Understanding the economic recovery potential of investing in biodiversity in the Global South

Report to NERC Programme on Synthesising Evidence in Economics of Biodiversity

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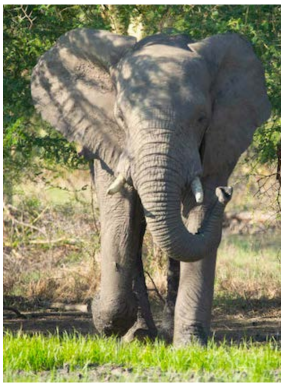

Degraded slopes in Mozambique's Gorongosa National Park are being reforested with native hardwood trees and premium shade-grown organic coffee and cashews. Innovative bee-hive fences keep elephants away from crops and produce organic honey. The community-based resource management venture employs 400 people and supports 5000 smallholder farmers, and biodiversity is returning to the forest.

Summary

Despite mounting evidence that we must reverse biodiversity loss to sustain the healthy soils, clean water and habitable climate that support life on earth, there has been little progress on a global scale. Nature-based Solutions (NbS) offer a way to reverse biodiversity loss while also providing benefits for people and tackling the climate crisis. However, while there are clear environmental benefits from NbS, uncertainty on their socio-economic outcomes may be hindering government support and investment.

This report presents a rapid synthesis of key evidence sources to address the following questions:

1. In the short term, could NbS generate good quality jobs and boost incomes and revenues as countries strive to 'build back better' in the recovery from the COVID-19 pandemic?
2. Could NbS play a role in the transition towards a sustainable resource-efficient circular economy that is more resilient to future commodity price shocks?
3. How are the economic benefits and costs of NbS distributed between different groups of stakeholders, and how can they be equitably distributed?
4. Are there trade-offs and synergies between different economic outcomes, or between economic, social and environmental outcomes of NbS?
5. How can investments in NbS be designed to deliver the greatest economic benefits?
6. What are the key evidence gaps?
7. How strong is the evidence of economic outcomes, and how could evidence gathering be improved in future?

To address these questions, we first analysed an existing systematic review of evidence on the outcomes of NbS for climate change adaptation and sustainable development (the Nature for Development (N4D) dataset, developed with IIED, the International Institute for Environment and Development), focusing on economic outcomes. We supplemented this with a systematic 'review of reviews', to rapidly assess evidence of short term economic recovery outcomes: jobs, incomes, revenue, skills, gross value-added and economic multipliers. Finally, we conducted a quick scoping review of analysed selected grey literature reports, which provided strong complementary evidence from economic modelling of outcomes for jobs per unit of investment, and economic multiplier effects. This report presents the preliminary findings from the review, funded by a grant from the NERC Programme on Synthesising Evidence in Economics of Biodiversity. The work is continuing with co-funding from the Oxford Martin School programme on Biodiversity and Society, and will lead to a joint final report at the end of 2022.

We found good evidence that NbS have predominantly positive economic outcomes for incomes and jobs, and strong multiplier effects for jobs and economic output throughout the economy. Importantly, available evidence shows that NbS can provide higher employment per dollar of public spending, compared to other stimulus measures. However, the strength of the evidence varied. Our analysis of the N4D database found that 93% of studies recorded positive economic outcomes, with 3% having mixed outcomes and 2% negative (the remaining 2% being unclear or having no effect). In contrast, our systematic 'review of reviews' found that only 53% of the outcomes recorded were positive, and 32% were mixed, although only 3% had predominantly negative outcomes, with 6% being unclear. This marked difference could be because the N4D database included many grey literature project reports, many of which were written by project implementers, which may have taken a less critical approach to evaluating outcomes. However, many of these projects were also specifically designed to deliver positive socio-economic outcomes, for example through participatory approaches that aimed to build local capacities and support livelihoods.

Positive economic outcomes can be generated through many pathways:

Reduced resource costs

- **Reduced agricultural inputs.** Nature-based agriculture can reduce the use of inputs such as fuel, fertilisers and irrigation, and associated costs. This pathway is expected to become more important as commodity prices rise due to geopolitical instability, climate change, ecological degradation and competition for land and water.
- **Energy savings in buildings.** Green infrastructure, especially green roofs and walls, can save energy costs by insulating buildings from extremes of heat and cold, reducing the need for heating or air conditioning.
- **Reduced urban water management costs.** Green infrastructure can also reduce storm-water runoff and associated water treatment costs.

