Seven Lessons on Using Ecosystem Restoration for Climate Change Adaptation

Policy brief

1. Introduction

Ecosystem restoration can play a critical role in helping societies address a range of climate hazards, such as intense precipitation, drought, heat and coastal hazards. Healthy ecosystems typically play a buffering role, mediating and moderating such hazards. But if ecosystems are degraded, their capacity to play this role is reduced, sometimes severely. Currently, the world's ecosystems are being degraded, in many cases at an accelerating rate; we are using the equivalent of 1.6 Earths to maintain our current way of life, and ecosystems cannot keep up with our demands (United Nations Environment Programme [UNEP] 2021). Through restoration, ecosystems can regain their capacity to play this buffering role.

In recent years, there has been increased attention to and understanding of the linkages between the climate and biodiversity crises. One sign of this change is the recent focus on nature-based solutions for climate and other challenges, as exemplified in the 2022 United Nations Environment Assembly resolution on nature-based solutions (United Nations Environment Assembly of the United Nations Environment Programme 2022). Another sign is the recognition of the importance of ecosystem restoration for climate adaptation.

The specific context for this paper is provided by two current initiatives: the UN Decade on Ecosystem Restoration (UN Decade), which was launched in 2021, and the Global EbA Fund, which is expected to operate until 2027. One of the three main goals of the UN Decade is to increase our understanding of the multiple benefits of successful ecosystem restoration (United Nations 2021). The Global EbA Fund aims to address planning and other governance gaps in policy and regulatory environments to increase the attractiveness and feasibility of using and upscaling ecosystem-based approaches for climate change adaptation. This briefing paper is intended to contribute to both initiatives by highlighting the role of restoration in climate change adaptation and identifying key lessons that need to be taken into account in promoting that role.

The next section of this paper identifies general features of ecosystem restoration and climate adaptation that have implications for how ecosystem restoration for adaptation can be advanced. The section after illustrates many of these features through an examination of a range of examples where restoration has built climate resilience. The final section sets out seven lessons on using ecosystem restoration for climate change adaptation.

2. General Features of Ecosystem Restoration and Climate Change Adaptation

The UN Decade emphasizes that ecosystem restoration is important not just as an end in itself but also for the range of benefits that restored ecosystems can deliver for human society (United Nations 2021). In the terminology of the Millennium Ecosystem Assessment, the three categories of ecosystem service that contribute directly to human well-being are provisioning services (including food and water), regulating services (including climate and flood regulation) and cultural services (including aesthetic, spiritual and recreational services) (Millennium Ecosystem Assessment 2005).

While ecosystem restoration will typically enhance the delivery of several different services across these three main categories, there will sometimes be trade-offs. The precise mix of services or benefits delivered will depend on a range of factors, including the type of ecosystem, the state of the system being restored and the manner in which it is restored. From a historical perspective, it is possible to identify long-term trends in trade-offs. Dasgupta notes that, over time, human society has, in effect, prioritized the delivery of provisioning services over regulatory services, with the deleterious results that are seen today (Dasgupta 2021). But even an individual instance of ecosystem restoration may exhibit trade-offs.

These trade-offs may affect not only which services are delivered through ecosystem restoration but also the identity of those who benefit from them. Depending, in part, on the social and economic circumstances in which restoration occurs, it may benefit men more than women or those with wealth and power more than those who live in poverty and are most vulnerable. Or vice versa. Decisions about restoration – Where? How? For what purposes? – will almost inevitably have implications for equity. Therefore, issues of equity, whether they are acknowledged or not, are likely to be a central rather than a secondary feature of ecosystem restoration. Where one of the primary aims of restoration is to build climate resilience, equity concerns may be particularly pressing, not least because those most vulnerable to climate change are typically those who have done the least to contribute to the problem.

Other general features of climate change adaptation are worth noting in the context of ecosystem restoration. Climate adaptation is typically not an end in itself, but a means to ensure continued access to a wide range of benefits under a changing climate, including food, clean water, secure homes, good health and rewarding work. This is part of why climate adaptation can appear complex: a diverse range of actions contribute to ensuring access to these benefits under a changing climate. It also helps explain the oft-noted connection between adaptation and development.

