Science-based ecosystem restoration for the 2020s and beyond

Science Task Force for the UN Decade on Ecosystem Restoration

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

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The IUCN-led Science Task Force provides an authoritative scientific reference for the UN Decade on Ecosystem Restoration, bringing together scientific experts and organisations working on terrestrial, freshwater and marine ecosystem restoration. It offers an overarching coordination and scientific rigour function in the production, collating and conveying of scientific information in support of the implementation of the UN Decade.

IUCN convened the Science Task Force to lead the production of this think piece through the development of concise and relatable key messages and supporting explanation on implementation of science-based ecosystem restoration for the Decade. IUCN expresses its deepest thanks to the members of the Science Task Force for their dedication and contributions to the production of this think piece. Through an active discussion and exchange they provided honest, science-based reflections about the topic. The wealth of their combined expertise and knowledge made it possible to identify the most critical aspects that need to be tackled for the Decade to succeed.

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EXECUTIVE SUMMARY

Actions that sustain and restore diverse and functioning ecosystems are essential for human safety, health and prosperity. With 2021–2030 declared as the United Nations Decade on Ecosystem Restoration, efforts are scaling up to halt, reverse and prevent future degradation of ecosystems worldwide, including natural, semi-natural, managed, production and urban ecosystems. Sustaining and restoring ecosystems requires public support and leadership from nation-states and civil society, underpinned by sound science, and is driven by the collective action of multiple actors whose actions impact and are impacted by ecosystems. To move the goals of the UN Decade on Ecosystem Restoration forward, the Science Task Force of the Decade presents this think piece, which addresses four fundamental questions, presents five key messages to bring effective and long-term action, and provides recommendations on how to build the ecosystem restoration movement.

What does it mean to undertake ecosystem restoration? In short, restoration actions prevent further degradation and promote the recovery of impacted ecosystems in landscapes, freshwater systems and seascapes, while ensuring that restoring ecosystems in one region does not displace pressures and cause ecosystem degradation elsewhere. Different solutions exist in a continuum of restoration actions to promote the recovery and function of local and regional socio-ecological systems to deliver nature-based services and support native biodiversity. Change does not happen overnight – positive impacts can be seen early on but whole restorative processes may take decades and require an intergenerational compact. Multi-sector coalitions and integrated programmes have the opportunity to take coordinated action at regional scales that have a longer timeframe and broader ecosystem outcomes than locally implemented projects.

Why have previous restoration efforts been only partially successful and what needs to change? Many previous restoration efforts have failed because of inadequate attention to livelihood needs, limited consideration of trade-offs, inequitable distribution of benefits and costs, limited or ineffective engagement with decision makers and planners, poor science underpinning and focus on unsustainable short-term actions. Future restoration efforts need to draw lessons from previous successes and failures and build on a holistic understanding of the drivers of ecosystem degradation and benefits of ecosystem restoration. Restoring ecosystems at the massive scale needed will require redesigning multiple systems that enable coordinated human use, financing of ecosystem goods and services and developing new institutional mechanisms. Effective restoration strategies need to accommodate the operational needs and vision of decision makers and communities in unique biogeographical contexts. Continued social and ecological research will help ensure that ecosystem restoration is based on the best scientific knowledge.

How can individuals, groups and sectors contribute to effective ecosystem restoration actions? Agents of change from different sectors of society, both rural and urban, need to be empowered to take actions that reverse degradative cycles and promote socio-ecological restoration actions and outcomes. The impetus for restoration can come from individuals, communities, governments, non-governmental organisations or the private sector. Restoration can be implemented under a wide range of governance mechanisms and financing arrangements. Local action is essential as community engagement in ecosystem restoration can boost social capital and livelihood security, in addition to providing direct economic benefits. Thus, restoration that incorporates local knowledge or cultural traditions and legitimises the role of communities as stewards of land and water is likely to be the most successful. Corporate sectors and industry leaders can also be powerful champions of ecosystem restoration by developing net positive practices in their supply and market chains that halt negative impacts on natural ecosystems and apply restorative action across their ecosystem-based operations. Entrepreneurship for ecosystem restoration can bring about innovation, create jobs and increase investment in local enterprises.

What are good starting points to implement long-lasting ecosystem restoration? Successful ecosystem restoration outcomes are more likely when founded on a common vision. Coalitions and partnerships that work towards this vision can support joint action to scale-up restoration efforts. Collaboration among sectors is also fundamental to realise ecosystem restoration. In a globalised, digital and connected world, online restoration platforms are likely to play a key role in integrating restoration movements, connecting actors, finance, tracking progress and disseminating good practices. This is an unparalleled opportunity for mainstream science to reach out to a larger audience, including implementers, decision makers and supporters.

Key messages to inform a framework for reversing ecosystem degradation

1. **Ecosystem restoration offers multiple benefits though they may be unevenly distributed (Key message 1).** Ecosystem restoration can produce multiple social and environmental benefits, including enhancing human health and well-being, helping mitigate and adapt to climate change, improving water quality and flows, reducing soil erosion and flooding, regaining soil fertility and preventing species extinction. The different outcomes, benefits and costs of restoration actions become manifest over various temporal and spatial scales. Understanding the distribution of benefits and costs associated with restoration is critical as aggregate benefits can hide significant imbalances,

with benefits skewed towards a few stakeholders and costs borne by others. Inclusive engagement in restoration planning may enable more equitable distribution of net benefit and increase the potential for long-term success.

2. **Key enabling conditions, particularly local norms and governance, can tip the balance towards restoration (Key message 2).** Effective restoration entails negotiating and balancing multiple objectives and forging enduring and meaningful partnerships with and across local communities and institutions. Secure tenure, property and use rights are critical foundations for local governance, resource stewardship, livelihood development, benefit-sharing and the realisation of human rights. Government financing and incentives are particularly important for restoring non-monetised public goods that do not attract to private sector investment. Scaling up ecosystem restoration may require the phasing out of counterproductive policies and subsidies and the repurposing of resources for conservation and restoration. Integrating and harmonising traditional and scientific knowledge is vital to foster effective restoration actions. Where key enabling conditions are not present, it is critical that additional resources be invested to create them, in order to build local and long-term capacity, motivation and engagement.

3. **Effective ecosystem restoration requires managing trade-offs equitably (Key message 3).** To ensure success, it is crucial that the different perspectives, goals and needs of stakeholders are communicated and accounted for in a spatially explicit manner, through participatory planning. Nature's contributions to people and biodiversity vary over time and space, and can be negative as well as positive, depending on which restoration actions are implemented; with different choices creating winners and losers and inescapable trade-offs. Robust spatial planning to support decision-making can ensure that the actions taken are ecologically sound and cost-effective, and address compromises among restoration goals, demands from other development challenges and available financing. National governments, international organisations, local communities and regional restoration stakeholders need to identify and prioritise locations and restoration approaches that balance benefits, costs and risks.

4. **Finance and market infrastructure is critical for scaling up and sustaining ecosystem restoration (Key message 4).** Restoration needs greatly exceed the budgets of national governments, international donors and multilateral development banks. Thus, meeting estimated large shortfalls in available funding for restoration will require drawing on both public and private sector resources. The potential of restoration to address multiple global challenges has stimulated the development of several innovative financial instruments, including those that supply capital and mitigate risk. Matching financial instruments to the scale of opportunities available will require significant modifications to private sector operations. A restoration economy can mobilise local stakeholders through livelihood enhancement, job creation and business development.

5. **Adaptive management and monitoring are keys to effective and long-term restoration actions (Key message 5).** Transparent monitoring, evaluation and adaptive management are integral and cross-sectional components of the ecosystem restoration process. Capitalising on good practices for ecosystem restoration relies on learning from both successes and failures. High restoration aspirations stimulate actions and motivate engagement and commitment, but failure to achieve ambitious goals can discourage action, reduce investment and generate distrust. Incremental moving restoration targets are likely to be more effective than static targets. Baseline ecological and social data and analysis are key to producing robust restoration action plans. Local communities can be actively engaged in the design of assessment, management and monitoring frameworks and tools. Monitoring indicators should incorporate information on broader societal outcomes.

Building the ecosystem restoration movement

This think piece details specific actions for ecosystem restoration by different social agents, based on the following broad recommendations:

- Restoration is a process that builds over a long period of time and opens up new opportunities for engagement, learning and innovation.
- Local communities must be empowered to lead restoration movements.
- Restoration requires fundamental shifts in economic and political institutions so that they pay attention to the long-term and varied benefits of functioning ecosystems.
- The ideals of the UN Decade on Ecosystem Restoration – partnership, inclusiveness and joint coordinated action – need to be based on shared core principles, good practices and practical approaches to monitoring and evaluation.
- Ecosystem restoration actions create opportunities for multiple agents of change to work together.

INTRODUCTION

Introduction

Ecosystem restoration has never been more relevant. The United Nations (UN) Decade on Ecosystem Restoration 2021–2030 launched this year, setting out the grand aim of supporting and scaling up efforts to halt, reverse and prevent future degradation of ecosystems worldwide and raise awareness of the importance of successful ecosystem restoration (UNEP, 2020). As identified by the UN, restoration is a cross-cutting strategy that can help achieve a wide range of social, economic and environmental outcomes. Globally, case studies of successful restoration showcase good practice and enabling policies and institutions that can motivate restoration (Woodworth, 2013; Hanson et al., 2015; Reij and Winterbottom, 2015; Besseau et al., 2018; Rakotoarisoa et al., 2020). In the next decade, we urgently need to enhance and scale-up ecosystem restoration by promoting established science-based practices and creating the appropriate conditions to drive ecosystem restoration as a critical response to multiple socio-environmental challenges.

Evidence shows that restoration actions contribute to human society right now, as well as benefiting future generations (Díaz et al., 2019). Ecosystems provide goods and services, ranging from production of fuelwood, fodder and food to removing pollutants and thereby improving air and water quality, as well as flood mitigation services, allowing human populations to thrive, though these benefits vary in space and time and between different members of society and can be positive and negative. Thus, sustaining diverse and functioning ecosystems, both natural and managed, is essential for human safety, health and continued prosperity (Sandifer et al., 2015). Conversely, ecosystem degradation, by contributing to the irreversible loss of species on land, in freshwater systems (Case study 9) and seas, risk of ecosystem collapse, ocean acidification, diminishing freshwater, soil erosion and climate change, increases the risks human communities face in their daily lives (UNEP, 2021b). Recent zoonotic disease pandemics, such as the COVID-19 virus, illustrate the strong links between human well-being and ecosystem degradation (Schmeller et al., 2020).

A recent global IUCN typology describes 108 unique ecosystem types, distributed across 25 biomes and five realms of the biosphere (Keith et al., 2020). These include natural, semi-natural, managed and urban ecosystems, such as temperate deciduous forests, tropical savannas, annual croplands, rivers, wetlands and lakes, coastal river deltas, surface ocean waters and deep-sea trenches. Deterioration of these ecosystems threatens critical life support systems, making attainment of the Sustainable Development Goals more challenging and potentially more costly. Degradation in many of these ecosystems is driven by both direct human actions and indirectly by catastrophic weather events and shifting climatic regimes. Managed ecosystems that provide food, fibre and fuel are also susceptible to degradation from climate change and unsustainable farming practices. Ecosystem collapse or the tipping point is often irreversible, but some ecosystems may recover over a long timeframe with restoration effort (Keith et al., 2013). The IUCN Red List of Ecosystems, which allocates ecosystem types into different categories of risk, is enabling countries to assess risk across different ecosystem types (Bland et al., 2019). While restoring many degraded ecosystems is vital for maintaining critical Earth systems, not all ecosystems can or need to be restored to prior natural conditions (Hobbs, 2016; Coleman et al., 2020). In many situations with a long history of anthropogenic stress it is important to be realistic about the potential for restoration towards a near-natural ecological system state (Geist and Hawkins, 2016) and intensively managed agriculture and urban systems are also essential to support humankind.

People are integral to restoring ecosystems and inhabit many areas to be restored. Successful restoration requires partnerships and a shared long-term vision (Ferwerda, 2015) with communities who use sea, land and riverscapes that need restoration actions (Walters et al., 2021). An estimated 1.87 billion people live on 44% of the Earth's terrestrial area identified as important for conservation and restoration (Allan et al., 2021). An additional 300 million people inhabit lands targeted for tropical forest restoration (Erbaugh et al., 2020) and over 1.6 billion people live near forests – and likely depend on their resources (Newton et al., 2020). In all instances, the agents of change living on restoration priority territories are predominantly from low or lower-middle income countries. Thus, to realise the ambitious targets of the UN Decade on Ecosystem Restoration, local peoples and local needs may need to be prioritised relative to other restoration commitments (Holl, 2017).

Ecosystems and human societies often operate at different scales, with ecosystems benefits accruing to a multiplicity of people living in different geographies and time periods. For instance, degraded forest can lead to local reductions in fuel and food, and to global climate

change, with widespread and long-lasting impacts (Lamb, 2011). Decisions regarding harvesting and management of ecosystems often result in changes that transcend local spatial and temporal scales, creating a divergence between private and public needs at each of these scales. Thus, the costs and benefits of restoration do not always align or accrue to the same set of people, which can paralyse action. Additionally, the impacts of changes in ecosystem services, for instance, reduction in pollination services, are challenging to quantify, let alone understand their monetary value. Hence, many services are unaccounted for in market-based decisions and in public allocations based on national indicators such as Gross National Product (Dasgupta, 2021). Sustaining and restoring ecosystems will, therefore, require public support from nation-states and global communities who benefit from them. It will require collective action by multiple actors in today's societies and intergenerational compacts.

To identify a set of pathways that can help achieve the goals of the UN Decade on Ecosystem Restoration, we first address some fundamental questions:

- What does it mean to undertake ecosystem restoration?
- Why have many previous restoration efforts been only partially successful and what needs to change?
- How can individuals, groups and sectors contribute to effective restoration?
- What are good starting points to implement long-lasting ecosystem restoration?

We present a framework, centred on empowering agents of change from different sectors of society, to reverse degradative cycles. We synthesise our learning on actions needed to drive restoration in five key messages that focus on: 1) ensuring that ecosystem restoration is designed and implemented to attain multiple benefits and generate long-term positive outcomes; 2) key enabling conditions to tip the balance towards restoration; 3) managing trade-offs when measuring costs and benefits in planning and implementing ecosystem restoration; 4) providing finance and market infrastructure for scaling up and sustaining ecosystem restoration; and 5) monitoring and adaptive management to ensure long-term ecosystem restoration success (Figure 1). We conclude with specific recommendations for action by different social actors and to build partnerships to restore ecosystems together in local areas and all around the world.

Why we need the UN Decade on Ecosystem Restoration

Despite many examples of projects and programmes focused on restoration approaches of all kinds and scales, restoration progress has been slow (Waltham et al., 2020), inadequately monitored (Lindenmayer, 2020), and poorly funded (Liagre et al., 2015; Löfqvist and Ghazoul, 2019) and communicated (Jellinek et al., 2019; Mills et al., 2020). If restoration is truly the win–win–win nature-based solution the world needs, why are we not overwhelmed by the massive scale of effective actions being undertaken? The reality is that restoration is more complicated than most people envisage. As with most interventions, restoration involves shared visions, trade-offs, negotiation among conflicting values and interests, and is often hampered by structural barriers that require coordination and strong society support to overcome.