Increased or sustained revenues

- **Increased yields.** Nature-based agriculture and agro-forestry can often increase crop yields, e.g. by increasing soil health and fertility.
- **Premium product prices.** Products may be higher quality or may attract a higher price, e.g. for certified organic or deforestation-free produce.
- **Increased profitability.** Even in the cases where yields decrease (such as due to reduced use of synthetic fertilisers in organic agriculture), the studies we reviewed found that this is often outweighed by cost savings from reduced inputs and/or premium product prices, leading to an overall increase in profitability and incomes.
- **Increased resilience to environmental change.** Nature-based agriculture and agroforestry can be more resilient to environmental change, e.g. healthier soils can hold more water, providing resilience to drought conditions and reducing the risk of crop losses.
- **Recovery of over-exploited resources**. Sustainable management of forest resources, grazing land and fisheries can allow depleted stocks to recover. There may be a short-term reduction of yield and incomes, but recovery of stocks will enable continued profitable production in the medium to long term.

Direct jobs and incomes from implementing NbS

- **Direct jobs and incomes.** NbS can generate direct jobs and incomes associated with protection and restoration of ecosystems. This can include short term jobs during the implementation phase, e.g. growing tree seedlings and planting trees, as well as permanent jobs associated with management, maintenance and monitoring, e.g. patrolling protected areas or maintaining green roofs and walls. Similarly, jobs can be full time or part time. For example, there can be opportunities for local communities to supplement their regular incomes with payments for occasional monitoring of wildlife in a protected area.
- **Direct payments.** Implementation of NbS can be associated with direct payments to local communities, e.g. via Payments for Ecosystem Services (PES), or for providing carbon credits, e.g. via REDD+. These payments may come from private investors such as water companies wishing to protect water quality and thus reduce treatment costs, or companies and individuals wishing to offset their carbon emissions. However, this needs to be managed carefully to ensure equitable distribution of benefits.

High economic multipliers

- **NbS have high multiplier effects**, so they create more indirect jobs and revenues (from business-to-business spending, for materials and services needed for NbS implementation) and induced jobs and revenues (from increased household spending due to incomes associated with direct and indirect jobs) than many other sectors.

- **NbS create more jobs per unit of investment** than most sectors conventionally targeted for economic stimulus spending (e.g. conventional agriculture, or construction of transport and energy infrastructure).

New economic opportunities

- **New activities**. NbS can create new economic activities such as eco-tourism associated with biodiverse protected or restored ecosystems, or sustainable recreational use.
- **New products**. NbS can create new products from sustainable use of natural resources (such as natural wood climbing holds for climbing walls), but it is critical that these products are harvested sustainably (and this is not always monitored).

Skills, knowledge, training and capacity building

- NbS provide jobs at a range of skill levels, including entry-level jobs suitable for a rapid response to unemployment, and high-tech jobs such as those involving remote sensing, geographical information systems or environmental monitoring
- NbS can promote eco-innovation and a transition to a clean, efficient circular economy.
- Many NbS projects have provided training and capacity building for local communities, which can be targeted at vulnerable groups such as women, young people and the long term unemployed.

Avoided damage costs

- Although not the focus of this review, there is also substantial evidence in the wider literature that NbS can reduce or avoid the costs from damage due to hydro-meteorological hazards (storms, floods, droughts, heatwaves). For example, coastal mangroves and saltmarshes can protect from flooding due to storm surges; forests in upper catchments can reduce soil erosion, inland floods and landslides; and bio-remediation can address soil salinization and pollution.

Benefits for health and well-being

- Similarly, although not the focus of this review, there is also substantial evidence in the wider literature that NbS can improve physical and mental health and well-being, e.g. by improving air and water quality, dietary diversity and food and water security, and providing green spaces for recreation. This can provide economic benefits by increasing productivity and reducing health care costs.

Mixed or negative outcomes also arose through a variety of pathways.

- **Limits on resource extraction from protected or sustainably managed areas** for dependent communities.
- **High up-front costs** for options such as agroforestry or green roofs, which were not always recovered through resource savings and other benefits.
- **Failure for projected benefits to materialise,** e.g. if certified products could not be sold at a premium because supply exceeded demand.
- **Distributional impacts,** typically if marginalised or low-income groups lack access to the land, knowledge, machinery, credit, and other resources needed to implement some types of NbS such as agroforestry or conservation agriculture, or when revenue streams are not equitably distributed.
- **Poor design** of interventions, failing to support both biodiversity and social capital.