When restoration has the specific aim of contributing to climate adaptation, it must be resilient to climate change and other pressures on the ecosystem. Otherwise, the restored system will quickly start to degrade again. In these circumstances, the attempted restoration will not contribute to increased resilience over time. Addressing this may mean that restoration efforts should not simply restore the same assemblage of species that were present earlier but should make use of species that are resilient to the future climate.

It should also be recognized that, in addition to restoration, the two other main types of ecosystem intervention – conservation and sustainable management – can also contribute to climate change adaptation. In this regard, it is noteworthy that the overarching goal of the UN Decade is to prevent, halt and reverse the degradation of ecosystems (UNEP 2021), which is broader than a narrow focus on restoration alone. Moreover, partly because of the wide scope of adaptation noted above, other means can be used to build climate resilience. These include the use of grey infrastructure. In some circumstances, this may be an alternative to restoration and other ecosystem interventions, or it may be used in combination with such interventions.

Since decisions about the use of ecosystem restoration for climate change adaptation may involve issues of equity and sustainability, trade-offs with other benefits and choices about how resilience is most effectively built, it is helpful if they can be as explicit and transparent as possible. For the same reason, tracking the outcome of such decisions is also invaluable.

Nevertheless, it has to be recognized that ascertaining the degree to which climate resilience has been achieved is far from straightforward (Leiter *et al.* 2019). Hallegatte and Engle (2019) have advocated for the increased use of process indicators in addition to outcome indicators as one way to help tackle this challenge.

3. Specific Examples of How Ecosystem Restoration Can Contribute to Climate Adaptation

We can now turn to specific examples of how restoration (alongside conservation and sustainable management) can address four important climate hazards. These illustrate many of the general points made in the previous section.

This section provides more detail on how ecosystem restoration can help deliver adaptation benefits to people in relation to four major groups of climate hazards that are already affecting people worldwide and are projected to increase in severity with climate change: intense precipitation, drought, heat and coastal hazards. Key points are illustrated with a series of examples from across different ecosystems. These examples show how climate-related economic damages are especially devastating for the most vulnerable in society, who have no insurance or protection from such losses, and the situation is further worsened by gender and social inequalities.

Intense precipitation

Flooding, landslides and soil erosion are some of the main impacts of intense precipitation. Between 1995 and 2015, floods affected 2.3 billion people and accounted for 47 per cent of all reported weather-related disasters (Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015). Looking into the future, 1.47 billion people are directly exposed to substantial risks during 1-in-100 year flood events and 132 million people are estimated to live in both extreme poverty and in high flood risk areas (Rentschler and Salhab 2020). Further to this, extreme rainfall can trigger landslides, which kill tens of thousands of people every year. It is also linked to soil erosion, which has significant economic implications, especially for the agriculture sector, as well as major impacts on water quality and aquatic ecosystems (Kapos *et al.* 2019).

The restoration, conservation and sustainable management of vital ecosystems can help reduce the impacts of these processes and support people's climate resilience (United Nations Office for Disaster Risk Reduction 2020). Key ecosystems for reducing the impacts of precipitation and storm hazards include upland forests and vegetated slopes in watersheds, as they are critical to increasing water infiltration and soil water storage capacity, improving drainage and promoting soil stability (World Wildlife Fund 2016) (Examples 1 and 2). These functions are important as they help reduce peak flows, in particular during short-duration heavy precipitation events that often cause flash flooding, thereby reducing impacts on downstream communities (Filoso *et al.* 2017). To be effective for flood regulation, restoration approaches in areas affected by ecosystem degradation must be implemented at scales relevant to hydrological processes, i.e., at the scale of the landscape or, ideally, the basin. Not only can restored watersheds then help reduce extreme floods, but their role in improving water regulation and quality could save water utilities in the world's 534 largest cities an estimated $890 million each year (McDonald and Shemie 2014).