The global economy clearly does not value ecosystem restoration sufficiently. Globally and nationally powerful entrenched economic interests drive habitat loss and degradation, and they resist the systemic transformations required to stimulate and sustain restorative actions. National governments have a poor track record for leading effective and consistent long-term restoration actions. National political agendas are generally focused on achieving short-term goals that are quickly reversed when there is a change in administration or policy. These realities further compromise the effectiveness of multinational agreements and resolutions, and the creation of policy and market incentives and disincentives for tipping the balance towards restoration (Brancalion et al. 2017).

Ecosystem restoration is not a simple 'fix-it' operation that can easily compensate for environmental damage done (Chazdon, 2020). This view reflects a lack of understanding of the spatial and temporal complexities of socio-ecological systems and the importance of addressing key feedbacks (Chazdon and Brancalion, 2019; Liu et al., 2021). When ecosystem restoration interventions are undertaken, the socio-economic benefits often fail to reach all stakeholders, especially dispersed and marginalised local communities. Documented benefits are usually expressed as aggregates, obscuring negative impacts on some stakeholder groups and disproportionate benefits to others (Example 2: Key message 1). Such inequities often lead to project failures, disengagement and lack of trust. Restoration cannot succeed nor persist without support and engagement from local and regional governments, institutions, local communities and businesses. In large-scale restoration, the goals, needs and knowledge of local communities are often disregarded in project planning and implementation, a key reason why restoration projects fail (Höhl et al., 2020). Failed projects and disappointed stakeholders lead to discouraged funders and decision makers. These cascading effects place a check on rising restoration ambitions.

Where restoration progress has been strong and steady, the positive influence of multi-sector coalitions and implementation platforms is evident (Case study 2). But strong and effective multi-sector policy platforms are lacking in most regions. Effective restoration actions often span traditional government silos of conservation, agriculture, forestry, water management, finance, law enforcement and sustainable development. But governments and their policies, agencies and institutions continue to operate within these silos and fail to address the integrated nature of socio-ecological problems and their solutions. Most of the time, one arm of government works to fix the problems created by another arm of government.

Strategies of international conventions and agreements – based on multilateral agreements and focused on targets informed by science – have failed to generate the governmental and societal changes needed. Despite the promise of the Paris Agreement, the world is not on course to limit global warming to 2°C above pre-industrial levels (UNEP, 2021b). Achievement of the Aichi Biodiversity Targets has been limited, with none of the 20 targets fully achieved at the global level (Secretariat of the Convention on Biological Diversity, 2020). These targets and agreements have been more effective in generating hope and commitments than in generating real change and progress.

FUNDAMENTAL QUESTIONS

Fundamental questions to achieve the goals of the Decade

What does it mean to undertake ecosystem restoration?

Restoration actions focus on preventing further degradation, fostering recovery and preventing future degradation of impacted ecosystems across the entire ecosystem spectrum. We define ecosystem restoration based on the central theme of the UN Decade on Ecosystem Restoration (UNEP, 2020) as: *Preventing, halting, and reversing the degradation of ecosystems worldwide to regain their ecological functionality and to improve the productivity and capacity of ecosystems to meet the needs of society* (UNEP, 2021a). Depending on objectives and socio-ecological context, the restoration of ecosystems can follow different trajectories and apply different approaches (Table 1). The scope of ecosystem restoration implicitly includes conservation and environmental protection – as well as actions to reduce the degradation of land, waters and ecological support systems. Consequently, to address the drivers of degradation and avoid further degradation in landscapes, freshwater systems or seascapes, it is essential to ensure that stakeholders understand where, when, how and to what degree ecosystem degradation has occurred, and the potential for restoration. Under varied circumstances, a 'wholescape' approach may be needed (Maltby et al., 2019) so that restoration of ecosystems in one region does not displace pressures and degrade ecosystems elsewhere (Mansourian and Sgard, 2021).

Ecosystem restoration action is about changing the nature of the human footprint within and across ecosystems rather than removing the human footprint. Ecosystem restoration aims to promote the recovery and function of socio-ecological systems to deliver nature-based services and support native biodiversity (see Table 1 and Figure 1). It is a broad concept that encompasses a continuum of restorative actions that combine human engineered and ecological solutions to assist recovery of native ecosystems (Gann et al., 2019, Table 1). Notably, ecosystem restoration is deliberate human activity to overcome the negative consequences of anthropogenic degradation across all ecosystem types (Table 1, Figure 1). We recognise that full restoration of all ecosystems to a pre-human intervention baseline is neither possible nor sometimes desirable due to the need to maintain intensively managed agricultural and urban systems in some places to support humankind.

Ecosystem restoration encompasses activities carried out at different spatial scales. Restoration actions can be undertaken within entire watersheds or catchments (Paudyal et al., 2017), across diverse agricultural landscapes (Barrow, 2014; Case study 7), or within more delimited sites (Table 1). Restorative practices can include enhancing the diversity and sustainability of crop production; silvicultural interventions to enhance sustainability of wood products and non-timber forest products (see Case study 1); aquaculture to enhance sustainability of fish production; reforestation practices to restore forest cover lost through harvesting, conversion to farmland, or fires; or ecological restoration practices to assist recovery of native terrestrial and aquatic ecosystems and biodiversity (Table 1).

Restorative processes may take decades or centuries and require an intergenerational compact. Recovery of lost properties of ecosystems can be a slow process, including the re-establishment or recovery of native species, populations, functional groups and species interactions that were constituents of the prior ecosystem (Moreno-Mateos et al., 2020). Restoration actions are an investment in future generations of people and all forms of biodiversity. Socio-economic benefits of restoration actions may lag behind the environmental benefits, requiring that planning and implementation focus on rapid delivery of economic benefits to meet the needs of local communities (Gregorio et al., 2015). Multiple project phases and funding cycles are usually required to build the momentum, leadership and governance for long-term restoration actions. Multi-sector coalitions and alliances can generate coordinated activities at regional scales that have a longer timeframe and broader ecosystem consequences than local projects (Case study 2).

Table 1. The scope of ecosystem restoration actions and objectives

This table is based on the Society for Ecological Restoration's Restorative Continuum, which includes a range of activities and interventions that can improve environmental conditions and reverse ecosystem and landscape degradation (Gann et al., 2019). The UN's broad concept of ecosystem restoration embraces all of these restorative actions.

Restoration context

Types of ecosystems for restorative actions	'Wild' native ecosystems*	Managed natural or semi-natural ecosystems	Damaged ecosystem	Managed production ecosystems	Matrix of ecosystems
Examples	Terrestrial, aquatic, coastal and marine ecosystems	Rivers, lakes, forests, wetlands, grasslands, coastal and marine areas	Open pit mines, post-industrial sites, landfills, polluted water bodies, drained wetlands or peatlands	Croplands, grazing lands, agroforestry systems, plantations, fisheries	Landscapes, watersheds, deltas, urban areas, seascapes
Restorative actions	Reduce human impacts; protect existing natural ecosystems, reintroduce lost species, protect highly vulnerable species	Increase sustainability of ecosystem management and natural resource extraction, manage for multiple social and environmental benefits	Remove or mitigate toxic waste, replace topsoil, replace grey infrastructure with green infrastructure, reconstruct hydrology	Improve management and sustainable production, reduce climate vulnerability, reduce negative impacts on adjacent ecosystems and native species	Restore connections within and across ecosystems; improve multiple functions and integrity of multiple ecosystem types
Terminology for restorative actions	Conservation, avoided degradation, assisted natural regeneration, ecological restoration, rewilding	Rehabilitation, invasive species control, sustainable forest management, wetland management, coastal zone management, fisheries management	Land reclamation, land remediation, land restoration	Sustainable production, sustainable land management, land restoration, climate-smart agriculture, regenerative agriculture	Landscape restoration, integrated landscape management
Objective	Protect unique and threatened biodiversity, cultures and ecosystems; fully regain ecological structure and composition	Sustain use and functions of natural or semi-natural ecosystems and enhance nature's contributions to people; avoid biodiversity loss	Reconstruction of a modified ecosystem with some natural components that reduces health and environmental risks in local communities	Recover and sustain ecosystems managed for production of food, fibre, clean water and energy; support sustainable livelihoods	Recover multiple ecological and socio-economic functions and enhance nature's contributions to people
Scale	Single or multiple associated spatial units	Single spatial unit	Single spatial unit	Single or multiple associated spatial units	Multiple associated spatial units

* Wild ecosystems are not managed for production and are targets for conservation and protection as intact or relatively intact ecosystems. Humans have coexisted with ecosystems for tens of thousands of years, and few or no ecosystems exist that are not influenced in some way by past or present human modification. A large extension of indigenous territories is located in these ecosystems which have been used for centuries for local production, through sustainable use practices.

Effective restoration requires considering interconnected socio-ecological systems. Ecosystems are interconnected within larger-scale landscapes, freshwater systems and seascapes (Case study 8). Terrestrial ecosystems, for instance, are tightly linked with freshwater, coastal and marine ecosystems through catchment, riparian and river systems, forming 'wholescapes' (Maltby et al., 2019). Ecosystems and how they are managed are also closely tied to social and economic systems. Changes in land and waterscapes are driven by economic and cultural demands placed on fish, forest products or coral reefs, for instance, and underlying governance systems that facilitate these needs. Thus, it is important to understand the nature of linked ecological and socio-economic systems in undertaking restoration. Ecosystem restoration requires connecting inputs and outputs in a positive feedback loop across spatial scales and actors (Chazdon and Brancalion, 2019; Fischer et al., 2021). The most effective engagement pathways depend on both local conditions and overarching policy contexts that create enabling conditions for restoration (see Key message 2).

Restoration can achieve a wide range of social and environmental outcomes. Degraded socio-ecological systems (depicted in grey shading) occur across a range of biophysical and socio-economic contexts from natural areas to semi-natural and managed land and urban and peri-urban systems. Figure 1 emphasises five key messages that are critical to achieving multiple outcomes and lasting benefits from ecosystem restoration.

1. Ecosystem restoration (from degraded to restored systems) is a means to attain multiple benefits and ensure nature's contributions to people across a spectrum of ecosystem types (Key message 1).

2. Key enabling conditions tip the balance towards restoration by changing the relationship between people and nature to one based on interconnection, cooperation and synergy (transformations within socio-ecological systems, Key message 2).

3. The specific goals and actions applied within each socio-ecological system will vary across the spectrum, making it essential to consider trade-offs when planning and implementing ecosystem restoration to maximise synergies and minimise negative outcomes (Key message 3).

4. Finance and market infrastructure are enabling conditions that are critical for scaling up and sustaining ecosystem restoration (Key message 4).

5. Monitoring and adaptive management (feedback to restoration process) are an important part of the learning process that ensures long-term success of ecosystem restoration (Key message 5).

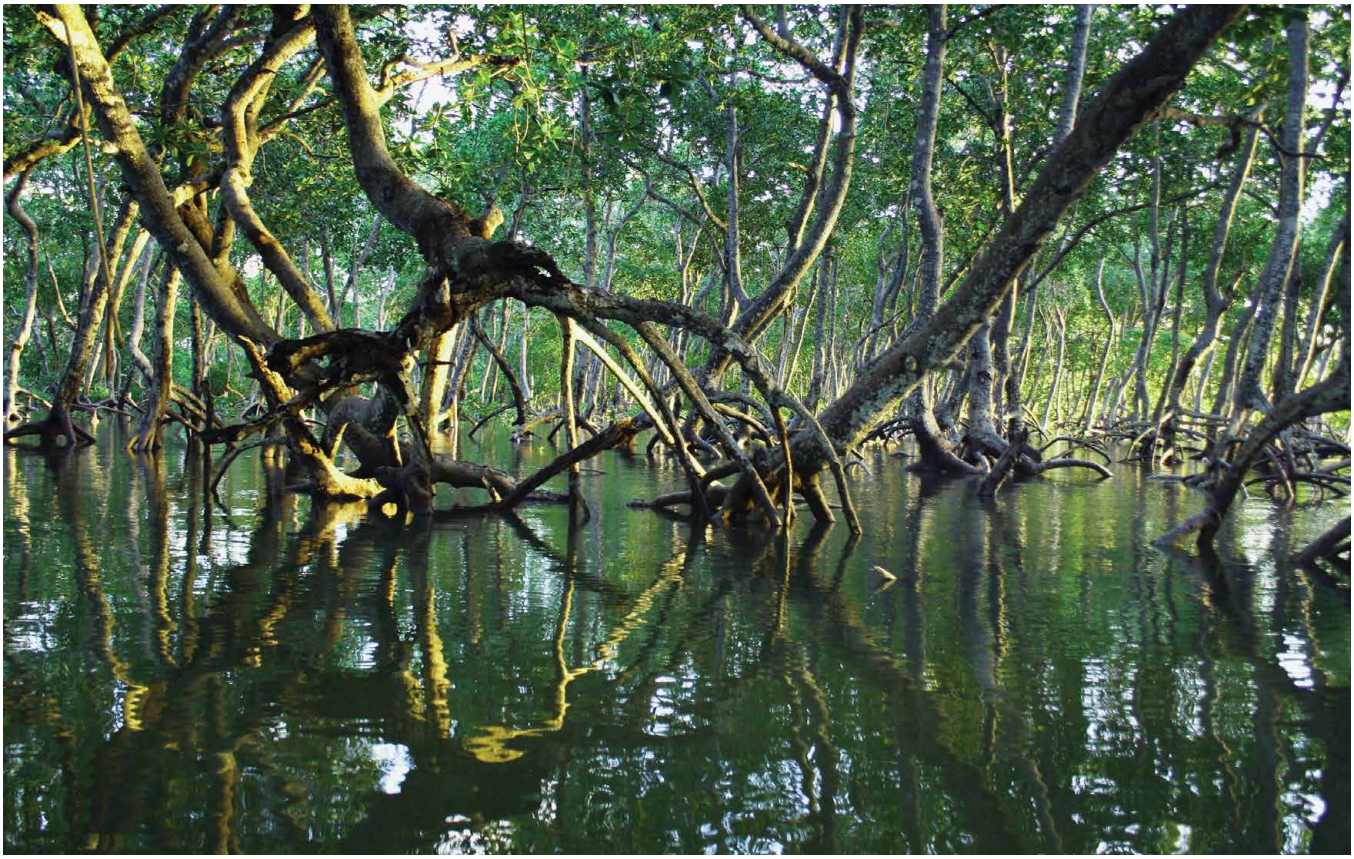

Figure 1. Key considerations to achieve lasting benefits from ecosystem restoration

Why have many previous restoration efforts been only partially successful and what needs to change?

Ecosystem management is not new. However, the challenge for the UN Decade is mainstreaming ecosystem restoration into a broader global development agenda, whilst helping achieve the aims of biodiversity conservation and climate change agendas. Many past restoration efforts have failed because of lack of attention to near-term livelihood needs, limited consideration of trade-offs, limited or ineffective engagement with decision makers and planners, poor science underpinning and a dearth of institutions focused on sustaining restoration efforts over longer periods (Suding, 2011; Höhl et al., 2020). Furthermore, development projects to improve agriculture, enhance water resources or exploit timber or minerals have often lacked awareness of ecosystem benefits, and have thereby contributed to ecosystem degradation and rarely involved restoration.

