted earlier in the chapter, national and local governments can mainstream the use of EbA into national and local development policy, planning and budgeting (section 4.1.2) and procurement processes (section 4.2.2), and ensure urban planning and zoning consider the use of green and blue infrastructure (section 4.2.3). Urban building codes, zoning restrictions, and local spatial planning (including hazard mitigation planning, storm water management, land-use and infrastructure planning) can be designed to promote the conservation, restoration or sustainable management of urban ecosystems, such as parks, rivers and wetlands, to enhance resilience to climate change (Browder *et al*. 2019; section 4.2.4). Robust zoning regulations which indicate which areas within low-lying cities can be built on, how far businesses or local communities should be located from rivers or estuaries, and which areas should be conserved or restored to natural floodplains or wetlands, will be key for protecting businesses and local communities from the risk of flooding (Dougherty-Choux *et al*. 2015). If done correctly, urban planning can operationalize the implementation of EbA and also help identify potential trade-offs across adaptation and other goals (Bush and Doyon 2019). Local governments can use a diverse suite of incentives for individuals, companies and other stakeholders to support and implement urban EbA measures, including reduced

There are also significant opportunities to use EbA to significantly enhance the resilience of coastal communities that are vulnerable to sea level rise, storm surges and erosion. Coastal areas are home to more than 40 per cent of the world's population, including communities from storms, prohibiting activities (such as sewage pollution, habitat damage and loss, overfshing and uncontrolled coastal development) that degrade existing coastal ecosystems and undermine their protective functions, or establishing marine protected areas or locally managed marine areas to protect vulnerable ecosystems (Fujita *et al*. 2013; USAID 2018; OECD 2020). The use of EbA can also be encouraged through increased investment of public and private funds to green and blue infrastructure projects in coastal areas (section 4.4.1). From 2004 to 2013, investment in coastal green infrastructure represented only 3.4 per cent of the global amount spent on coastal gray infrastructure (McCreless and Beck 2016), so there is clearly signifcant scope for greater investment. Novel incentives can be developed to promote greater use of EbA by homeowners, companies and land managers, for example by decreasing property taxes or reducing insurance premiums for coastal homeowners who implement EbA measures on their properties and enhance their resilie(enhatd0047occlimate change (Hill and)] TJETBT9.5 0 0 9.5 51.0236 471.528 Tm[(Mar)-24.8(tinez-Díaz 2019

There are also important opportunities to scale up the use of EbA in agricultural landscapes to improve the *et al*. 2014; Shames and Scherr 2019). While EbA can be applied across a wide range of different agricultural systems, it is particularly well-suited for smallholder farmers who often lack the resources to invest in alternative adaptation measures such as improved seed varieties, fertilizers and pesticides, irrigation systems and insurance schemes (Vignola *et al*. 2015).

In order to scale up the use of EbA within agricultural systems and landscapes globally, a diverse set of actions is needed. One key aspect is to build capacity of farmers, agronomists, extension agents and farmer-led organizations so that they can design and apply EbA measures that address the specific vulnerabilities and adaptation needs of local stakeholders and build

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