A key strength of NbS is that they generally offer very strong synergies between multiple objectives. Numerous sources cite strong evidence that NbS can deliver a wide range of positive outcomes as well as economic recovery, including food and water security, climate change mitigation and adaptation, social cohesion and human health and wellbeing. However, trade-offs can also occur. Sometimes short-term economic losses occur as part of the path towards longer term gains, such as if grazing or fishing levels must be reduced to enable sustainable resource use in future, or when there is a delay before trees mature or soil fertility increases. Trade-offs can also emerge between livelihoods and biodiversity, e.g. due to limits on resource use in protected or sustainably managed areas.

Trade-offs and negative outcomes can be avoided or mitigated through good design of NbS, following best practice guidelines and the IUCN Global Standard. The literature also identified two specific groups of enabling factors. Firstly, full participation of local stakeholders is essential to ensure successful economic, social and ecological outcomes and to tailor NbS to the local context, making use of local knowledge. Secondly, targeted livelihood-focused support is needed to address any trade-offs or time lags before benefits are delivered, and support must be pro-actively targeted to ensure that benefits reach the most vulnerable households.

We identified many evidence gaps where further work is needed. In addition, economic outcomes are often recorded using a wide variety of different indicators, they do not always assess distributional impacts and they do not always use suitable counterfactuals or baselines. In the next phase of work, we will develop a protocol for best practice robust evidence gathering to inform future monitoring and assessment of the economic outcomes of NbS.

Based on this evidence, there is a strong case for governments to place well-designed and equitable NbS at the heart of economic investment programmes, as they provide a unique mechanism for simultaneously supporting economic recovery while also tackling the climate, biodiversity, food security and fuel price crises.

Contents

1 Introduction

There is growing recognition that well-designed Nature-based Solutions (NbS) (Box 1) can address the interlinked crises of climate change and biodiversity loss, helping to reverse the degradation of the natural world (Seddon, Smith et al., 2021). The COVID-19 pandemic has highlighted additional imperatives for protecting nature: over half of emerging human infectious diseases are linked to land conversion for agriculture, and anthropogenic changes to ecosystems are key drivers of zoonotic disease risk (Allen et al., 2016; Rohr et al., 2019), with vector-borne pathogens evolving more rapidly with climate change (Bartlow et al., 2019). Pandemic lockdowns have also raised the importance of engagement with nature for mental health and wellbeing.

Box 1. Definition of Nature-based Solutions (NbS)

NbS are defined as 'actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits' (UNEP, 2022).
Four guidelines for successful sustainable NbS have been developed by a consortium of environment and development organisations:

1. **NbS are not a substitute for the rapid phase-out of fossil fuels** and must not delay urgent action to decarbonize our economies
2. **NbS involve the protection, restoration and/or management of a wide range of natural and semi-natural ecosystems** on land and in the sea; the sustainable management of aquatic systems and working lands; or the creation of novel ecosystems in and around cities or across the wider landscape
3. **NbS are designed, implemented, managed and monitored by or in partnership with Indigenous peoples and local communities** through a process that fully respects and champions local rights and knowledge, and generates local benefits
4. **NbS support or enhance biodiversity**, that is, the diversity of life from the level of the gene to the level of the ecosystem

However, NbS can also play a key role in delivering socio-economic benefits. They can generate high quality jobs, boost incomes, reduce the costs of damage from climate impacts such as floods and droughts, and reduce healthcare costs. Businesses and private finance are increasingly recognising that supporting biodiversity can reduce their exposure to environmental risks, ensure legitimacy with investors, and provide innovative market opportunities. This understanding has accelerated momentum to place nature at the heart of 'building back better' post-COVID.

The commodity price shocks following the Russian invasion of Ukraine have highlighted further reasons for investing in NbS. Many NbS have the potential to reduce demand for fuel, fertiliser and energy-intensive materials, as part of a transition to a resource-efficient circular economy (such as for agroecology, see van Der Ploeg et al. 2019).

However, while NbS could play a vital role in a green economic recovery and a just transition to a low carbon economy, they (and other environmental measures) have been largely neglected in economic recovery packages to date. Only 2.5% of total spending and 18% of 'economic recovery' investments in 2020 were green, with investment flowing mainly towards conventional sectors of the economy that tend to be associated with environmental damage (O'Callaghan and Murdock, 2021). Additionally, the global value of annual subsidies for environmentally damaging activities (including in agriculture, fisheries, and energy sectors) amounts to $US 1.8 trillion (approximately equivalent to Canada's entire GDP) (Koplow and Steenblik 2022). It seems that many policymakers do not consider the potential for NbS to contribute both to short term economic recovery and to a longer-term transition to a climate-resilient economy. In response, the United Nations Environment Assembly in March 2022 adopted a new resolution to 'commit to promoting a sustainable, resilient and inclusive post COVID-19 recovery, and a green and just transition, by incorporating biodiversity, climate change and pollution concerns into all policies and tools', as well as adopting a resolution to support the implementation of Nature-based Solutions.