Restoration often requires attending to multiple socio-environmental elements to restore different functions and processes in ecosystems (Suding et al., 2015; Perring et al., 2018; Chazdon and Brancalion, 2019). For example, economic benefits, intergenerational fairness, inclusive governance, indigenous knowledge, gender and social equity are some social considerations that may play a role in decisions about effective restoration actions suited for different contexts (Osborne et al., 2021). Restoration in its next phase has to draw lessons from previous successes and failures and build on an understanding of what drives development projects that degrade ecosystems without addressing restoration needs. Additionally, restoration-related information and guidance need to be delivered in a way that resonates with citizens, entrepreneurs, decision makers, planners and actors.

Systemic change is needed to bring ecosystem restoration to scale. Ecosystem restoration requires engagement and cooperation among different types of social agents that work together towards a common vision (Table 2). Yet, achieving unity is elusive and may require changing habits, questioning assumptions, and making personal sacrifices. Effective ecosystem restoration actions require long-term thinking, planning, policy alignment and social innovation, to provide at least some short-term benefits and ensure their equitable distribution (UNEP, 2021a). Restoring ecosystems at the massive scale needed to sustain and improve the quality and diversity of life on Earth will require redesigning multiple systems that enable coordinated human use and financing of ecosystem goods and services.

Global economic and political systems can be unfavourable to restoration. Distant global and national market interests often drive habitat loss and degradation (for instance, deforestation driven by global markets for products such as meat, fish, soy and timber) and resist the systemic transformations required to stimulate and sustain restorative actions. Externalities, such as biodiversity loss from land degradation or water pollution are not valued in the same manner as associated market goods such as crops that may contribute to degradation. This precludes their inclusion in traditional cost–benefit analyses. Lack of investment in ecosystem restoration stems from systemic issues, such as entrenched institutions and policies that advance short-term gains, differences between beneficiaries of degradation and those who bear the costs of degradation and restoration, and spatial variation and uncertainties related to who gains or loses from changes in ecosystem services due to degradation. Furthermore, the long-term nature of restoration means it is invariably less favoured relative to land and water uses with higher short-term returns on investment (Chazdon, 2020). Thus, for ecosystem restorations to be successful, we need to develop new institutional mechanisms that can help surmount these challenges and alter incentives that drive degradation.

National governments have a poor track record for leading effective and consistent long-term restoration actions. Scaling up requires clear goals, resource mobilisation, technological expertise, inclusive and informed governance schemes and monitoring protocols, which are often absent from ecosystem restoration efforts in many countries (Guariguata and Brancalion, 2015). Political agendas are generally focused on achieving short-term goals. These realities can compromise the effectiveness of multinational agreements and resolutions, and challenge the creation of policy and market incentives and disincentives for tipping the balance towards restoration (Brancalion et al., 2017).

There is an urgent need to identify fit-for-purpose ecosystem solutions. The Decade on Ecosystem Restoration is partly a communication exercise to convince resource managers, rights holders, planners, decision makers and engineers that ecosystem restoration and healthy functional ecosystems can help meet their goals (Table 1). This requires re-orienting restoration strategies to accommodate the operational needs and visions of decision makers in each biogeographical context. Today we have a better scientific understanding of the benefits and costs of ecosystem restoration; methods to help

develop strategic portfolios of restoration measures and to predict the responses of species and communities to individual and multiple-stressor configurations (Palmer et al., 2005; Sabater et al., 2018). New tools, including advances in remote sensing technology, enable low-cost monitoring of restoration progress (Reytar et al., 2021) and a better understanding of funding mechanisms, participatory approaches and enabling conditions. These new approaches will need to be deployed to strengthen local social networks that can advocate for restoration because it meets their needs. For instance, strengthening tenure could secure stakeholder benefits, through investments that facilitate business development in sustainable supply chains and by triggering sustainable financing (Lovelock and Brown, 2019; McLain et al., 2021). Fit-for-purpose restoration will need to attend to both what information is delivered and how it is delivered to multiple decision makers and planners, whose background may be in agriculture, economics, law or politics and who may have limited knowledge of biodiversity and ecosystem processes. Additionally, we need a continued research effort to develop, test and adapt tools to ensure ecosystem restoration is based on best scientific knowledge.

How can individuals, groups and sectors contribute to effective ecosystem restoration actions?

Different social agents, motivated by differing needs, can all contribute to the restoration process. The impetus for restoration can come from individuals, communities, governments, non-governmental organisations or the private sector, and its implementation can happen under a wide range of governance mechanisms and financing arrangements (Mansourian and Sgard, 2021; Walters et al., 2021). In the restoration supply chain, farmers or land managers, for example, often provide critical knowledge, labour, land and materials, while investors and financiers can provide capital and promote restoration activities that yield a return on investment (see Key message 4). Government agencies are, often, involved in planning, assessment and policy development (see Key message 5), with research groups and civil society organisations providing data and tools, raising awareness, communicating and demonstrating restoration possibilities. Different actors (see Table 2) will need to be aligned under the right set of enabling conditions (Key message 2) for successful restoration. This alignment is, however, not always easy to achieve and may require innovative institutional arrangements, supported by critical financing (Kingsford et al., 2021).

Local actions are essential avenues for ecosystem restoration across urban and rural spaces. Local community and landscape stakeholders will need to be at the centre of restoration movements, as they often have the knowledge to guide and the motivation to proceed or block restoration if it does not benefit them (Valencia, 2019; Gritten et al., 2018). Furthermore, decision-making processes that ignore local knowledge or cultural traditions and the legitimate role of communities as stewards of land and waters, are unlikely to be successful (Reyes-García et al., 2019). Individual restoration actions can be small-scale but when combined, within appropriate landscape planning, can have a large-scale impact. Local activities can include many different opportunities, such as restoring community land or public areas (rural and urban), establishing community gardens and farmers' markets to support local production, sharing cultural values and practices, and involving schools, clubs, youth groups, women's collectives, sport teams and religious organisations to establish or monitor plants, coral reefs, animal populations or assist in natural habitat recovery (Constant and Taylor, 2020). Community engagement in restoration can boost social capital and livelihood security in addition to providing direct economic benefits (Valenzuela et al., 2020; Wainaina et al., 2021). Restoring urban green spaces provides opportunities for engagement of local governments (Case study 3). In both rural and urban contexts, communities and institutions can partner with groups in other regions to enhance their knowledge of ecosystem processes, scale up their effort and maximise beneficial outcomes (Hall et al., 2021). Some stakeholders may require scientific and technical support to understand, visualise, design and implement best practice within their restoration plans and actions.

Corporate sectors and industry leaders can be powerful champions of ecosystem restoration by changing market incentives. The risk to businesses from nature loss has become material and therefore the incentive to engage in preserving and restoring ecosystem function has gained strategic importance particularly for those companies directly relying on these services for the products that they are sourcing. As a result, a growing number of coalitions and platforms suggest that corporate and industry leaders are recognising their pivotal role in creating net positive practices in their supply and market chains, including the Net Positive Project and the 1t.org Corporate Alliance. Corporate leadership has the power and the potential to meet the needs of both stakeholders and implementers. Commitment voiced by coalitions of corporate as well as financial actors has led to optimism in recent years (see Key message 4). For example, six Principles for Responsible Investment (UNEP, 2006) were

developed by investors to embrace environmental, social and governance factors in global investment practice. The number of signatories to these principles has increased significantly over the last few years, from under 1,500 in 2015 to over 3,500 in 2021 (PRI, 2021). Moving from aspiration to action must be the next critical step. More than 20% of the world's largest 2000 companies now have net-zero targets, which heightens their interest in ecosystem restoration and increases the potential of interventions such as Natural Climate Solutions for unlocking investment from the private sector (World Economic Forum, 2021b).

Table 2. Different types of social agents and entry points for their engagement in ecosystem restoration

Social agent	Entry points for engagement in ecosystem restoration	What has helped or prevented this happening before 2020?	What needs to change to enable this to happen more in the future?
Landowners, landholders, managers and workers that own or manage the areas to be restored, including Indigenous Peoples and local communities, farmers and fisherfolk	People and communities play a critical role in ecosystem restoration, as they work and live in the ecosystems to be restored and are directly impacted by ecosystem degradation. Local ecological knowledge generated by Indigenous Peoples and local communities forms the basis through which restoration decisions can be made to both leverage natural recovery processes and benefit local livelihoods (Reyes-García et al. 2019).	Local communities have not been consulted, nor local knowledge taken into account. Appropriate local organisations were not in place to involve them. Planners and decision makers were not sufficiently aware of the value of local community involvement.	More awareness raising and training is required for planners and decision makers to help them realise that local land user community involvement can produce positive outcomes and local knowledge can strengthen interventions and make them more sustainable. Training is needed for the communities on sustainable land use/management. Install improved governance structures and leaders in the communities so that common problems can be raised. Local institutions (for instance, watershed management organisations) may need to be strengthened to enable collective action required for managing shared ecosystem resources.
Private sector companies and industries	The private sector can influence the actions of landowners and managers, tipping the balance from restorative/sustainable resource use to degradative/ unsustainable use. Companies influence the supply and market chains for the inputs and the outputs of ecosystem restoration. Entrepreneurship for ecosystem restoration can bring innovation, create jobs and increase investment in local enterprises. The agriculture, forestry, water supply, energy and mining sectors are major stakeholders in ecosystem restoration and can become engaged at many levels.	Many private sector companies have not recognised the benefits of ecosystem restoration and not given adequate incentive to support actions. The costs of ecosystem degradation have not been internalised within private sector finances, though this is changing.	Planners and decision makers need to work in partnership with landowners and managers in ecosystem restoration, to bring innovation, create jobs, and increase investment in local enterprises. Large companies, who are often large landowners, need to be included as they have resources and power to implement ecosystem restoration. Incentives to encourage private sector engagement in sustainable or restoration practices are required along with procurement practices that support restoration and regenerative practices, and enabling environments for local regenerative enterprises. The costs of ecosystem degradation need to be internalised more widely within private sector finances. Global agreements related to biodiversity and climate change, with accompanying national policies, can help shift the norms among private companies, enabling them to attend to restoration needs.
Government agencies and organisations	Governments are key agents of restoration at local, regional and national levels (Chazdon et	Governments have tended to opt for development projects based on built infrastructure as	Governments need to direct the flow of more public finance into ecosystem restoration projects and

Continued...

Social agent	Entry points for engagement in ecosystem restoration	What has helped or prevented this happening before 2020?	What needs to change to enable this to happen more in the future?
	al., 2020). Local governments play a critical role in supporting ecosystem restoration, particularly when they partner with local businesses and community organisations. Regulations and government institutions mediate interactions among social agents and influence who pays costs and who receives benefits. These governance arrangements include legal instruments and policies, roundtables, market regulations and cooperation among countries. Governments control the flow of public finance into ecosystem restoration projects and programmes, including construction of infrastructure, funding of incentive or compensation programmes, and providing services and utilities to communities.	safer options and have tended to view ecosystem restoration as a 'nice to have' rather than an essential element.	programmes, including construction of infrastructure, funding of incentive or compensation programmes, and providing services and utilities to communities. Natural capital accounting can help reflect the contributions of healthy ecosystems on a national level and price the risks associated with nature's losses. Clear incentive systems, such as payments for ecosystem services and environmental safeguards for public procurement are required.
Finance and investment sectors	Private sector investors play key roles in supporting ecosystem restoration in ways that complement and enhance public sector investments. Private sector investment can take many forms and can also involve partnerships with local governments and businesses (Key message 4).	Investment opportunities in ecosystem restoration were limited or not attractive to investors.	More opportunities need to be initiated to integrate private investors in ecosystem restoration in ways that complement and enhance public sector investments. Reductions in barriers to growth in offset markets would also provide additional financing.
Civil society (non-governmental organisation)	Civil society organisations can play key roles in resource mobilisation, capacity building and raising awareness on the degradation of ecosystems and the need to restore them. These include women's, youth and environmental organisations.	Civil society organisations were often not fully involved or represented adequately and did not have confidence that outcomes could work in their favour.	Involvement of civil society organisations needs to be mainstreamed and support provided to ensure they have essential information in a form they can understand and are represented adequately in planning and decision-making. New global coalitions (for instance, the Extinction Rebellion) can galvanise civil society to support restoration.
Research groups	Researchers have a key role in identifying and communicating the causes of degradation. They need to design appropriate restoration interventions based on scientific understanding of ecological processes, recovery potential and social, economic and political dimensions of different restoration approaches.	Research results have been employed in many projects, but ignored in others either deliberately or due to lack of availability in readily understandable form. The evidence base for restoration practices is poorly developed and communicated, despite strong research, such as in the positive and negative influences of forests (Gilmour, 2014) and wetlands (Bullock and Acreman, 2003) in the water cycle.	Research results need to be synthesised and made available in understandable form, such as the effectiveness of nature-based solutions to water problems (Acreman et al., 2021). Further research and outreach efforts are required to enable the outcomes of ecosystem restoration to be projected accurately and for adaptive management strategies to be defined. There are also research gaps in identifying how short- and longer-term trade-offs can be minimised.

Note: Specific restoration actions for each of these groups are listed in Table 5.

What are good starting points to implement long-lasting ecosystem restoration?

Implementing ecosystem restoration will be easier and more likely to succeed when founded on a common set of widely shared principles. Shared understanding and principles can reduce uncertainty regarding what actions may benefit different stakeholders and avoid unintended consequences (see Key message 1). A global consultative process was underway in 2021 to adopt principles for ecosystem restoration to underpin implementation throughout the UN Decade and across sectors, biomes and regions (see the ten principles below). Alignment on principles may also help create large, like-minded coalitions and enable partnerships that support joint action for up-scaling restoration successes. Partnerships (SDG 17) are essential to bring about systemic change and to coordinate and align scientific understanding, finance, infrastructure and capacity development with implementation of ecosystem restoration actions (MacDonald et al., 2018). Within countries, multi-sector coalitions and networks can provide a highly effective platform for collective action across business, government and research (Boedhihartono and Sayer, 2012; Imbach and Vidal, 2019). They can also enable communities, such as Indigenous Peoples, for instance, to engage in and trust that restoration processes will also bring benefits for them (Arthington et al., 2018; Anderson et al., 2019).

The Task Force on Best Practices for the UN Decade on Ecosystem Restoration adopted ten principles for underpinning ecosystem restoration, following a global consultation in 2021:

Principle 1: contributes to the UN Sustainable Development Goals and the goals of the Rio Conventions.

Principle 2: promotes inclusive and participatory governance, social fairness, and equity from the start and throughout the process and outcomes.

Principle 3: includes a continuum of restorative activities.

Principle 4: aims to achieve the highest level of recovery for biodiversity, ecosystem health and integrity, and human well-being.

Principle 5: addresses the direct and indirect causes of ecosystem degradation.

Principle 6: incorporates all types of knowledge and promotes their exchange and integration throughout the process.

Principle 7: is based on well-defined short-, medium- and long-term ecological, cultural and socio-economic objectives and goals.