Example 1:
Hillside restoration in South Korea

In South Korea, the restoration of more than 6 million hectares of degraded hillsides, together with supportive measures that ensured the restoration was a success (such as reducing pressures on forested areas and addressing illegal timber harvesting) is estimated to have resulted in erosion control services valued at $11.23 billion, and prevented damage from landslides amounting to $3.95 billion (New Climate Economy 2018).

Example 2:
Sloping Land Conversion Programme

The Sloping Land Conversion Programme in China is one of the largest Payment for Ecosystem Services initiatives in the world. By 2012, nearly 30 million hectares were afforested, with a total investment of around 440 billion yuan ($70 billion), of which approximately 325 billion yuan ($51.5 billion) was paid directly to 32 million households in 25 provinces (Liu and Lan 2015). The programme aimed to reduce soil erosion, deforestation and flood risk by restoring forests and grasslands in sensitive locations. Evidence suggests the conversion of land from cropland to forest and grassland through this payment programme has contributed to carbon fixation, helped control soil erosion and reduced flood risk at local scales in some areas (Gutiérrez Rodríguez *et al.* 2016).

The restoration of rivers and their floodplains is also critical to limiting flood damage by slowing run-off and capturing sediment before it reaches the watercourse, preventing downstream damage. In Europe, flood damage to crops and forests was reduced for five out of six restored rivers, while restoration was also associated with increasing agricultural production, carbon sequestration and recreation value. The total ecosystem service value in restored reaches of these rivers increased by €1400 ± 600 ($1,550 ± 664) ha^{-1} yr^{-1} (Vermaat *et al.* 2016), demonstrating that restoration contributed to adaptation as well as other benefits. In Singapore, restoring rivers, streams and lakes to accommodate stormwater better and improve recreation opportunities in urban environments has reduced flood-prone areas in the city from 3,200 hectares to 32 hectares (Lim and Lu 2016). Similarly, the restoration of wetlands can help collect and slow, or even prevent, the release of floodwater, filter out sediment and reduce the impacts of soil erosion on water quality and economic activities. For example, in the Glacial Ridge Project in Minnesota, United States of America, 1,240 hectares of wetland were restored and 8,100 hectares of prairie were replanted, mitigating flood risk and improving water quality for nearby communities, all while re-establishing native vegetation (Gerla *et al.* 2012).

Drought

Drought has wide-reaching social, economic and environmental impacts, ranging from agricultural losses, death of livestock and wildlife, famine and associated human mortality to energy shortages and exacerbated conflict. As well as increasing hazards linked to intense precipitation, climate change is also leading to water shortages. It is estimated that 4 billion people live in areas already prone to water scarcity (Damania *et al.* 2020), and the frequency and intensity of droughts are expected to increase in many regions by 2050 (Intergovernmental Panel on Climate Change [IPCC] 2018).

In order to help people adapt to these mounting problems, ecosystem restoration can be targeted to enhance water supply (and raise water quality) by improving soil properties (e.g. water infiltration and retention capacity and resistance to erosion). Restoration of vegetation in catchment areas, for example, can not only reduce flood risks but also increase groundwater recharge that permits continued water availability during periods of reduced rainfall (Kapos *et al.* 2019). In the Horqin grasslands of China, for example, grassland restoration approaches facilitated by tree replanting have been shown to improve soils and reduce desertification by enhancing groundwater availability (Yuan *et al.* 2012).

In drylands, where the impacts of drought are particularly harsh, climate change contributes to further decreasing important crop harvests such as maize, beans and coffee, leading to increased poverty and food insecurity and exacerbating migration from rural areas. In countries impacted by drought, such as those in the Central American Dry Corridor (Example 3), restoration activities can have a significant impact on food production, income generation and employment.

Example 3:
Central American Dry Corridor Restoration (A UN Decade Flagship)

More than one million families in the Central American Dry Corridor rely on agriculture for their livelihoods. Increasingly, severe droughts in the region have resulted in the need for considerable humanitarian assistance. The land area suitable for growing crops is also expected to decrease across the region, exacerbated by soil degradation linked to the fact that rainfall, when it does occur, is increasingly intense. To address this, countries of the region have focused on restoration activities with a high impact on income generation, employment and food production.