The omission of NbS from economic recovery plans to date could partly reflect uncertainty on the economic impact of NbS for national economies. Although there is evidence of their job creation potential (e.g. WWF & ILO, 2020; BenDor et al. 2015a), there is a need for more extensive analysis to demonstrate their potential compared to alternatives, to understand the pathways by which NbS deliver economic impact, and how ensuing benefits are distributed, and assess potential trade-offs between economic, environmental and social outcomes.

This lack of evidence poses a substantial risk to the uptake of NbS, as economic recovery packages default to investing in conventional industries including environmentally damaging activities such as fossil fuel extraction. It is vital that economic stimulus packages, climate and development policies are informed by robust evidence-based guidelines around what good investments in NbS look like and the benefits they can bring. This is particularly true in the Global South where the impacts of COVID and climate change are most severe.

To address these needs, this report presents a rapid synthesis of key evidence sources, focusing on the short-term economic recovery potential (e.g. job creation, income, gross value added, economic multipliers) but also considering the longer term development outcomes (e.g. climate change adaptation, food and water security) of investments in NbS. We aim to address the following questions, determined through consultation with target research users:

1. In the short term, could NbS generate good quality jobs and boost incomes and revenues as countries strive to 'build back better' in the recovery from the COVID-19 pandemic?
2. Could NbS play a role in the transition towards a sustainable resource-efficient circular economy that is more resilient to future commodity price shocks?
3. How are the economic benefits and costs of NbS distributed between different groups of stakeholders, and how can they be equitably distributed?
4. Are there trade-offs and synergies between different economic outcomes, or between economic, social and environmental outcomes of NbS?
5. How can investments in NbS be designed to deliver the greatest economic benefits?
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7. How strong is the evidence of economic outcomes, and how could evidence gathering be improved in future?

The overall aim is to identify the potential for NbS to contribute to a just and sustainable economic recovery, and to develop a better evidence base to guide future investment in well-designed NbS. This is intended to ensure that finance is channelled towards projects that have robust biodiversity and social safeguards and deliver multiple economic, social and environmental benefits over the long term.

The target users for this research are those focusing on economic recovery, climate and development policy, including in the Global South. These include international organisations such as GIZ, IMF (Fiscal Affairs), UNEP (Environment's Resources & Markets Branch), WWF, and IUCN; and regional organisations such as the United Nations Economic Commission for Africa, African Union, UN Latin American Countries Team. In the

UK the target users include Defra (International Climate Finance), BEIS (CoP26 Cabinet Office), HM Treasury and the Foreign and Commonwealth Development Office.

This report presents the preliminary findings from the evidence review, funded by a grant from the NERC Programme on Synthesising Evidence in Economics of Biodiversity. The work continues with co-funding from the Oxford Martin School programme on Biodiversity and Society, leading to a joint final report at the end of 2022.

2 Method

2.1 Types of economic outcome considered

To frame and determine the scope of the review we classified the potential economic outcomes of NbS into conventionally recognised economic impact indicators (e.g. jobs, income and revenue generation, and economic multiplier effects), and the wider economic outcomes of NbS that may be neglected by policymakers. These groups are closely interlinked, e.g. the wider outcomes in terms of avoided climate damage can help to sustain livelihoods, jobs and incomes.

1. **Conventionally recognised economic outcomes:**
    a. **Creation of new jobs (and associated incomes)**, through implementation of NbS (e.g. in ecosystem protection and restoration), or through new business opportunities such as eco-tourism.
    b. **Profitability and security of existing livelihoods (and associated jobs, revenues and incomes)** such as agriculture, forestry, non-timber forest products (NTFPs) and fishing, including possible adverse impacts e.g. due to exclusion from protected areas or limits on exploitation of resources.
    c. **Knowledge, skills, training and innovation**. Impacts of NbS on innovation and the skill level of the workforce.
    d. **Multiplier effects:** Associated impacts on the local and national economy (jobs and incomes / gross value added) due to indirect and induced effects. **Indirect effects** are creation of jobs and/or increased revenues in sectors supporting NbS delivery (e.g. supply chain, retail, hospitality, etc.), or loss of existing jobs/ incomes / revenues if existing businesses become unviable. **Induced effects** are changes in jobs and incomes in other sectors via increased or decreased spending of household incomes related to the direct and indirect effects.