Principle 8: is tailored to the local ecological, cultural and socio-economic contexts, while considering the larger landscape or seascape.

Principle 9: includes monitoring, evaluation and adaptive management throughout and beyond the lifetime of the project or programme.

Principle 10: is enabled by policies and measures that promote its long-term progress, fostering replication and scaling up.

(FAO, IUCN CEM & SER, 2021)

Collaboration between sectors can be very effective in motivating ecosystem restoration. The potential for enhanced collaboration between engineers and ecologists is a prime example. Finding solutions to natural resource management issues is often not a simple choice of either hard engineering or nature-based solutions; where appropriate ecosystem restoration integrates with built infrastructure to provide optimum solutions to human welfare, development and conservation issues (Case studies 5 and 6).

Platforms can speed up the process of scaling up restoration. Platforms will become the 'community centres' of restoration, uniting people and organisations across borders, languages and backgrounds. They can make restoration action visible and will create entry points for engagement, knowledge exchange, monitoring, and communicating lessons learned and effective practices (see for instance, the UN Decade online platform that seeks to provide information and facilitate linkages amongst different components of the global restoration movement). In a globalised, digital and connected world, online restoration platforms are likely to play a key role for integrating restoration movements, tracking progress and disseminating good practices. Platforms can also provide data and technical skills to enable spatial planning (Linke et al., 2019), which can help ensure that ecosystem restoration brings social, economic and environmental benefits to multiple stakeholders (see Key message 3). Good examples of country-led initiatives exist, such as the Bonn Challenge as the largest global movement for forest landscape restoration and the regional platforms that support it such as AFR100, Initiative 20x20 and ECCA30 (Saint-Laurent et al., 2020).

Innovative restoration policies and institutions are essential for wins to biodiversity, climate and human well-being. Effective restoration actions will require a focus on governance mechanisms, property and user rights, and clarity on who has, or should have, access to resources. If these aspects, for instance, tenure-related uncertainties, are not properly resolved and integrated within restoration actions, it is unlikely that net positive outcomes will emerge for people or for ecosystems (McLain et al., 2021). Building effective governance arrangements and policies to achieve net positive outcomes from restoration is possible by increasing alignment and interaction across sectors and levels of government (Chazdon et al., 2021b). Existing policies, institutions and power relations may create obstacles for ecosystem restoration and may require modification and realignment to provide the right enabling conditions (Sapkota et al., 2021; Sayer et al., 2021). Institutional arrangements need to address the spatial and temporal mismatch between restoration benefits and socio-economic needs.

KEY MESSAGES

Key messages to inform the framework for the reversal of ecosystem degradation

1. Ecosystem restoration offers multiple benefits though they may be unevenly distributed

Ecosystem restoration has the potential to produce multiple social and environmental benefits. Restoration is an approach that can raise capacity for environmental stewardship within communities (Kittinger et al., 2016), enhance people's mental and physical health and well-being (Aronson et al., 2020; Breed et al., 2020), help mitigate and adapt to climate change (Example 1: Key message 1), improve water quality (Acreman et al., 2021), reduce soil erosion (Teng et al. 2019), restore soil fertility (Case study 7) and prevent species extinction (Newmark et al. 2017). In many cases, benefits can be long-lasting and cost-effective (Reij and Garrity, 2016), broadening ecosystem-related options for future generations. However, in some cases there will be trade-offs where ecosystem restoration disbenefits some members of society.

Ecosystem restoration, typically a nature-based solution, can complement technical engineering solutions and production-based ecosystems. Natural and engineered infrastructure can work together to increase benefits for society and the environment (Case study 4). Where engineered infrastructure is required, ecosystem restoration should also be implemented to support effective functioning and to mitigate potential damage to local ecosystems. Ecosystem restoration can also be implemented at larger scales, such as catchment landscapes, coastal areas and seascapes, to provide refugia and corridors for biodiversity, to protect water supply, and to create buffers that minimise impacts of windstorms, floods, landslides, tsunamis and fires. Built infrastructure can be repurposed to support ecosystem restoration (Case study 5). Natural systems can be engineered to increase goods and services (Case study 6). For example, many countries around the world receive flood protection benefits from natural and replanted mangroves (Menéndez et al., 2020).

Different outcomes and benefits and costs from restoration actions become manifest over different temporal and spatial scales. Benefits and some outcomes may be achieved only after a significant time, particularly in the case of forest and coral reef restoration where tree and coral lifespans can exceed several centuries. High up-front implementation costs and delays in receiving material benefits are major obstacles to ecosystem restoration. Innovative financing approaches and new institutional arrangements are needed to overcome these impediments to action (see Key message 4).

Understanding the distribution of benefits and costs associated with restoration is as critical as assessing the overall returns to restoration investments. Land, coastal waters, rivers and ocean systems are often contested resources that are used by multiple stakeholders. Thus, aggregate benefits from restoration can hide significant imbalances (Lele and Srinivasan, 2013, Example 2: Key message 1), with benefits skewed towards a few stakeholders and costs borne by others. Restoration decisions can be replete with trade-offs. For example, restoring forests and headwater wetlands may be good for biodiversity and climate mitigation, but usually reduces downstream water yield (Filoso et al., 2017; Acreman et al., 2021). Or, provisioning ecosystem services can be unevenly distributed among community members and forest user groups (Lakerveld et al., 2015), leading to challenging questions regarding who may benefit if degraded forests are restored. Also, as discussed above, the costs of restoration may occur immediately, while the benefits occur over time. Identifying how, when and to whom the benefits of restoration accrue is critical for successful restoration. Inclusive engagement in restoration planning from the onset may contribute to more equitable distribution of net benefits (Hall et al., 2021) and increase the potential for successful restoration.

2. Key enabling conditions, particularly local norms and governance, can tip the balance towards restoration

Robust restoration entails negotiating and balancing multiple objectives. Restoration actions and decisions emerge from interactions between actors with competing claims and interests across biophysical, biodiversity, livelihood, gender or spiritual parameters (Mansourian, 2021). Stakeholders might expect different outcomes from managing a shared natural resource (Stanturf et al., 2019). Understanding the political, social and economic processes that influence decision-making at multiple scales and across different stakeholder groups is key to navigating potentially conflicting motivations to restore ecosystems (Ellis et al., 2021). Global motivations to restore ecosystems (e.g., avoiding species extinction, climate change mitigation or adaptation) may not resonate with local motivations to restore, which often centre on local needs (e.g., clean water, spiritual and livelihood benefits) (Holl and Brancalion, 2020; Höhl et al., 2020). Within any location, people's motivation to restore will depend on ecological, social, political, economic and legal contexts, influenced by historical processes, social relations and inequities. These motivations may be overlooked if rapid 'at scale' restoration initiatives prioritise top-down approaches as opposed to plural, democratic and localised strategies (Ellis et al., 2021). Simultaneously, satisfying global demands will be critical to safeguard financial support. Mechanisms and strategies at multiple scales, ranging from global agreements to community-driven associations, that can negotiate varied interests are vital for long-term restoration.

Restoration requires forging enduring and meaningful partnerships with local peoples and institutions. Designing restoration actions in a way that is inclusive, responds to local perceptions and demonstrates how restoration can meet local needs is key to successful restoration in places where people use the land (Wilson and Coomes, 2019). Degradation of natural resources is often driven by conflicts over ownership, unclear tenure, and/or weak governance (International Fund for Agricultural Development (IFAD), 2016). For instance, while half the Earth's terrestrial area falls under the customary ownership of Indigenous Peoples and local communities, only a tenth has any legal recognition (Rights and Resources Initiative, 2015). Secure tenure and property rights are absolutely critical for restoration success (Bissell, 2020; Mansourian, 2017; McLain et al., 2021). They are foundational for local governance, resource stewardship, livelihoods, benefit-sharing and the realisation of human rights (Larson and Springer, 2016). Without clearly recognised rights, respect for rule of law, law enforcement and accountability mechanisms in place; local norms, conflicts, histories and traditional knowledge systems (Lopes et al., 2021) (see Example 3: Key message 2) can be overlooked, making restoration success uncertain.

Restoration policies and actors span multiple government sectors. Many of the systemic changes required to foster ecosystem restoration rely on government decisions, through policy interventions that promote or hamper degrading and restorative activities. Government incentives are particularly important for promoting restoration of public goods that are not monetised and are not attractive to private sector investment (Ding et al., 2017). Several countries have made ambitious pledges to global restoration commitments to achieve climate and other global ecosystem service goals, but achieving these goals relies on integrating restoration pledges across multiple political and regulatory levels, so that national aspirations can become action plans that are able to mainstream restoration on the ground (Holl, 2017). Like any emerging economic activity, restoration is likely to proceed more rapidly with government support to overcome critical barriers and reduce risk for private investments (Hanson et al., 2015; Chazdon et al., 2017). The establishment of cross-sectoral restoration initiatives aligned with public policies and social agendas at multiple levels can leverage restoration actions, reform tenure regimes and link local interventions with political aspirations (Rights and Resources Initiative, 2020) (Case study 2). The growth in new markets for nature-based solutions is illustrative. Currently, few countries recognise community rights to carbon on lands owned or designated to communities. Thus, as new financial opportunities rise, we will need adaptations to existing legal frameworks or new frameworks that incentivise local action and benefit-sharing while safeguarding against elite capture (Rights and Resources Initiative and McGill University, 2021).

The scaling up and the dissemination of ecosystem restoration may call for the phasing out of counterproductive policies and subsidies and the repurpose of resources for conservation and restoration. The current agricultural policies and subsidies are often not conducive to conservation and restoration goals. In fact, support for conservation, production retirement and other public goods account only for 5% of

the US$ 600 billion per year in agricultural financial support provided on average, from 2014 to 2016, by countries that produce two-thirds of the world's agricultural output (Searchinger et al., 2020).

Combining and co-producing traditional and scientific knowledge is the key to effective restoration. Ecosystem restoration is a multidisciplinary activity that can be promoted through many different approaches and relies on different types of knowledge. Having the right information and expertise available to guide decisions in the appropriate timing is key to overcoming the ecological and social barriers preventing an effective and long-lasting restoration process. Both traditional knowledge and scientific knowledge are equally vital, and must be properly integrated and harmonised (Arthington, 2021). Research and development initiatives can greatly contribute to creating restoration solutions that help address implementation challenges. In many cases, critical information exists but is not available for decision makers. Combining traditional and scientific knowledge requires equitable partnerships and reconciling historical processes that marginalised plural knowledge systems to allow their entry into policy (Anderson et al., 2019). Capacity-building initiatives that focus on applying knowledge to practice in a way that is fitting and appropriate to the local context can be an important step towards creating enabling conditions for restoration (Bloomfield et al., 2019). The co-production of interdisciplinary knowledge will require engaging with diverse and legitimate biodiversity perspectives and applying ethical and adaptive procedures negotiated with local actors (Pascual et al., 2021).

Some places are more amenable to restoration than others. Many different enabling conditions exist, with their relative importance for restoration varying across different socio-ecological contexts. Many previous documents have addressed this topic. Table 3 presents a comprehensive, but not exhaustive, list of enabling conditions that are generally important for restoration success that focus on governance and rights. One strategy for ecosystem restoration is to focus efforts on localities where the conditions are most likely to yield successful outcomes and reduce costs and risks (see Key message 3). Where key enabling conditions are not present, it is often critical that additional resources be invested to create them (Baynes et al., 2017).

Table 3. Key aspects of local governance and rights relevant for ecosystem restoration

Aspect	Guiding questions to assess status or situation	Potential action based on assessment	References
Land tenure and rights	*Are resource rights/ tenure arrangements secure and amenable to restoration (including zoning regulations)? Do landholders feel that their rights to access/manage resources are secure?* The perception of secure land tenure/use rights is key for successful restoration in a range of contexts, as it allows those managing the land to benefit from the restoration in the future. *Is there political will to recognise land rights?*	Governments need to recognise, assess and adapt land and user rights where necessary to allow those governing or managing the land and water to benefit from the restoration in the future.	Baynes et al., 2015; Baynes et al., 2017; Byron, 2001; Cronkleton et al., 2017; Mansourian et al., 2019; Mercer, 2004; RRI, 2020; Wilson, 2016
Engagement of women and marginalised groups	*Are women engaged in decision-making processes around natural resource use and rights? Are there marginalised groups who depend on natural resources for their livelihoods? Are the access, benefits and control equitable?* Gender, race, caste, class and so forth can affect how people interact with their environment, and different groups may consider different benefits more or less important. Women in particular have been found to be essential for nature conservation in a range of contexts. Engaging the full spectrum of users is important for restoration success.	Governments, NGOs, civil society organisations and others involved in implementing restoration need to engage community members in decision-making processes in an inclusive way, with a special effort to include voices that may otherwise not be heard, and address gender inequalities.	Baynes et al., 2019, Broeckhoven and Cliquet, 2015; Singh et al., 2021; Siqueira et al., 2021
Polycentric governance structure	*Does the region have mechanisms in place for, or a history of, collaboration and partnership between different levels of governance?* Polycentric governance – where many different governing levels and bodies work together to make and enforce rules – can promote restoration because it is more adaptable and less risky than other governance models.	Implementers should work to connect different relevant governing bodies and levels through engagement, awareness building, training and (if needed) governance restructuring to ensure collaboration and partnership between different scales and levels of governance.	Carlisle and Gruby, 2019; Long et al., 2018; Ota et al., 2020
Political context	*Are social conditions transparent and relatively stable (e.g. in terms of political stability and internal conflict)? Are culturally appropriate systems in place for conflict resolution and rule enforcement?* Areas that are politically unstable may be more subject to conditions that could detract from restoration (including corruption, lower prioritisation of restoration compared to other issues, more pressing issues, volatility around rights and tenure, etc.). Conversely, locally relevant processes for resolving conflict can aid restoration implementation and promote longevity.	Awareness building and training are required for planners and decision makers to appreciate how resolving conflict can aid restoration implementation and promote longevity. Places where conflict is rife may not be the best candidates for restoration until conflict is resolved.	Baynes et al., 2015; Le et al., 2012
Policy context	*Is the policy context supportive of restoration or do policies contradict each other? Do 'overlapping policies' – where*	Policies governing resources at the national and sub-national levels	Baynes et al., 2015; Chazdon et al., 2016; Djenontin et al., 2018

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Aspect	Guiding questions to assess status or situation	Potential action based on assessment	References
	some policies support while others do not – exist? Policies governing resources at the national or sub-national levels can promote or hinder restoration, even if the policies do not address restoration explicitly. Overlapping policies can cause confusion and regulatory issues during implementation.	need to be reviewed and changed to ensure they promote rather than hinder restoration.	
History of social cohesion	*Are communities or areas with a history of community cohesion and self-organisation present? Do areas have a history of self-organisation, working collaboratively across sectors, or social movements?* Where there are local conflicts over resource use or there are no systems in place of working together, the social investment required to restore can be considerable. Finding places where people are able to work well together is important for cost-effective restoration.	Implementers should focus on finding places where people are able to work well together for mutual benefit through cost-effective restoration. Where social cohesion is lower, implementers may have to invest in trust building, resolving local conflict and/or developing community groups and collective governance capacity.	Baynes et al., 2017; Wilson and Coomes, 2019
Local leadership	*Are leaders able to engage with restoration?* Visionary leaders can be important for bringing restoration into the culture of a local area and building the support needed for lasting stewardship.	Implementers can identify, train and support leaders and champions for ecosystem restoration to develop and enhance a culture of restoration within development activities.	Le et al., 2012; Metcalf et al., 2015; Nerfa et al., 2021; Wilson and Coomes, 2019
History of resource use/culture	*Do regions have a history of sustainable natural resource use and management, and/or ties to the resource base?* Places with a history of natural resource use and management may make good candidates for restoring ecosystems for livelihood benefits.	Implementers, governments, researchers can create partnerships with communities and document good practices where restoring ecosystems through sound natural resource use and management has benefitted livelihoods and use these to catalyse work in other areas.	Reyes-García et al., 2019
Market access and information	*Do communities/organisations in the region have a history of local production through cooperatives or other means? Are there existing mechanisms for coordinating market access?* If this is not the case, resources will have to be allocated to develop them.	Implementers can provide support to create co-operatives and associations for aggregating production, (for example, sustainable shade-grown coffee cooperatives). Allocate resources and time to developing mechanisms for ensuring market access.	Byron, 2001; Le et al., 2012; Brancalion et al., 2017
Knowledge and its availability	*Is a plurality of knowledge – local, traditional, scientific, citizen science approaches that produce evidence, etc. – accessible to planners and decision makers? Is local knowledge incorporated or documented?* Scientific, local and traditional knowledge are crucial for making the right decisions in restoration	Implementers and planners can: 1) undertake assessments of available local and scientific knowledge; 2) ensure the active equitable inclusion and participation of knowledge holders; 3)	Djenontin et al., 2018; Reyes-García et al., 2019; Garzón et al., 2020; Chazdon et al., 2021a

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Aspect	Guiding questions to assess status or situation	Potential action based on assessment	References
	projects, so critical knowledge for guiding decisions must exist and be available, understandable and adapted to be readily incorporated in decision processes. *Are certain systems of knowledge being actively or passively excluded from decision-making?*	ensure that all knowledge is available in appropriate forms and languages, and 4) ensure knowledge gaps are identified and investment is made into future research and knowledge revitalisation. Technical advisors need to be available to help those with different expertise or experience.	