The Flagship is focused on scaling up functional landscape restoration in the Central American Dry Corridor and the Dry Arch of Panama, contributing to implementing the UN Decade according to regional and national commitments. The Flagship is founded on a regional development model based on the sustainable use of land and the conservation of natural resources and includes:

- Active rescue and adjustment of traditional practices linked to production under agroforestry systems that partly resemble the functioning of natural systems and allow the recovery of ecosystem services
- Governments have committed to restoring degraded areas as a strategy to address multiple problems, from adaptation to climate change to the migratory crisis resulting from environmental vulnerability and agricultural production systems that degraded soils and forests. This political will was manifested in the commitments to initiatives related to restoration, such as the Bonn Challenge and Initiative 20x20.

The Flagship aims to promote ongoing initiatives in functional landscapes and their connectivity with key conservation areas. Prioritized activities include mangrove restoration, cocoa agroforestry, grain agroforestry, silvopastoral and agrosilvopastoral systems and improvements in hydrological capacity in watersheds. One of the main impacts sought is the generation of employment, which is particularly important in the context of the COVID-19 economic recovery (Thorbjarnarson *et al.* 2006; United Nations Environment Programme and Food and Agriculture Organization [UNEP and FAO] 2021a).

Using drought-tolerant species with low water consumption in restoration efforts can be especially important for establishing ecological processes that increase water availability, improve soil quality and provide shade and windbreaks. For example, in farmer-led reforestation in the Maradi and Zinder regions of Niger, the development of new techniques allowing deep rooting plants to regrow into trees when pruned properly and the planting of carefully selected tree species and drought-resistant shrubs were key to the effective re-establishment of over 5 million hectares of woodland over time (Sendzimir *et al.* 2011). This large-scale restoration effort has boosted crop yields, improved soil fertility and lifted communities out of poverty. Tree cover in the area has soared tenfold and the daily time spent gathering firewood – a task that mainly falls to women – has dropped from 3 hours to 30 minutes (Sendzimir *et al.* 2011). In Kenya, the restoration of severely degraded semi-arid rangeland enclosures has helped buffer agropastoral communities and farmers against the impacts of drought while also building their resilience by improving the health of their livestock, their income sources and their general standard of living (Wairore *et al.* 2016). In this case, and others (such as in the above-mentioned Central America Dry Corridor), restoration can help address the basic needs and build the resilience of vulnerable societal groups, such as smallholder farmers and pastoralists, through addressing climate change impacts and delivering co-benefits such as increased food and fuel production. Like other nature-based solutions, the capacity for ecosystem restoration to deliver adaptation impacts and co-benefits for the most vulnerable is enhanced when these objectives are identified early and built into the design and planning of restoration initiatives (Terton 2022; Giordano *et al.* 2020).

Heat

Steadily rising global mean surface air temperatures are leading to longer, more intense and more frequent periods of extreme heat, contributing to increasing droughts. Exposure to heat and heatwaves also negatively impacts human health and quality of life and leads directly to increased mortality and illness – in Europe alone, over 70,000 people died as a consequence of the 2003 heatwave (Robine *et al.* 2008). It is estimated that by 2050, nearly 1,000 cities will experience summertime temperature highs of at least 35°C, and the urban population exposed to these temperatures will increase by 800 per cent (Urban Climate Change Research Network 2018).

Restoring ecosystems, including forests and wetlands, can play a key role in decreasing local temperatures in both rural and urban areas by, for example, increasing canopy cover, shade and evaporative cooling (Kapos *et al.* 2019). Restoration of urban green spaces, including parks, can maintain air temperatures 4°C below those of less vegetated areas (Gago *et al.* 2013). An annual investment of $100 million in urban tree planting could reduce the maximum temperature on hot days by an estimated 1°C for 77 million people in the world while also contributing to pollution control, improved human health and well-being, biodiversity and carbon sequestration and storage (The Nature Conservancy 2016). Combining urban nature-based solutions, like green and blue spaces, with other measures, such as improved building design and early warning systems, offers the potential to develop more effective strategies to cope with heat impacts while delivering co-benefits for society and the environment.