2. **Wider economic outcomes of NbS**:
    a. **Avoided damage** to property and livelihoods from climate impacts and natural hazards such as flooding and landslides.
    b. **Cost savings** due to reduced dependence on fuel, fertiliser, concrete, metal or other expensive resources.
    c. **Possible adverse impacts** e.g. impacts of afforestation on local water supplies.
    d. **Health care savings** and reduced time off work from health benefits such as from pollution and noise reduction, provision of urban cooling and green space for recreation.
    e. **Associated multiplier effects** due to the impact on spending from cost savings or loss of income due to adverse effects.
    f. **Capacity building** and shaping of institutions (including those that influence the efficacy and distributive effects of NbS).

2.2 Evidence sources

To rapidly synthesise evidence on the economic outcomes of NbS in the timescale of this project, we used three sources. First, we conducted a deeper analysis of an existing systematic review of evidence on the outcomes of NbS for climate change adaptation and sustainable development in the Global South (the Nature for Development database), to extract the broad range of economic outcomes (groups 1 and 2 above). We then supplemented this with a systematic 'review of reviews', to rapidly assess further evidence on the conventionally recognised economic outcomes (group 1 above). Finally, we briefly analysed selected additional grey literature reports collated from governmental, multi-lateral and non-governmental organizations, as well as stakeholder networks and consultancies. These three steps are described below.

2.2.1 Re-analysis of the Nature for Development (N4D) database

Working with the International Institute for Environment and Development (IIED), and on the request of what was the Dept. for International Development (now the Foreign and Commonwealth Development Office, FCDO), NbSI created a database of 508 coded cases drawn from 301 studies (Roe et al., 2021), from the following sources:

1. Peer-reviewed academic studies for low, lower-middle and upper-middle income countries drawn from NbSI's global systematic map of NbS outcomes for climate change adaptation (Chausson, Turner et al. 2020), containing 53 studies up to April 2018. This dataset only includes studies that report at least one outcome for climate change adaptation. Note that the main focus was on low to lower-middle income countries and thus the dataset may not be exhaustive for upper middle-income countries, which were not included in the report by Roe et al. (2021).
2. An extension of this dataset with an additional 30 studies up to May 2020, using the same systematic search protocol but for lower income countries only (used for Woroniecki et al., 2021).
3. Grey literature reporting on investments in nature for development outcomes (2010-2020). This includes 306 cases drawn from 218 reports, compiled from a targeted search of the websites of conservation/natural resource management organizations, UN agencies and development organizations.

The database includes NbS projects implemented by government, private sector, and not-for-profit organisations, covers a wide range of longer-term development outcomes, and considers the influence of political, institutional and macro-economic contexts. It provides evidence on both the conventionally recognised economic indicators (jobs, incomes, skills) and also the wider economic benefits, for low to upper middle-income countries (but not high-income countries). However, it excludes studies that do not also contain evidence of climate change adaptation outcomes.

The conventional economic outcomes in this database (jobs, incomes and revenues) were included mainly in an aggregate category "Local economies", although training and skills were included as part of a separate category "Rights and empowerment". We therefore reanalysed the dataset to extract separate outcomes for the individual indicators: jobs, income or revenue, job security, skills / training, GVA and economic multipliers.

2.2.2 Systematic review of reviews on economic outcomes of NbS.

The N4D database captures a broad range of economic outcomes but it was designed to search for climate change adaptation and development outcomes rather than specifically economic outcomes. We therefore carried out a separate search focusing on the conventional economic outcomes most related to short term economic recovery: jobs, incomes, revenue, skills, gross value-added and economic multipliers. The time limitations, the broad scope of the research questions and the global geographical scope did not permit a full systematic search of the primary literature. We therefore carried out a systematic "review of reviews" to capture a broad evidence base informed by the primary literature.

We catalogued evidence in a transparent and objective manner following systematic review guidelines from the Collaboration for Environmental Evidence (2018). We revised the question scope, search string, study selection criteria, and coding framework in early March/April 2022 through a series of meetings with internal project partners (Smith School of Enterprise and the Environment, Environmental Change Institute, Department of Biology), as well as feedback from external experts with expertise covering environmental economics (DEFRA international climate and biodiversity team, and World Resources Institute). This ensured relevance to policy makers interested in the economic impact and recovery potential of Nature-based Solutions.

2.2.2.1 Searching and screening

The search was carried out using SCOPUS and Web of Science CORE index collections on 18 April 2022, selecting only articles tagged as reviews. The search string (see Annex 1) was framed by the study scope. We systematically applied a set of selection criteria (see Annex 1) to screen results through a stepwise procedure (title, then abstract, then full text) assisted by a web-based screening tool (rayyan.ai). Approximately 10% of abstracts and full texts were screened by both reviewers to ensure inter-reviewer coding consistency. Finally, we prioritised the reviews for screening in this phase of the work by selecting only systematic reviews that specifically aimed to address economic outcomes. Coding of the remaining reviews will continue under the next (co-funded) phase of work.