3. Effective ecosystem restoration requires managing trade-offs equitably

The goals and values of stakeholders, when properly represented, will often drive restoration-related actions. Restoration can result in varied benefits and costs, with stakeholders and rights holders weighing these benefits and costs differently based on cultural values and knowledge systems (Constant and Taylor, 2020). Planners, practitioners and communities often face a menu of decisions regarding benefits and outcomes, ecosystem types to restore, restoration methods to use, species to plant, location and area targets, financing, and considerations of risks and uncertainties (Brancalion et al., 2019). The decision problem is complex because all aspects can, and typically do, vary by location and time across landscapes, and the relative importance of each aspect can vary across stakeholders. Thus, to ensure success, it is crucial that different perspectives are thoroughly understood and accounted for in a spatially explicit manner. Participation should be promoted across all steps of a restoration process, from vision, design and implementation to monitoring (Evans et al., 2018; Kingsford et al., 2021). To make participatory planning a reality, restoration planners and other actors will need to set aside the necessary time and resources.

Critical trade-offs among different ecological, economic and social objectives and outcomes may emerge in a restoration programme. Restoration may create winners and losers and inescapable trade-offs (Case study 8). Nature's contributions to people will vary over time and space. Early stages of restoration often provide greater regulatory services, with older stages providing greater provisioning services, such as timber products (Naime et al., 2020; Zeng et al., 2019). Generally, forests can increase infiltration of water into the ground but this does not make up for very high interception and evaporation losses, so that overall forests reduce water yield downstream in the same catchment (Filoso et al., 2017; Acreman et al., 2021), even if potentially increasing water yield elsewhere via increased precipitation. Furthermore, headwater wetlands normally increase floods and reduce water resources (Bullock & Acreman, 2003; Acreman et al., 2021). In arid and semi-arid regions, increased vegetation cover from restoration can decrease water flows (Shi et al., 2021). Additionally, restoration of urban wetlands can expose humans to mosquito- and other vector-borne diseases; and the maintenance of large woody debris in rivers to provide fish habitat can create a recreational hazard (Finlayson and Horwitz, 2015). These realities highlight the need to develop a shared understanding of benefits and potential costs that different groups may experience from restoration over time to motivate people and mobilise resources (Boedhihartono and Sayer, 2012).

Trade-offs can be better analysed by addressing key questions related to the distribution of restoration costs and benefits in the planning process. These questions are: 1) How do ecosystem goods and services change with degradation, conservation or restoration? 2) What are the causes and risks of ongoing ecosystem degradation and who gains and who loses? 3) What benefits/outcomes/disbenefits are likely to be achieved with restoration, at what time scales, and what is their distribution? 4) What are the implications of identifying trade-offs for restoration priorities? 5) Which areas or types of restoration may maximise multiple benefits while minimising costs? 6) Where and when should restoration actions be scheduled in space and time? 7) Where and how intensively should restoration actions be implemented? Answering these questions and negotiating between different viewpoints is fundamental for lasting

Best practice for the use of scenarios for restoration planning

1: Spatial planning process must involve, engage and consider aspirations of a broad range of stakeholders, regardless of their land tenure status. This process needs to be facilitated and scientifically as well as socially informed but does not prescribe decisions. The input of diverse stakeholders remains an essential part of the planning and decision process.

2: Decision-support strategies need to be designed to inform both top-down policy and bottom-up ecosystem restoration initiatives based objectively on best available scientific and local knowledge.

3: It is usually not possible to maximise multiple aspects and outcomes simultaneously as there are trade-offs, interactions, feedbacks and time-lags among them. Evaluating trade-offs among benefits/outcomes/disbenefits and costs is critical for reaching better-informed decisions, and balanced, 'good compromise' solutions. This approach enables the identification of solutions that perform well against multiple benefits/outcomes/disbenefits and costs.

4: Scenario analyses can be used to compare the performance of alternative restoration options, actions and policies, and are important to facilitate communication among scientists, practitioners, landowners and decision makers. Evaluation of the expected benefits/outcomes/disbenefits of restoration actions, including 'business-as-usual' approaches is key for evaluating the expected improvements in performance relative to existing alternatives.

5: Monitoring, adaptive management, capacity building and knowledge exchange are key for the successful implementation and review of the spatial planning process (Key message 5).

Metzger et al., 2017

and successful restoration (see the five pointers above) (Metzger et al., 2017). Partnerships with practitioners and scientists are critical and require that scientists participate in on-the-ground restoration projects and collaborative decision-making. Successful restoration projects are characterised by community involvement and transfer of knowledge among scientists, practitioners, community members and administrative organisations in the decision-making process (Dickens and Suding, 2013). It is critical to consider research groups' knowledge of ecological processes and interactions alongside site-specific knowledge of stakeholders.

Robust restoration spatial planning to support decision-making can increase the likelihood of cost-effective and sustainable restoration outcomes. Spatial restoration planning can help make restoration decisions that clarify benefits, acknowledge trade-offs and limit the risk of restoring ecosystems in inappropriate places (see Example 4: Key message 3) (Strassburg et al., 2019, 2020; Hermoso et al., 2015). Spatial planning also helps ensure that decisions are ecologically sound and cost-effective, which is important given the inevitable need to make some compromises among ecosystem restoration ambitions, demands from other important development challenges and available financing (Example 5: Key messages 3 and 4). It is important that spatial planning incorporates social aspects at the appropriate scale and through inclusive processes, or clarifies its limitations when unable to do so.

National governments, international organisations, local communities and other restoration stakeholders at sub-national levels need to identify and prioritise cost-effective locations for restoration actions. Locations where benefits are high relative to their socio-economic costs and risks are places where restoration is more likely to achieve sustainability (Hermoso et al., 2015). These locations are also where restoration actions are more likely to attract private investment needed to augment government funding and official development assistance. As the global community prepares to scale up efforts during the UN Decade on Ecosystem Restoration, it is important to support decision makers with a robust spatial restoration planning approach and process to strike the right balance across different restoration aspects. The five guidelines below synthesise conceptual understanding, applied frameworks and key principles to help create the social capital needed to manage and deal with restoration trade-offs through a robust spatial restoration planning approach and process.

4. Finance and market infrastructure is critical for scaling up and sustaining ecosystem restoration

Restoration investments need public and private sources of finance. Restoration needs exceed the budgets of national governments, international donors and multilateral development banks (Sewell et al., 2020). While restoration can generate significant net benefits (e.g. forest landscape restoration may create between US$ 7 and US$ 30 for every US$ 1 invested (Verdone and Seidl, 2017)), there is an estimated US$ 300 billion per year shortfall in global funding for restoration and conservation combined (Ding et al., 2017). Filling this global investment gap will require financing from both public and private sectors (Liagre et al., 2015). Emerging from the COVID-19 pandemic, economic recovery packages in several countries have enhanced the availability of public funding for restoration tied to rural development, climate change and biodiversity conservation. For example, some resources tied to the EU's long-term budget 2021–2027 and NextGenerationEU (budget of €1.8 trillion), aimed at rebuilding a post-Covid Europe (Directorate-General for Budget, 2021), will contribute to restoration. More generally, in addition to funds directly allocated to restoration, public schemes focused on rural development also offer resources for restoration. For instance, India's Mahatma Gandhi National Rural Employment Scheme, one of the world's largest livelihood support programmes, supports large-scale land restoration (Ravindranath and Murthy, 2021). Private funding for restoration can be tied to different sources such as corporate social responsibility funds, market-based carbon offset schemes, or mitigation banks and various financial instruments (see Example 5: Key messages 3 and 4).

There is a business case for corporations to invest in restoration. Increasing evidence of the negative effects of land, sea, freshwater and climate deterioration, growing realisation of how these nature losses directly affect business (World Economic Forum, 2020), pro-environmental consumer preferences, regulatory changes and shifts from a shareholder to stakeholder models (Schoenmaker, 2017) have begun to shift private sector incentives, encouraging companies to look beyond short-term profits. A business case for restoration lies in recognising that there are restoration opportunities to grow profits, reduce risks and increase business resiliency, and provide value-based leadership (World Economic Forum, 2021 a, b). In the US alone, the restoration economy creates US$ 25 billion per year in economic output, including US$ 9.5 billion in direct annual revenue and US$ 15 billion annually in economic output through indirect (business-to-business) linkages and increased household spending (BenDor et al., 2015). In southern England, recent evidence points to landscape-scale restoration of agricultural land potentially increasing the contribution of farmland to economic development and employment by increasing flows of multiple ecosystem services (Newton et al., 2021). Carbon-markets, though currently small, are growing in the forest and land use space (Forest Trends' Ecosystem Marketplace, 2020), offering additional market-based financing opportunities.

Many public and private sustainable finance instruments are available to support restoration. Restoration's potential to address multiple global challenges such as climate mitigation, poverty alleviation and biodiversity loss has stimulated the development of several innovative financial instruments (Table 4), including those that supply capital (equity and debt instruments including green bonds) and mitigate risk such as insurance mechanisms. Financial and market mechanisms, which offer products or services that make a profit while restoring lands and waterways, can create the right economic incentives for restoration (Brancalion et al., 2017; Besacier et al., 2021). However, matching financial instruments to the scale of opportunities available will require significant modifications to private sector operations. For instance, the low-risk appetite of institutional actors such as long-term pension funds and bureaucratic procedures, and time scales at which corporations operate, run counter to the needs of local restoration actors. Institutional innovations such as blended finance mechanisms, which bring together private financing with public or philanthropic resourcesand intermediary organisations, which can respond to local needs while reducing investor risks (Example 5: Key messages 3 and 4), will need to grow.

A restoration economy can mobilise local stakeholders through local livelihood enhancement, job creation and business development. Jobs, business opportunities tied to a restoration economy, and clarity on how restoration complements and improves local livelihoods, are essential for restoration to occur at global scale. In the US, for instance, the restoration economy supports some 220,000 jobs (BenDor et al., 2015) and India's rural employment guarantee scheme employs millions of people to undertake land restoration (Ravindranath and Murthy, 2021). Coastal habitat restoration projects in the US created an average of 17 jobs per US$ 1 million spent, a similar ratio to conservation sectors, and much higher than traditional industries including coal, gas and nuclear energy

generation (Edwards et al., 2013). Generally, initiatives that link restoration to broader economic, social and cultural activities are likely to grow because they add value on multiple fronts. Delivering such an approach, however, requires planners to recognise that restoration is more than a technical activity (e.g. tree planting). National regulations need to incentivise restoration, and financial opportunities should be made accessible to a wider group of restoration actors over lengthier periods.

The private sector can be a major driver of restoration, with the right enabling policies and incentives. Private financing is generally based on assessments of returns and risks to investors. Policies and incentives that increase revenues (e.g. improve price and market conditions for restoration products by reducing competition from illegal deforestation; regulations that lead to a higher value of carbon sequestration), reduce costs (e.g. improved tax structures) and mitigate risks (e.g. improved legal frameworks supporting investments in restoration) can contribute to an increase in private investment in restoration. The uneven distribution of costs and benefits of restoration projects can make them risky investments. Additionally, where restoration primarily yields public benefits (for instance, improvements in water quality) and few short-term private benefits (improved agricultural yields or jobs, for example), private financing may be limited to the realm of corporate social responsibility. On the other hand, with the right conditions, restoration products (e.g. sustainable wood harvesting) and services (e.g. carbon sequestration) can provide attractive returns to investors. Public actions that increase mutual knowledge among financiers and restoration communities about their respective domains and improve trust among governments, investors and civil society would contribute to growing private financing (Tobin-de la Puente and Mitchell, 2021). National and sub-national institutions have an essential role to play as good governance will reduce risks, improve trust and increase the likelihood of funding flowing into restoration investments and environmental service payments with long-term returns (Canning et al., 2021). In addition, the social capital created by corporate social responsibility programmes can provide a kind of insurance policy that pays off when investors and the overall economy face a severe crisis of confidence (Lins et al., 2019).

Table 4. Innovative finance mechanisms promoting natural capital (restoration and conservation) - examples

Green financial instruments	What are they?	Examples
Debt-for-nature swaps	Debt is purchased from a developing country in exchange for local investments in conservation.	Leonardo di Caprio Foundation and TNC facilitated US$ 26 million low interest loan and grants for Seychelles marine project comprising 30% of ocean surrounding islands.
Mitigation and conservation banking	Credits to compensate for genuinely unavoidable environmental damage, endangered species or ecosystems. Revenues are used to conserve or protect elsewhere.	Mitigation banking instruments were introduced in the US for the protection of wetlands, with standards for mitigation banks set in 2008.
Impact investment	Aims to maximise the positive environmental and social impacts of business activities.	Eco.business Fund set up in 2014 by German Development Bank, Conservation International and Finance in Motion. Has attracted over US$ 600 million. Terra Bella Fund, a private equity fund that provides seed capital to high impact, community-based emission reduction projects.
Climate and green bonds	Debt security that can be traded between parties.	Global Environment Facility (GEF) issued Blue Bonds focused on coastal ecosystems. International Finance Corporation (IFC) issued Forest Bonds generated by the Kasigau REDD+ Corridor Project in Kenya. In 2017 HSBC launched US$ 1 billion Sustainable Bond to support SDG-related outcomes.
Biodiversity offsets	Economic instruments used to facilitate economic development whilst delivering biodiversity objectives. Should be a last resort after attempts to avoid and minimise biodiversity loss.	The EU Birds and Habitats Directives support the use of biodiversity offsets across the EU-wide Natura 2000 network.
Asset class	Broad group of investments in ecosystems that bundle projects together by region.	Credit Suisse and McKinsey launched position paper 'Conservation Finance: from Niche to Mainstream' in 2016.
Grants	Funds provided for specific purposes that are not paid back.	Adaptation Fund, an international fund for initiatives that help communities in developing countries adapt to climate change.