Extreme heat and heatwaves are also associated with an increased incidence of wildfires, exacerbated by drought (Parente *et al.* 2018). Although fires can be naturally occurring and are essential to ecosystem health in certain circumstances, the incidences and severity of wildfires are projected to rise, leaving people and ecosystems more exposed to potential harm (Lee *et al.* 2015). The Black Summer bushfires in Australia in 2019-2020 burned more than 24 million hectares and have been shown to be linked to climate change, with a trend of increasingly dangerous fire weather conditions and larger forest areas burned (Canadell *et al.* 2021). Ecosystem restoration can help manage the severity of wildfires under the changing climate (O'Donnell *et al.* 2018). In south-east Belarus, where forest fires have dramatically increased in recent years, and degraded peatlands represent a source of large-scale prolonged peat fires, the Greening Dryland Partnership has restored around 1,000 ha of peatland and is planning to restore an additional 2,000 hectares in the coming years (Annagylyjova 2020). These efforts are expected to restore the hydrological regime over the next decade, reducing the risk from peat and forest fires to nearby cities (Annagylyjova 2020).

Coastal hazards

Climate change-related hazards in coastal zones include flooding and erosion due to sea level rise, wave impacts and storm surges. The negative impacts of tropical cyclones are increasing (IPCC 2022), putting coastal communities at greater risk, especially in small islands and low-lying areas. An estimated 680 million people currently live in low-lying coastal zones, and this number is projected to reach more than one billion by 2050 (Intergovernmental Panel on Climate Change 2019). Small island developing states (SIDS) have been suffering some of the worst consequences of coastal climate hazards, including loss of life and severe erosion of coastlines due to sea level rise, forcing communities to relocate. Several low-lying Pacific Islands have already been lost entirely (Thomas *et al.* 2020).

Restoring, as well as conserving and sustainably managing, natural coastal ecosystems – from mangroves to seagrass beds, coral reefs and coastal wetlands – can significantly contribute to buffering people against such hazards while also providing numerous other benefits (Kapos *et al.* 2019) (Example 4). The restoration of coastal ecosystems can help reduce wave energy, contribute to vertical soil build-up and stabilize sediments, thereby reducing coastal erosion and flooding, including during storm surges (McIvor *et al.* 2013; Chang *et al.* 2018). Restoring mangroves in the Philippines could protect more than 267,000 people from flooding, saving $450 million/year in damage (Losada *et al.* 2018; New Climate Economy 2018). Mangrove restoration also has the potential to increase the lifespan and/or effectiveness of grey infrastructure adaptation interventions. For example, Red Cross investments in mangrove restoration in Viet Nam were estimated to have helped avoid damages of the order of $15 million, including by preventing up to $295,000 in damages to dikes (International Federation of the Red Cross and Red Crescent Societies 2009).

Example 4:
Small Island Developing States Ecosystem Restoration (A UN Decade Flagship)

SIDS face unique structural and endogenous development challenges that have been exacerbated by the pandemic. Despite these, COVID-19 economic recovery represents a unique opportunity for SIDS to catalyse transformative change for people and their blue environment. Through the SIDS Flagship, the UN Decade will contribute to unlocking the blue economy potential and reducing nature-based economic and financial risks in four SIDS: Saint Lucia, Comoros, Fiji and Vanuatu.

Well-informed and coordinated ecosystem restoration and conservation can transform SIDS' unique ocean-based challenges into opportunities in order to accelerate the implementation of Sustainable Development Goal 14 and other ocean-related Sustainable Development Goals. A global and country-based accompanying communication strategy will leverage the SIDS Flagship as an inspiring example and elevate marine and coastal restoration/conservation as a theme within the global ecosystem restoration movement. The overall objective of this Flagship is to promote the integration of marine and coastal ecosystem restoration and conservation and sustainable blue finance into COVID-19 economic recovery and growth in the four SIDS. This will be done through a 'ridge to reef' and seascape management approach, connecting inland, coastal and marine ecosystems in order to build back 'better and bluer'. The Flagship will put marine and coastal ecosystems at the heart of socioeconomic decision-making in the participating countries (UNEP and FAO 2021b).