2.2.2.2 Coding

We coded each study, capturing aspects of the study, the intervention, and the economic outcomes (see Annex 1 for full coding framework). Interventions were not explicitly restricted to those meeting the full definition of NbS (Cohen-Shacham et al., 2016) or explicitly using the NbS terminology, as this would have excluded many relevant studies, but where the information was available, we excluded interventions without an explicit focus on supporting or promoting biodiversity. Following Chausson, Turner et al. (2020) interventions were broadly categorized into (a) protection; (b) restoration; (c) other forms of management of natural or semi-natural ecosystems (hereafter management); (d) creation or management of created ecosystems (hereafter termed “created ecosystems”); or (e) nature-based food production (e.g. agroforestry, conservation agriculture). We also coded the ecosystem type in which the intervention took place, and the geographical location, although as we were coding reviews of multiple primary studies the location was typically global or regional.

For each reported economic outcome (jobs, incomes, revenue, skills, gross value-added and economic multipliers) we coded the reported overall direction of effects (positive, negative, neutral, mixed, unclear). As our focus was strictly on conventional economic impacts, we excluded economic valuations of ecosystem services where the economic impact of these was not specified. We also recorded whether the reviews restricted their component studies to those that presented evidence in relation to a counterfactual or baseline.

To assess wider outcomes of the intervention, we also recorded any reported impacts on biodiversity, climate change mitigation and adaptation (including disaster risk reduction) and livelihoods, as well as trade-offs and synergies, distribution between different beneficiary groups, and impact pathways (i.e. *how* the outcomes materialized, including any mediating factors). Additionally, we recorded any comparisons of economic impact between different types of NbS, or alternative non-NbS interventions.

2.2.2.3 Data analysis

The evidence base was characterized through descriptive statistics, mapping the number of reviews with respect to type of intervention/type of ecosystem, and the direction of economic impact outcome measures. We also record the number of underlying studies included in each review; in most cases these are primary studies, but there were also some reviews. We did not check whether any reviews included the same studies as another review, but this seems unlikely because most of the reviews addressed different types of interventions in different regions.

In the results section we provide descriptive summaries of the main types of economic outcome for different combinations of intervention type and ecosystem. We also present selected illustrative case studies. In the discussion, we pull out key themes, and describe trade-offs and synergies, distributive effects, and outcome pathways. Finally, we record key evidence gaps and consider the scope to improve measurement of economic outcomes in future NbS projects.

2.2.3 Other key academic and grey literature

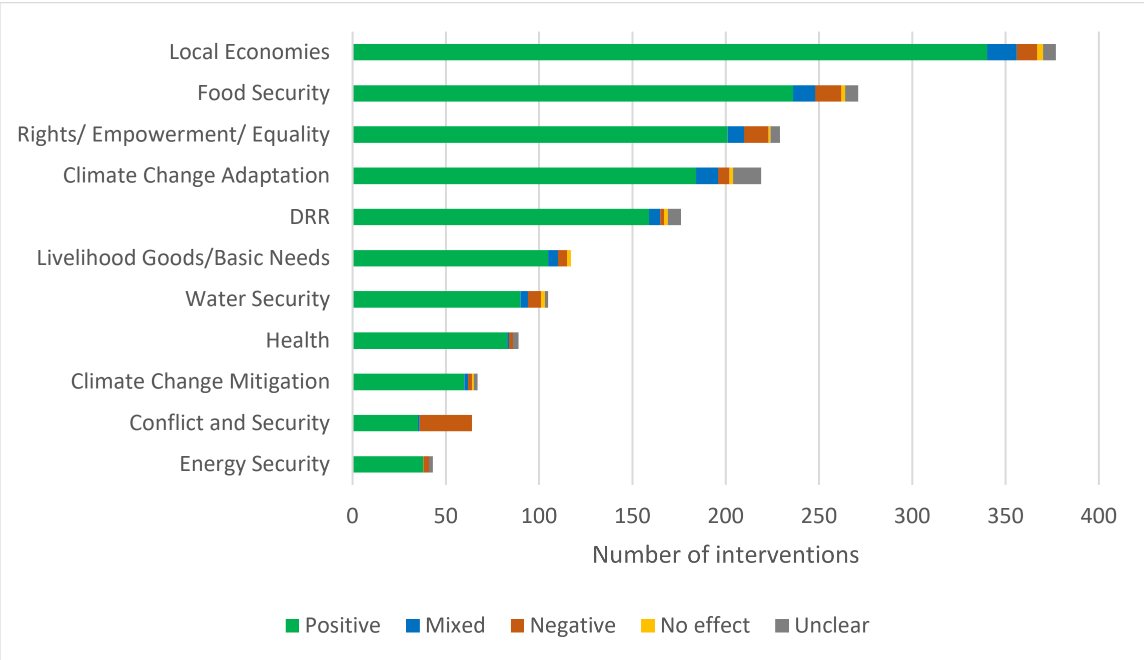
To complement the above, we carried out a brief targeted (not systematic) search for key academic papers not covered by the previous two analyses (e.g. primary studies rather than reviews, or studies that did not contain evidence of climate change adaptation outcomes) and grey literature reports from websites of international organizations (AID agencies, development NGOs, and UN agencies). These were rapidly coded to extract key information on economic outcomes.