5. Adaptive management and monitoring are keys to effective and long-term restoration actions

Transparent monitoring, evaluation and adaptive management are integral and cross-sectional components of the ecosystem restoration process. Restoration monitoring can be conducted from a local project scale to global scale (Reytar et al., 2020). Yet, many restoration actions are not monitored and do not have any formal monitoring plan or funds allocated to monitoring programmes (Wortley et al., 2013). In a survey of restoration projects in Mexico, only 2% monitored social indicators (Méndez-Toribio et al., 2021). Adaptive management is a vital component of a project cycle; a systematic framework involving four phases: visioning, conceptualising, acting and sustaining. Feedback at regular intervals in the cycle allows for opportunities to shuffle priorities, shift implementation activities, and re-align resources in response to changing conditions and new information by continuous learning coupled with adapting to increased knowledge (Stanturf et al., 2019). Adaptive management promotes flexible decision-making to modify existing activities or create new activities if new circumstances arise or if projects are not meeting their goals. Adaptive management has been used to enhance coastal restoration projects in Florida (LoSchiavo et al., 2013), as well as in watershed restoration in Nepal (Bhattarai et al., 2021), among other examples (see Examples 6 and 7: Key message 5).

Efforts to capitalise on good practices for ecosystem restoration rely on learning from both successes and failures. Learning about how the socio-ecological system and its many components respond to ecosystem restoration actions creates opportunities to adapt and adjust in ways that reduce uncertainties, identify conditions that impede progress and improve outcomes of projects, programmes and practices (Murray and Marmorek, 2003). Often, in emphasising the success stories, failed aspects of ecosystem restoration projects, programmes, or practices are ignored and are not effectively used as learning experiences (see Key message 2; Bull et al., 2018). Efforts to capitalise on good practices for ecosystem restoration rely on learning from both successes and failures that are revealed from robust case studies, analysis of project monitoring data, and documentation of experiences and outcomes. Learning pathways are important at all levels: within government agencies that set policy; non-governmental organisations that implement programmes to achieve social and environmental impacts; investors and financiers that aim to reduce risk in their investments; corporate and industrial sectors that rely on supply chains for their products, and communities that are directly impacted by ecosystem degradation and restoration.

The goals of ecosystem restoration should be moving, rather than static targets. Ecosystems are complex and dynamic, and it is typically impossible to know how socio-ecological systems will respond to restoration action and ecosystem change (Timpane-Padgham et al., 2017). Most ecosystems and their surroundings face an unpredictable future, including significant impacts of climate change and effects of established invasive species (Belote et al., 2017). In the future, novel types of ecosystems may be outcomes of restoration, as returning to reference ecosystem conditions may not be possible or feasible (Acreman et al., 2014; Higgs et al., 2014). Although high restoration aspirations stimulate action and motivate engagement and commitments, failure to achieve ambitious or impossible goals can discourage actions, reduce investment and generate distrust. Being adaptive by proposing incremental goals and resetting aims and action plans over time in response to observed changes allows restoration actions to be embedded within a theory of change and within the context of a wide array of objectives (Newton et al., 2016; Table 2).

Effective monitoring and evaluation require baseline assessments. All too often, restoration actions are taken without a robust assessment of baseline social and ecological conditions. While available science can often provide guidance, precise knowledge of ecosystem processes is not readily transferable from site to site. Baseline ecological and social data and analysis are key to producing robust local action plans; without them real progress cannot be assessed quantitatively. Baseline assessments provide an important entry point for engagement of multiple stakeholders, allowing them to become agents of change (Arthington, 2021). Restoration actions may provide the first opportunity for input on how to halt or reduce degradation and undertake restorative actions. Baseline assessments should include biophysical indicators of degradation of land, freshwaters, or seawaters and indicators of socio-economic conditions and human well-being, indicators that are monitored throughout the restoration process.

Monitoring criteria are highly context dependent, particularly when considering the entire ecosystem spectrum of ecosystems (Figure 1). Monitoring frameworks for ecosystem restoration can be based on

a principle–criteria–indicator framework (Chazdon et al., 2020) or on a suite of project objectives (Buckingham et al., 2019). In either case, local communities can be actively engaged in the design of assessment, management and monitoring frameworks and tools. Participatory monitoring can be a highly effective way to engage local communities and to track multiple aspects of socio-ecological change (Evans et al., 2018). Successful participatory monitoring systems collect information on a few simple indicators, respond to local priorities, provide appropriate incentives for participation, catalyse learning and decision-making based on frequent analyses and multilevel interactions with other stakeholders (Evans et al., 2018). Acknowledging the multi-layered and differentiated responsibility of various stakeholders and the power dynamics that embed decision-making, assessment of outcomes, and enforcement of rules and regulations is crucial for adaptive management and stakeholder participation (Osborne et al., 2021). In this context, recognising and empowering the agents of change contributes to their sense of ownership of the restoration process and their motivations for continued engagement. Remote sensing-based monitoring can be effective for evaluating changes in vegetation quality and tree or shrub cover across a range of spatial scales (Reytar et al., 2021; Almeida et al., 2021), but is unlikely to provide information on social dimensions or changes in populations or diversity of animals or understory plant species in forest ecosystems.

Local, regional, national and global monitoring frameworks should be designed to provide complementary and verifiable information for a range of purposes. At the scale of local projects, monitoring indicators should include outcomes of specific practices and implementation techniques; ecological conditions; social conditions and human well-being, including women, youth and marginalised groups; leadership and capacity; and cost-effectiveness. At the local level, monitoring indicators should incorporate information on broader societal outcomes of ecosystem restoration actions such as disaster risk reduction, livelihood development and job creation; capacity development and training; impacts on biodiversity; policy development and cross-sector integration. For example, application of the Landscape Sustainability Index for Restoration in El Salvador shows how different socio-economic and biophysical indicators interact to provide a general status of restoration in a landscape (Zamora-Cristales et al., 2020). At the national level, these metrics should also include impacts of ecosystem restoration actions on reducing degradation within and across different land-use and water-use categories. Global monitoring of restoration actions will focus on use of remote sensing imagery to detect changes in vegetation cover and its properties, land-use change, impacts on rivers, and to identify areas where degradation and recovery are occurring at significant spatial scales. Independent national and international monitoring tools and platforms can support reporting to UN conventions and to global platforms such as the Restoration Barometer, developed by IUCN initially to track progress on forest landscape restoration and from 2022 across all terrestrial ecosystems, including coastal and inland waters. Similar coordinated action does not yet exist to track progress across all areas of ecosystem restoration (Tickner et al., 2020). FAO and partners of the Decade's Monitoring Task Force launched in 2021 the Framework for Ecosystem Restoration Monitoring, as a collaborative effort to monitoring progress under the Decade.

RECOMMENDATIONS

Recommendations: building the ecosystem restoration movement

Restoration is a process that builds over a long period of time and opens up new opportunities for engagement, learning and innovation. Restoration is an opportunity to engage in collective action and to forge new alliances with multiple stakeholders, including Indigenous, marginalised or poorly recognised societal groups. Successful restoration requires the development of effective long-term partnerships, and in so doing, creates multiple social, economic and ecological, even cultural and spiritual benefits. Restoration actions need to be long-lasting, making it important that these actions are inclusive and responsive to the needs of diverse individuals and entities who have stakes in land and waterscapes that need restoring.

Local communities must be empowered to lead restoration movements. Community and landscape right-holders and stakeholders need to be at the centre of restoration movements through their legitimate positions as land stewards, property owners and local decision makers. Local and community organisations can directly address local needs and may have the capacity, motivation and local knowledge to take effective restoration action. Local knowledge can, additionally, be supplemented with technical support to enable restoration based on the best scientific practices. Empowering local decision-making processes for restoration by incorporating local knowledge and cultural traditions can contribute to enduring outcomes.

Restoration requires fundamental shifts in economic and political institutions so that they pay attention to the long-term and varied benefits of functioning ecosystems. Learning from previous restoration successes and failures must be implemented to bring ecosystem restoration to scale. To drive the investment and commitment needed to achieve the goals of the UN Decade on Ecosystem Restoration, the immediate and long-term values of restoring ecosystems need careful attention. Restoration offers varied benefits in different settings and over different time periods, enabling both short-term improvements in livelihoods and adaptation to uncertain future climate threats. New forms of economic and governance institutions that recognise the short- and long-term roles of ecosystems in growing resilient economies may need to be forged.

The ideals of the UN Decade on Ecosystem Restoration – partnership, inclusiveness and joint coordinated action – need to be based on shared core principles, good practices and practical approaches to monitoring and evaluation. As ecosystem restoration becomes increasingly adopted, implementation must be supported by evidence, tools and methods that translate generic concepts to the realities of socio-environmental contexts. Coordinating and aligning actions may require time and support to strengthen local social capital, which is needed for effective implementation (Chazdon et al., 2021b). Shared core principles can form the basis for developing priorities for restoration interventions and guide monitoring and adaptive management (Chazdon et al., 2020; Kingsford et al., 2021). These principles will need to be adapted to local realities by incorporating local and traditional ecological knowledge and practitioner experience.

Ecosystem restoration actions create opportunities for multiple agents of change to work together. Restoration requires user-friendly information sharing and inclusive engagement from the outset for collective actions that can contribute to trust, social and political capital, creating more resilient economies (Ostrom, 1990). In addition to the sector-level actions recommended in Table 5, we emphasise the importance of forming multi-sector alliances, particularly at sub-national levels (Case study 2). These alliances can play a unique role in building bridges for communicating, understanding and balancing restoration trade-offs, galvanising support for long-term and effective partnerships between public and private sectors. They can also support building an evidence base for restoration from scientific knowledge, practitioner experience, traditional and local knowledge, and policy experience that dispels myths and poor science and recognises trade-offs.

Table 5. Specific recommendations for ecosystem restoration actions by different social agents

Each of these agents has its own needs and motivations. They contribute to restoration in unique ways, but these efforts need to be synergised in ways that build on each other and that make ecosystem restoration actions a shared enterprise. In some cases the optimum approach to restoration may be integration of nature-based solutions and hard engineering (see Case Studies 5 and 6). Below is a non-exhaustive list of recommendations for all types of actors.

Actions for landowners, landholders and resource managers

- Organise to form cooperatives to support each other in implementing restoration.
- Be open to adopting and sharing new practices and demonstrating results to others.
- Recognise and reduce the drivers of degradation from poor land use or resource management practices.
- Engage family and community members in restoration activities on farms and managed areas, in surrounding landscapes/seascapes.
- Apply and document local knowledge and experiences.

Actions for the business sector

- Innovate new commercial products, services and technological platforms that support restoration activities and knowledge sharing.
- Identify and recognise the risk reducing benefits of restoration to varied supply chains.
- Create new markets for restoration-based products and services.
- Transition to a nature-positive, net-zero economy.
- Recognise and reduce the drivers of degradation within corporate supply chains, including unsustainable extractive activities.
- Become leaders of the ecosystem restoration movement, in partnership with governments, Indigenous Peoples and civil society.
- Integrate and promote community decision-making into investment models.
- Invest in local and regional conservation and restoration actions.

Actions for government agencies and organisations

- Develop and enforce laws, accountability frameworks, metrics and transparency mechanisms that regulate and restrict activities that drive ecosystem degradation (including mining, habitat loss, illegal animal trade, illegal hunting, overharvesting).
- Recognise and reduce the drivers of degradation within government initiatives.
- Develop long-term vision and planning for restoration with engagement of key right-holders and stakeholders.
- Encourage cross-sector task forces that align restoration with climate mitigation, biodiversity conservation and sustainable development.
- Reform land tenure policies and devolve land management to local communities.
- Reward/pay local stewards for protecting and restoring ecosystems services.
- Raise capacity at all levels, including developing new institutions focusing on long-term effective governance objectives.
- Enhance transparency and fight corruption in governance systems that relate to ecosystem management.

Actions for finance and investment sectors

- Find innovative ways to reduce risk in restoration investments and to increase opportunities, including by integrating natural accounting into investment decisions.
- Develop social safeguards, due diligence, accountability frameworks, metrics and transparency.
- Expand opportunities to integrate natural capital accounting into investment decisions.
- Divest from companies and sectors that degrade ecosystems.
- Provide microfinance for local restoration actions through investments.
- Develop blended finance mechanisms in partnership with public agencies and civil society organisations.
- Support long-term process funding for restoration.

Actions for civil society organisations

- Create channels for community engagement, action and leadership and for women's groups and youth groups.
- Identify and promote restoration 'champions' across society and inspire young people.
- Help build a community of restoration practitioners across all levels of society.
- Work holistically. Couple restoration actions with economic opportunities and livelihood support, including opportunities for women and youth.
- Incentivise stewards of ecosystem restoration through direct cash payments and other reward schemes.
- Showcase restoration actions through pilot projects.
- Become leaders of the ecosystem restoration movement, in partnership with governments and civil society.

Action for scientists and technical advisors

- Synthesise past research and indicate in an unbiased manner how and where ecosystem restoration can work and the limitations of available knowledge.
- Assess how ecosystem restoration fits with other development priorities and approaches (such as engineering solutions).
- Identify social and economic benefits of restoration and the distribution of these benefits. Be clear about trade-offs and disbenefits of restoration.
- Disseminate best scientific advice in readily understandable language.
- Provide a service to interpret scientific findings and advice.
- Undertake new research in priority areas that helps to design effective restoration actions and inform decision makers.

CASE STUDIES AND EXAMPLES

Case studies and examples linked to key messages

This section presents case studies of ecosystem restoration projects and examples that relate directly to the key messages. While the case studies cover a broad range of ecosystem restoration projects across a wide number of regions, the relevant key message numbers are referenced in the example box titles so they can be easily linked.