The restoration of coral reefs, oyster reefs and seagrass beds also provides coastal protection by attenuating wave force, thereby limiting coastal erosion. Coral reefs have been estimated to reduce non-storm wave heights by as much as 70 per cent (Narayan *et al.* 2016), while effective restoration of oyster reefs in Mobile Bay, Alabama, United States of America, reduced average wave heights and energy at the shoreline by 53 to 91 per cent (Kroeger 2012). Rehabilitating coastal wetlands can help with restoring sediment balance, thereby reducing or redressing land subsidence and helping reduce saltwater intrusion. Restoration of wetlands and oyster reefs on the coast of Florida could prevent an estimated $50 billion in losses from flooding, with a projected benefit-to-cost ratio of 3.5 (Reguero *et al.* 2018). Restoring sand dunes through, for example, sand trapping and planting pioneer dune plants, also contributes to preventing erosion, stabilizing the coastline and reducing damage to assets by absorbing and dissipating wave energy and preventing stormwater from flooding inland areas (Bridges *et al.* 2018).

Restoration activities can also be combined with grey infrastructure to reduce coastal and other hazards (Browder *et al.* 2019). Examples include installing living breakwaters alongside mangrove restoration and using engineered structures to support dune restoration (Green-Gray Community of Practice 2020).

Planning for multiple benefits

Restoration has the potential to help people adapt to climate change while delivering a range of other benefits. Careful planning is needed to realize this potential. For restoration to be an effective and long-term response to the four hazards discussed above (and others), it needs to be combined with other measures that reduce the pressures that led to degradation in the first place, such as sustainable management and conservation of ecosystems (Organization for Economic Cooperation and Development 2019). As illustrated above, restoration can also be combined with grey infrastructure to help people better adapt to climate change (Green-Gray Community of Practice 2020). However, restoration can also lead to equity issues if rights are not respected, or robust stakeholder consultation is not conducted. Restoration must be carefully planned if it is to achieve its full potential while also avoiding unintended consequences and recognizing trade-offs (UNEP 2021).

4. Seven Lessons on Using Ecosystem Restoration for Climate Change Adaptation

1. **Ecosystem restoration is important for building resilience to climate change.** There is a growing body of evidence to support this. Restoration can help address a number of important climate hazards, and a range of interventions are possible for each hazard.

2. **Restoration must be sustainable.** If restoration is to contribute to climate adaptation, then the restored ecosystem must itself be resilient to climate change and the other pressures that might lead to degradation.

3. **Restoration is a part of the solution.** Other types of ecosystem intervention – such as conservation and sustainable management – also contribute to climate resilience when they result in the delivery of needed services under a changed climate. This is implicitly recognized in the overall goals of the UN Decade. Moreover, ecosystem interventions, including restoration, will often need to be combined with other types of adaptation measures, including the use of grey infrastructure.

4. **Restoration can often deliver other benefits.** As is often the case with nature-based solutions, ecosystem restoration can deliver more than one benefit. Along with supporting adaptation, restoration may contribute to such goals as climate change mitigation, biodiversity conservation, gender equality, food security and health.

5. **Sometimes, compromises have to be made.** When designing and planning restoration interventions, choices must be made, implicitly or explicitly, about which services to prioritize for which beneficiaries. There are ways to achieve an appropriate balance, both within individual interventions and across a set of interventions at different sites.

6. **Equity considerations are central.** The choices to be made when planning restoration relate not just to which services it delivers but also to the identity of the beneficiaries. In the context of climate change, it is critical to consider the needs of the most vulnerable. Often the most effective way of promoting equitable outcomes is through inclusive decision-making processes that embed gender equality and human rights.

7. **Tracking delivery is important but challenging.** This is particularly true when adaptation is one of the primary aims of the restoration. Since measuring adaptation outcomes has difficulties of its own, it is not easy to track whether vulnerability is reduced or climate resilience increased. One way forward is to make more use of process indicators.

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