3 Results

3.1 Reanalysis of N4D database

The N4D dataset reports a wide range of outcomes for development. The majority (87%) of all reported outcomes are positive, 4% are mixed and 5% negative (the remaining 4% being unclear or having no effect). Direct impacts on local economies are the most frequently reported outcome, followed by food security and then rights / empowerment / equality (Figure 1).

Figure 1: Development outcomes from nature-based interventions for climate change adaptation (based on the dataset created by Roe et al., 2021)



Although the aggregate category of 'Local economies' captures the conventional direct economic outcomes for jobs, incomes and revenues, all the reported development outcomes could also have indirect economic impacts. For example, improving food security or livelihoods at the household level, or improving access to green space in urban areas, can also improve physical and mental health (e.g. Robinson and Breed, 2019), which will in turn reduce healthcare costs (Freijer et al., 2013; van Den Eeden et al., 2022) and increase workforce productivity (Buckley and Brough, 2017). Benefits for climate change mitigation, adaptation and disaster risk reduction equate to reduced economic costs of damage to infrastructure or crop production from events such as storms, floods or droughts. For example, coastal flood damage from a 100-year storm event would increase by US$272 billion without the protection offered by coral reefs (Beck et al., 2018), and hazard risk reduction by reefs across 3,100 km of US coasts is worth US$1.8 billion/yr (and US$10 million/km where coasts are highly developed) (Reguero et al., 2021). Benefits for conflict and security will reduce the economic cost of local conflicts or geopolitical instability. Similarly, empowerment of women can enable them to play a greater role in the economy, e.g. by working outside the home or starting new businesses (e.g. Lamptey et al., 2013). The review also found that NbS can provide resilience to economic shocks, e.g. by providing food and livelihood security when other sources of income are lost (Roe et al., 2021), which also contributes to climate change adaptation (Vignola et al. 2015).

Our reanalysis broke down the category of 'Local economies' into outcomes for income/ revenue/ livelihoods; jobs; and job security. We also extracted outcomes for skills/ training/ knowledge/ education from the category of 'Rights / empowerment / equality' (Figure 2, Table 1). This shows that the outcomes for these conventional economic indicators are largely (93%) positive with only 3% mixed and 2% negative.

Figure 2. Breakdown of types of economic outcomes from nature-based interventions for climate change adaptation, based on a reanalysis of the dataset created by Roe et al 2021