CASE STUDY

CASE STUDY 1. RESTORING FARMS AND LIVELIHOODS BY HELPING TREES REGENERATE NATURALLY IN DRYLANDS

Drylands occupy more than 40% of the world's land area and are home to an estimated two billion people. In the 1970s and 1980s, the Miradi and Zinder dryland regions of Niger in the West African Sahel faced multiple droughts and famine in addition to severe scarcity of fuelwood, building materials and fodder. Soil degradation made agriculture nearly untenable. Farmer-managed natural regeneration (FMNR) was included as part of a Food for Work programme in the 1980s, in which farmers were incentivised with food aid to encourage the growth of trees on portions of uncultivated land (Tougiani et al., 2009). The FMNR approach generally involves selecting existing tree stumps and seedlings to be protected, pruning stems, and protecting regenerating seedlings by fencing and/or establishing social rules and norms around tree protection and fire control (Tougiani et al., 2009). Adoption of FMNR techniques vastly improved agricultural yields, and once accepted by farmers, was relatively easy to implement. The benefits of FMNR to local livelihoods were overwhelmingly positive: increased yields, firewood availability, income and production diversity (Chomba et al., 2020). Within the first year of adoption, farmers saw an increase in fuelwood and fodder and reduced soil erosion (Sendzimir et al., 2011). FMNR spread throughout the region through both external interventions, and by word of mouth and farmer-to-farmer learning and exchange. Vast areas of these regions went from severely degraded farmland to agroforests through the spread of FMNR. These simple methods are now encouraged by multiple levels of government in Niger, and practised over hundreds of thousands of hectares in dryland ecosystems of Niger and throughout many countries of Africa and Asia.

CASE STUDY 2. MULTI-SECTOR RESTORATION INITIATIVES FIND FERTILE GROUND IN BRAZIL

The Atlantic Forest Restoration Pact (Pact) in Brazil exemplifies a bottom-up, smart governance mechanism that promotes stakeholders' participation and engagement for ecosystem restoration (Brancalion et al., 2013). Formed in 2009, with the goal of restoring 15 million hectares of Atlantic Forest by 2050, the Pact has grown to 350 institutional members and is organised into six working groups and 18 regional units. During 2011–2015, 673,000–740,555 ha of forest was restored through natural regeneration and restoration plantations (Crouzeilles et al., 2019). The Pact has a coordinating council, elected in plenary by the signatories, a general coordinator and a vice coordinator, elected by the council. Part of the Pact's success in promoting large-scale ecosystem restoration is related to the development of governance, communication and articulation strategies to engage, connect and promote capacity building and involvement in different sectors of the restoration supply chain, also promoting a vision and strategies to influence public policies and actions at multiple scales (Crouzeilles et al., 2019). Inspired by the Pact's success, the Alliance for Restoration of the Amazon (Alliance) was founded in 2017. The Alliance has grown to 80 institutional members, which include 10 governmental groups, 13 academic/research groups, 21 companies, and 36 civil society organisations and associations. This past year they produced a map showing 2,773 restoration initiatives across the Brazilian Amazon, totalling 113,520 ha, that were largely initiated or supported by Alliance members. In their latest position paper, they present ten pathways to expand the scale of restoration in the Amazon, through a positive agenda focused on compliance and improvement of legislation, development of sustainable production chains and the engagement of the government, private sector, financial, training, research and extension sectors, and all of civil society.

CASE STUDY 3. RESTORING URBAN FORESTS IN NEW ZEALAND

The Hamilton Ecological District (159,376 ha) in the northern North Island is one of the most modified districts in New Zealand – only 1.6% of the indigenous vegetation remains. At least 20% of its indigenous flora is threatened or extinct and more than one half of its indigenous bird species have disappeared. Research on urban restoration ecology has been conducted in Hamilton City (population 160,000) since the mid-1990s (Wallace and Clarkson, 2019). The potential for reconstructing indigenous forest within the city was recognised in 2000 when 60 ha of abandoned pasture on public land was set aside for the establishment of Waiwhakareke Natural Heritage Park in an effort to restore parts of the distinctive gully landform that occupies some 750 ha (8% of the city). Forest restoration has been a joint effort between local government and community, continuing a 15-year partnership that has overcome political inconsistency and turnover in leadership of charitable groups. A strong emphasis on partner engagement made the progression of the restoration plan possible. Partners receive benefits through their connection to on-the-ground restoration work (Wallace and Clarkson, 2019). Urban green spaces do not have to be completely restored for citizens to enjoy them. Participating in early stages of ecological restoration can be a therapeutic experience; planting and weeding by volunteers provides a needed connection with nature and builds community for urban residents (Matsuoka and Kaplan, 2008). In addition to ecological recovery of indigenous forest biodiversity and aquatic life, forest restoration brings numerous and wide-ranging improvements to urban residents, including environmental, aesthetic, scenic and cultural benefits.

CASE STUDY

CASE STUDY 4. FOREST RESTORATION EMPOWERS A HYDROELECTRIC DAM

Itaipu, a huge hydroelectric dam on the Paraná River on the border between Brazil and Paraguay, is one of the most economic and financially efficient hydropower projects in the world. Soil erosion due to deforestation of the Itaipu dam's watershed leads to huge dredging costs of several million US$ per year. During 2000–2010, 1.02 million ha of forests were lost in the whole watershed, with Paraguay showing a greater rate of forest loss. Continued forest degradation at this rate is likely to impact the Itaipu dam operationally and economically. Forest restoration in the buffer zone of the Itaipu reservoir through the Cultivating Good Water Program has contributed to reducing siltation and increasing flows of streams into the reservoir. The programme, operated in 29 cities across the Paraná River Watershed from 2003 to 2017, consists of 20 programmes and 63 initiatives dedicated to issues including environmental education, watershed management, biodiversity, sustainable rural development, medicinal plants, fish production and fish farming.

CASE STUDY 5. ENHANCING ECOSYSTEM RESTORATION THROUGH ENGINEERING

The National Trust's Holnicote Estate comprises around 40 km^2 of land from Exmoor (in the south) northwards towards Porlock Bay in the UK. Two main rivers drain this area, namely Horner Water and the River Aller. Significant flooding events from 2000 to 2007 caused much economic damage and prompted greater interest in the role of surface water runoff from the rural environment and the inter-relationships between river channels and floodplains and adjacent settlements. Ecosystem restoration of the Holnicote catchment (National Trust, 2015) involved reforestation of the upland catchment and reconnection of the river and its floodplain. However, the most significant benefit of the work was reduced flood risk to downstream settlements that was actually achieved by building embankments and deflectors on the floodplain to increase flood water retention, demonstrating the success of integrating natural and engineering approaches. Palmer et al. (2014) provide another example of an emerging form of urban stream restoration, which involves transforming the stream channel into a stormwater management structure designed to reduce peak flows and enhance hydraulic retention of stream flow with the goals of reducing bank erosion and promoting retention of nutrients and suspended sediments.

CASE STUDY 6. RE-PURPOSING BUILT INFRASTRUCTURE FOR ECOSYSTEM RESTORATION

Under natural conditions some 6,000 km^2 of the Waza-Logone floodplain in northern Cameroon is inundated annually by the River Logone, which runs north into Lake Chad (Tchamba, 1995). For centuries, this natural flood supported vital ecosystem services for local communities. The fishing, grazing and flood recession agriculture of the floodplain has been valued at US$ 2.5 million per year (Loth, 2004). Approximately 150,000 ha of the floodplain was designated as the Waza National Park in 1968 supporting elephant, giraffe, lions and various antelope. Due to low rainfall in the 1970s and increasing food demands from a rising population, a dam and embankments were built along the river and across the floodplain creating Lake Maga to supply water to an intensive rice cultivation scheme. This led to reduced floodplain inundation, devastating the floodplain fisheries and pastoral economy, and loss of biodiversity that reduced tourist potential of the park (Acreman, 1994). To rectify this situation, the embankments were modified in 1994 and large water releases were subsequently made from Lake Maga to allow flood waters to reach the floodplain once again, revitalising the traditional natural resources, farming and fishing practices and biodiversity in the park. The existence of the dam and embankments means that floods can be controlled and are more consistent from year to year compared with the natural high hydrological variability which often brought massive floods one year and no flood the following year. This provides an example of integrated management of natural floodplain functioning and built infrastructure to deliver optimum benefits to people.

CASE STUDY

CASE STUDY 7. RESTORING DEGRADED SOILS THROUGH REGENERATIVE AGRICULTURE

The core intent of regenerative agriculture is to improve soil health, which enhances the quality of water, vegetation and land productivity. Regenerative agriculture seeks to produce more crops from less land area, with less input of chemicals, less use of water, less emission of greenhouse gases, less risk of soil degradation, and less use of energy-based inputs (Lal, 2020). Regenerative agriculture is essentially a recasting of sustainable agriculture, sustainable intensification, climate-smart agriculture, organic farming, and agroecology into one package (Giller et al., 2021). Methods of regenerative agriculture not only increase the amount of soil organic matter (SOM) in existing soils, but also build new soil. Enhancing SOM content also increases retention of water, soil fertility and disease resistance (Lal, 2020). The greatest opportunities to increase soil carbon are found in low yielding regions on clay (as opposed to sandy) soils, where increasing crop yields increase available biomass stock and inputs of organic matter to the soil. Among the practices associated with regenerative agriculture, agroforestry in its many practices probably has the greatest potential to contribute to climate change mitigation through carbon storage by both above- and below-ground components (Giller et al., 2021). Transitioning from conventional to regenerative agriculture involves more than a suite of mitigation and adaptation practices. Rather, it involves subjective decisions associated with culture, values, ethics, identity and emotion that operate at individual, household and community scales and interact with regional, national and global processes (Gosnell et al., 2019).

CASE STUDY 8. TRADE-OFFS IN COASTAL RESTORATION AND PROTECTION

On 29 October 2012 Hurricane Sandy struck the New York–New Jersey area causing US$ 50 billion in damage and resulting in 117 fatalities (Eastern Research Group, 2016). This catastrophic event provided opportunities to restore ecosystems and make informed decisions that take into account the trade-offs among different benefits from ecosystem restoration. A survey evaluated trade-offs between four ecosystem services provided by saltmarsh restoration at Forsythe National Wildlife Refuge (NWR): 1) bird habitat; 2) recreation; 3) protection of homes from storm surge; and 4) protection of homes from non-surge flooding. Perceptions of trade-offs were evaluated based on individual's willingness to pay for different ecosystem services resulting from saltmarsh restoration. People living 100 miles from Forsythe were willing to pay 60%, 95%, 35% and 49% of the amount that people within a mile of Forsythe are willing to pay for protecting 5,000 homes from flooding, for minimal or significant habitat improvements, for minimal recreational improvements, and for significant recreation improvements, respectively. Also, people who reported no impact of Hurricane Sandy were not willing to pay anything for protecting homes from flooding, very little for minimal recreation improvements, and slightly more for significant recreation improvements and significant habitat improvements.

EXAMPLE

EXAMPLE 1: KEY MESSAGE 1

Ecosystem restoration in the context of climate change

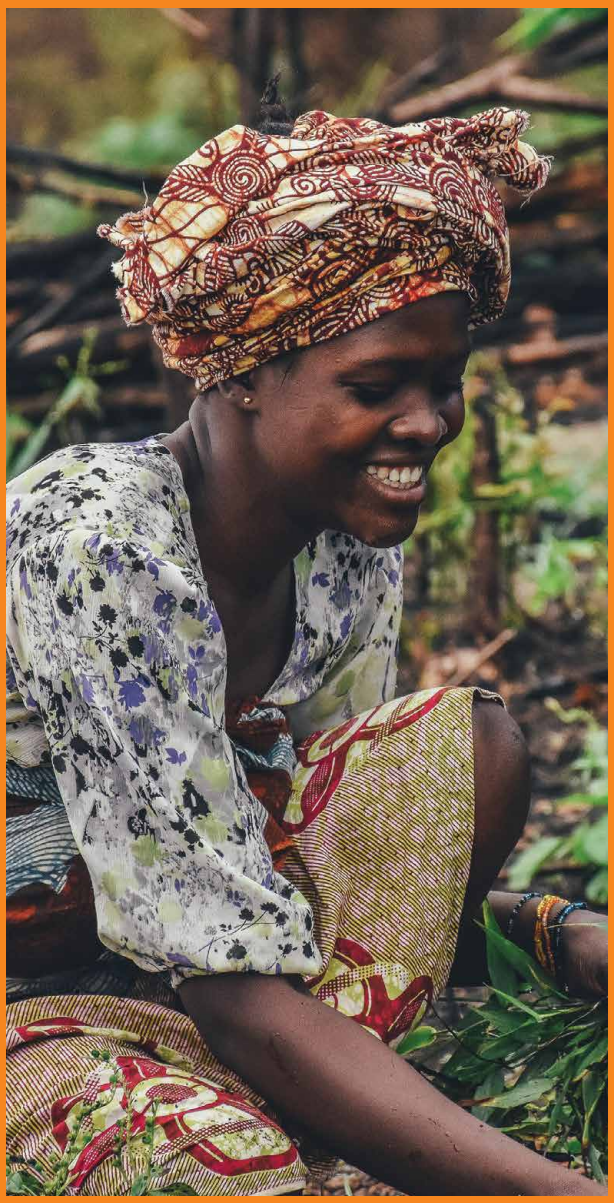
As terrestrial ecosystems recover, carbon accumulates in above- and below-ground biomass and soils, providing a sink for atmospheric carbon dioxide that can partially counteract carbon sources and mitigate climate change, in addition to providing other ecological and socio-economic benefits (Locatelli et al., 2015; Griscom et al., 2017). In regions of China where six major forest restoration projects were conducted since the 1970s, over half of the total annual carbon sequestration during 2000–2010 was attributed to implementation of restoration projects (Lu et al., 2018). Restored coastal wetlands, such as mangroves, seagrasses and salt marshes, can also be important sinks storing carbon on a larger area basis compared to inland wetlands (Taillardat et al., 2020). Although they occupy less than 0.05% of the world's ocean surface area, these 'blue carbon' ecosystems store 50–70% of the total carbon stored in ocean sediment (Nellemann et al., 2009; Donato et al., 2011). Carbon capture and storage on abandoned farmland can be accelerated via managing plant diversity through restoration approaches, creating and applying biochar to soil, and co-developing renewable energy technologies (Yang et al., 2020). Grassland restoration significantly increased carbon in soils based on experimental studies in China and Kenya (Mbaabu et al., 2020; Song et al., 2018). Restoration is also a means to address climate adaptation in the context of sustainable development, while also contributing to climate mitigation (Locatelli et al., 2015; Stanturf et al., 2015). Community-based restoration of degraded subtropical thickets in South Africa aims to achieve broad climate mitigation and adaptation goals as well as enhancing local livelihoods and economies (Favretto et al., 2018). Climate change also brings risks and challenges for ecosystem restoration, emphasising the importance of identifying sources of ecological resilience as a critical step in restoring ecosystems in a changing climate (Timpane-Padgham et al., 2017). The ecosystem attributes of species diversity and connectivity are commonly considered to confer resilience because they apply to a wide variety of species and ecosystems (Timpane-Padgham et al., 2017).

EXAMPLE 2: KEY MESSAGE 1
Disbenefits of wildlife for farmers in southwestern Ethiopia

In southwestern Ethiopia, a survey of community members revealed an uneven distribution of benefits from conservation and reforestation activities that emerged from household interactions with the natural and biophysical components of the landscape (Dorresteijn et al., 2017). While the rural community members benefitted from growing coffee in the forest, for example, they also experienced disbenefits, such as wild animals raiding their agroforestry plots. Disaggregation of benefits and disbenefits across different household types revealed that some households experienced higher benefits and lower disbenefits from forests than others and this had to do with characteristics such as household size and proximity to the forest. This case study underscores the importance of evaluating the costs and benefits of conservation and restoration actions alongside livelihood activities, and understanding trade-offs between different community groups. This data can improve the evaluation of management strategies that can minimise or mitigate for existing disbenefits and tailor strategies based on the targeted groups affected (Pascual et al., 2017).

EXAMPLE 3: KEY MESSAGE 2
Empowering Indigenous Peoples and local communities to restore ecosystems

Around the world, indigenous lands and territories have demonstrated better management of natural resources, including lower levels of deforestation and better resource stocks (Baragwanath and Bayi, 2020). Local management by non-indigenous groups can also lead to better outcomes if communities are able to benefit from the lands and resources they manage (Bray et al., 2003). Working with these groups to restore ecosystems has demonstrated success in a range of contexts (Reyes-García et al., 2019). Indigenous and local peoples are ideally situated to do the work and provide the stewardship required to restore ecosystems, provided they are empowered to benefit from their work in a way that supports local livelihoods and is culturally relevant (Oldekop et al., 2020). At the local level, land tenure security and good governance are keys for restoration success (Le et al., 2012; Baynes et al., 2015). But good governance practices take time to implement – for example, processes for consultation, inclusion, identifying who is impacted, capacity building of actors and so forth, and are often costly. Working with communities and organisations that have these processes in place can save time and effort.



EXAMPLE

EXAMPLE 4: KEY MESSAGE 3
Optimising selection of global priority areas for ecosystem restoration based on biodiversity, climate and costs

A global analysis showed that cost-effectiveness for biodiversity conservation, climate change mitigation and cost savings can increase up to thirteenfold with optimised multi-criteria spatial planning compared with business-as-usual approaches that do not take into account spatial optimisation planning (Strassburg et al., 2020). Restoring 15% of converted land in priority areas could avoid 60% of expected extinctions while sequestering 299 $GtCO_2$, or 30% of the total CO_2 increase in the atmosphere since the industrial revolution. This analysis also highlights the value of considering several ecosystems simultaneously in the spatial planning process, as these ecosystems vary in their relative contribution to the benefits (biodiversity conservation and climate change mitigation) and costs (implementation and opportunity costs). Wetlands and forests are of the highest relative importance for biodiversity conservation and the mitigation of climate change, respectively. Arid ecosystems and grasslands are of the highest relative importance for cost savings. When targeting all benefits and costs, all ecosystems provide important priority areas for restoration.

EXAMPLE 5: KEY MESSAGES 3 AND 4
Blended finance for integrated landscape restoration

Blended public and private finance is essential for generating monetisable and non-monetisable social, natural and financial returns. Commonland (CL) is a landscape-scale integrated framework for ecosystem restoration (over a minimum period of 20 years) that clarifies the need and arrangements for blended finance. Seeking four types of returns (inspiration or hope, and natural, financial and social capital) (Ferwerda, 2015), restoration under this framework includes social, ecological, economic and cultural interventions necessary for achieving impacts. Non-monetisable values (inspiration) include building common ground and trust between stakeholders and creating opportunities for sharing purposes that connect and energise.

There are many advantages to this approach. By intertwining business prototyping and development early on with partnership-building, the approach seeks to promote innovation that can lead to the creation of companies and market access. For example, Almendrehesa in Spain, a company which now exports regenerative almonds to the EU market, emerged about a year after the establishment of the landscape partnership 'Association AlVelAl' in 2015. The long-range (20-year) financial plan for this landscape-scale project estimates that 30% of the funds will come from grants and public works funding and 70% will come from business investments in regenerative agriculture, forestry, processing plants and composting (Ferwerda and Moolenaar, 2016).

Other examples show how businesses within a restoration landscape can also generate income for project interventions. Wide Open Agriculture, a regenerative food and agriculture company formed by farmers in the Wheatbelt region of Western Australia in 2015, was listed in the Australian Stock market in 2018. Funding pots generated by the company are directed to social interventions at landscape level in order to build trust and partnerships with Aboriginal communities, local NGOs and other stakeholders, who jointly aim to restore and connect native vegetation, sacred land and regenerative agriculture.

EXAMPLE 6: KEY MESSAGE 5

Adaptive management challenges

Analysis of ecosystem restoration projects in eight tidal salt marshes in the Sacramento–San Joaquin Delta of San Francisco Bay, USA revealed several challenges for implementing adaptive management. In the delta, adaptive management is not yet a well-defined or easily implemented strategy for restoration managers. In some cases, challenges arise due to conflicting regulatory priorities. From a regulatory perspective, tidal marsh restoration is complex because it generally involves converting one wetland type into another (e.g., managed wetland to tidal marsh), which can have a harmful effect on pre-existing species. Fulfilling mandated restoration targets creates challenges for practitioners in property funding to fulfill restoration obligations. Coordinating science and management, and coordinating multiple agencies involved in restoration projects are additional challenges reported by practitioners and managers (Nagarkar and Raulund-Rasmussen, 2016).

EXAMPLE

EXAMPLE 7: KEY MESSAGE 5

Restoration of vegetated coastal ecosystems

Vegetated coastal ecosystems, including mangroves, seagrasses, saltmarshes and kelp forests, are critical habitats that provide a diverse array of ecosystem services such as fisheries production, sediment and nutrient trapping, storm protections and carbon storage. Mangroves are confined to tropical and sub-subtropical coasts (Giri et al., 2011). Seagrass beds are found from cold polar seawaters to the tropics, while salt marshes are found in all regions, but most commonly in temperate areas. Kelp forests are primarily associated with temperate and arctic seawaters worldwide (Wernberg et al., 2019). Combined, these ecosystems cover approximately 207 million ha; with more than 10% of each habitat type occurring within marine protected areas (UNESCO, 2020).

Rapid loss of coastal habitats is experienced around the world as a result of human activities (over-exploitation of resources, hydrological alterations, decreased coastal sediment supply, pollution and emplacement of coastal infrastructure) as well as climate change (Mcleod et al., 2011). Cumulative losses over the last 50–100 years have been measured at 25–50% of total global area of each habitat type (Giri et al., 2008; Bunting et al., 2018). This decline continues today, with estimated losses of 0.5–3% annually depending on ecosystem type (Pendleton et al., 2017). At current conversion rates, 30–40% of tidal marshes and seagrasses and nearly 100% of mangroves could be lost in the next 100 years (IPCC, 2019). Loss of kelp forests has been variable across the world, with some ecoregions such as South America recording a 38% decline over the last 50 years (Filbee-Dexter and Wernberg, 2018).

Restoration of marine ecosystems can transform degraded ecosystems to healthier and productive states. Depending on the approaches used, marine restoration can be an expensive undertaking, but in most cases potential benefits of restored areas are significantly higher than the real costs. The average reported cost of restoration of one hectare of marine coastal habitat is around US$ 1,600,000 (Bayraktorov et al., 2016); though significantly lower in developing economies. Seagrass ecosystems are among the most expensive ecosystems to restore, when compared to mangroves and salt marshes.

EXAMPLE 8. KEY MESSAGE 2
Freshwater ecosystems

Freshwater ecosystems include springs, rivers, lakes, wetlands (such as bogs, fens, marshes), groundwaters and transitional environments such as estuaries and coastal lakes with variable salinity. Freshwater makes up only 0.01% of the world's water and freshwater ecosystems cover only approximately 0.8% of the Earth's surface, yet freshwater ecosystems support almost 6% of all described species (Dudgeon et al., 2006). Some 2,314 freshwater sites are designated as Wetlands of International Importance (Ramsar Sites) covering 242,409,779 ha (Ramsar Convention on Wetlands, 2018). However, not all sites are well managed or adequately protected from threatening processes (Acreman et al., 2018; Acreman et al., 2020) and many are degrading and require restoration.

The major threats to freshwater ecosystems have been synthesised in six main categories: hydrological alterations, habitat degradation and loss, pollution, over-exploitation, invasive species, and climate change (Dudgeon et al. 2006). These have been mapped at global scale (Reis et al. 2017; Grill et al. 2019) and elaborated as new pollutants and configurations of stress emerge (Reid et al. 2019). Yet, in spite of considerable restoration efforts, freshwater biodiversity loss and ecosystem degradation continue in most countries. The Freshwater Living Planet Index of 944 species of mammals, birds, amphibians, reptiles and fishes has declined by an average of 84% – far exceeding the rate of decline found in species populations in marine or terrestrial biomes (WWF, 2020). Freshwater biodiversity was the over-riding conservation priority during the International Decade for Action – 'Water for Life' – 2005 to 2015, but considerable restoration action is still needed. To this end, an Emergency Recovery Plan for freshwater biodiversity (Tickner et al., 2020), sets out six major priorities for global action and policy development to "bend the curve of freshwater biodiversity loss".

Freshwater ecosystems are distributed around the landscape, from mountains to coasts. They are interconnected with the landscape and with each other by the movement of water that carries nutrients and sediment and allows species to disperse and migrate into diverse habitats. Connectivity among them needs to include longitudinal (between upstream and downstream reaches), lateral (between river and adjacent side channels and floodplains) and vertical (between surface water and groundwater) dimensions. However, this connectedness makes them vulnerable to environmental change in catchments, riparian zones, upstream channels as well as locally at any site. In particular, dams and weirs have led to fragmentation of freshwater ecosystems and only 23% of large rivers flow uninterrupted to the sea (Grill et al., 2019). Climate change has altered water availability to and within freshwater ecosystems worldwide (Gudmundsson et al., 2021). Land use changes, such as deforestation, have altered river flows such as in Brazil (Levy et al., 2018) and Malawi (Palamuleni et al., 2011) and pollutants have decreased water quality, such as in China (Yan et al., 2015) and river channel alterations have degraded habitats, such as in Europe (Aarts et al., 2004). We recognise that some alteration of freshwater ecosystems, such as dams, diversions and water withdrawals, is essential to support human life, but these activities can be restricted to a few carefully selected river basins allowing others to be restored and conserved.

Restoration of freshwater ecosystems presents many challenges, not least the need to address numerous issues in the whole catchment feeding these water-dependent systems. Restoration actions often need to include reinstatement of terrestrial ecosystems within the catchment upstream, riparian restoration, release of appropriate water flows from storages, installation of fish passes at barriers, reduction of pumping from groundwater, prevention of pollution from farming and industries, and at-site replacement of habitats. These restoration activities have implications for many businesses, government departments and agencies, non-governmental organisations and dispersed local communities, with potential for diverse, conflicting aspirations. Freshwater ecosystem restoration typically requires collaborative planning, design, decision-making and action at landscape or catchment scale (Finlayson et al., 2018) and significant effort to integrate traditional cultural and scientific knowledge (Arthington et al., 2018). The emerging model is that freshwater ecosystems and their catchments are coupled human and natural systems, wherein setting restoration objectives and devising management solutions require engagement and collaboration among engineers and hydrologists, ecologists, social scientists and citizens (Bunn 2016; Arthington, 2021).

GLOSSARY

Adaptive management
A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. (Millennium Assessment). It uses management as a tool to not only change the system, but also learn about the system.

http://www.millenniumassessment.org/documents/document.776.aspx.pdf

Ecological restoration
A process intended to assist the return of an ecosystem to its historical trajectory and to recover a self-sustaining native ecosystem as close to the original state as possible. Restoration can involve a continuum of interventions that vary in scale, intensity and cost and may require long time frames for full recovery.

Ecosystem collapse
A condition when it is virtually certain that an ecosystem's defining biotic or abiotic features are lost, and the characteristic native biota are no longer sustained. Collapse is considered an endpoint of ecosystem decline and degradation.

Ecosystem degradation
A persistent reduction in the capacity of an ecosystem to support native species and provide ecosystem services.

http://www.millenniumassessment.org/documents/document.776.aspx.pdf

Ecosystem functionality
How well ecosystem processes work together. Ecosystem functions include all of the biological and physical interactions that occur in an environment, such as the exchange of energy and nutrients in the food chain.

Indigenous knowledge (or local knowledge)
The understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For many Indigenous Peoples and local communities, indigenous knowledge informs decision-making about fundamental aspects of day-to-day life.

Managed ecosystems
Complex, dynamic systems with spatially varying inputs and outputs that are the result of interrelated physical processes, biological processes, and human decision-making processes. Examples include agricultural and agroforestry systems, forestry plantations, fish farms and other grazing systems.

Multi-sector coalition
An alliance or partnership created when individuals and organisations from different sectors – e.g., nonprofit, government, philanthropic, research and business – use their diverse perspectives and resources to jointly solve a societal problem and achieve a shared goal.

Nature's contributions to people
The contributions, both positive and negative, of living nature (i.e. diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to the quality of life for people. These contributions include material and non-material aspects.

https://ipbes.net/glossary/natures-contributions-people

Net positive practices
A way of doing business that puts back more into society, the environment and the global economy than it takes out. Becoming net positive requires organisations and companies to plan for long-term outcomes, going beyond risk avoidance, externalising environmental damage and incremental improvements.

https://www.forumforthefuture.org/net-positive

Reclamation
Commonly used in the context of mined lands where the objective is to return land and watercourses to an acceptable standard of productive use, ensuring that any landforms and structures are stable, and any watercourses are of acceptable water quality. Reclamation typically involves a number of activities such as removing any hazardous materials, reshaping the land, restoring topsoil, and planting native grasses, trees, or ground cover.

Rehabilitation
The reparation of ecosystem processes, productivity and services rendered with regard to achieving the fullest possible re-establishment of the species composition and community structure of the original ecosystem.

Remediation
The reduction or elimination of contaminants from a place where they are not wanted. Phytoremediation is the process of removing toxic metals or other substances from soils or substrates using plant species that accumulate these substances in their tissues. Bioremediation involves a suite of techniques using bacteria or other microorganisms to break down toxic contaminants.

Restoration
A process intended to assist the return of an ecosystem to its historical trajectory and to recover a self-sustaining native ecosystem as close to the original state as possible. Restoration can involve a continuum of interventions that vary in scale, intensity and cost and may require long time frames for full recovery.

Restoration supply chain
The entire process of making and selling commercial goods to support restoration activities, including every stage from the supply of materials and the manufacture of the goods through to their distribution and sale.

Restorative actions
Actions to prevent, halt and reverse the degradation of ecosystems. Examples of restorative actions can include reducing emissions from deforestation; halting ecosystem degradation; conserving, sustainably managing and enhancing forest carbon stocks; reducing vulnerability and increasing adaptation to climate change; restoring the structure, function and composition of ecosystems, landscapes and seascapes; improving sustainability of agriculture and fisheries; and rehabilitating mined and polluted areas (see Table 1 for examples).

Rewilding
The practice of returning areas of land to a wild state, including the reintroduction of animal species that are no longer naturally found there.

Semi-natural ecosystem
An ecosystem that has been altered by human actions, but which retains significant native species and ecological interactions.

Silvicultural interventions
Pre-logging or post-logging treatments in natural forest stands or plantations designed to increase sustainable production of commercial timber or to reduce risks of disease and fire. Treatments can include enrichment planting, thinning, or applying herbicides.

Socio-ecological system
An interdependent and linked system of people and nature, nested across spatial and temporal scales. The social-ecological system is influenced by many external factors such as population growth, technological change, markets, trade and political change.

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