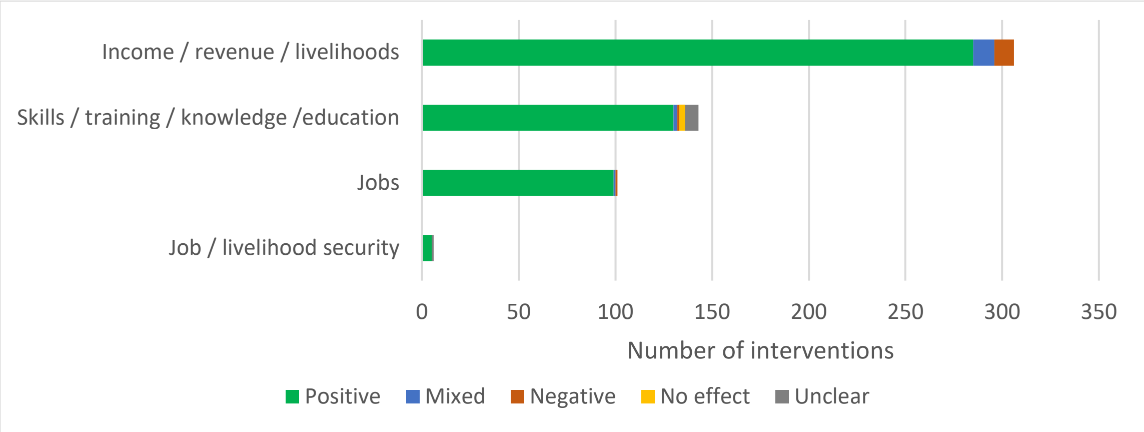


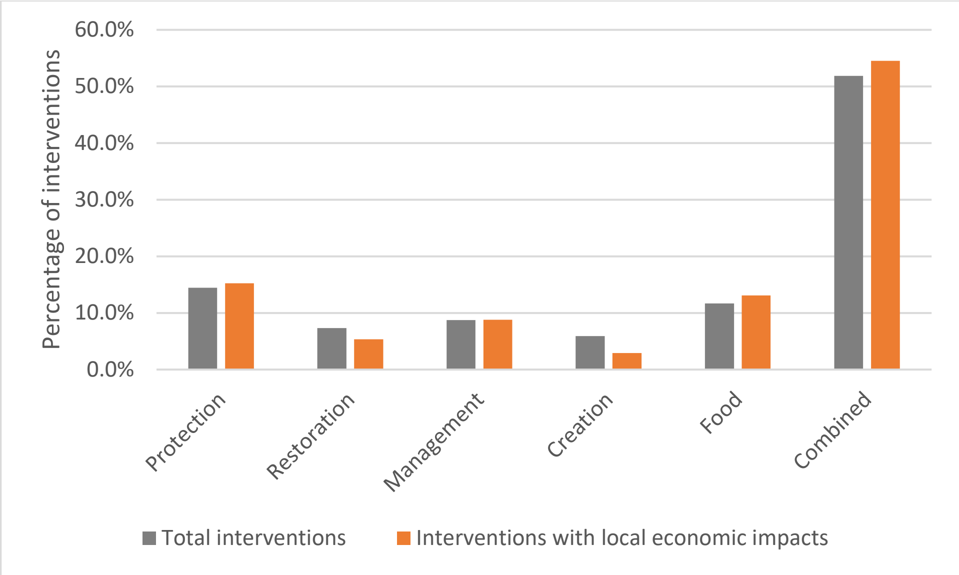
Table 1. N4D review: outcomes for economic recovery. Percentages reflect the split of each outcome type (row) into directions (positive, negative etc).

	Positive	Mixed	Negative	No effect	Unclear	Total
Job / livelihood security	5 (83%)	0 (0%)	0 (0%)	0 (0%)	1 (17%)	**6**
Jobs	99 (98%)	1 (1%)	1 (1%)	0 (0%)	0 (0%)	**101**
Skills / training / knowledge /education	130 (91%)	2 (1%)	1 (1%)	3 (2%)	7 (5%)	**143**
Income / revenue / livelihoods	285 (93%)	11 (4%)	10 (3%)	0 (0%)	0 (0%)	**306**
Total	**519**	**14**	**12**	**3**	**8**	**556**

Direct jobs and income were reported to be generated both from implementation of the NbS (e.g. planting trees; patrolling protected areas) and from goods and services generated by the NbS, which in turn channel revenue (e.g. eco-tourism; improved crop yields; carbon finance; PES). A few articles also mentioned indirect or induced effects, such as the use of direct NbS incomes for purposes such as building schools, clinics or other infrastructure, though these were typically not quantified. However, although reported economic outcomes are largely positive, there can also be negative or mixed impacts.

There is little difference between the split of intervention types with and without reported local economic impacts, although slightly more of the protection and food production and slightly fewer of the restoration and creation interventions report local economic impacts, compared to the overall total (Figure 3). However, it is difficult to draw firm conclusions because over half of all interventions included a combination of actions.

Figure 3. Percentage of different types of interventions with and without local economic impacts



When considering the direction of outcome, there are small differences between types of intervention. Interventions based purely on habitat protection are the most likely to report negative impacts when all outcomes are considered, and the second most likely to report negative impacts when only local economic impacts are considered, although 72% of all outcomes and 81% of local economic impacts are still positive (Figure 4, Table 2). This reflects adverse impacts when protected area governance imposes restrictions on access to and/or use of natural resources that local people rely on, e.g. for grazing, hunting, fishing or harvesting wild products (e.g. timber, firewood, honey, wild fruit) or cultivated products (e.g. clearing the forest for agriculture). Negative outcomes can also occur when protection results in human-wildlife conflicts and associated damage to crops or danger to life. Similar adverse local economic impacts can result from exclusion of local people when areas are being restored. In contrast, nature-based food production results in almost entirely positive reported outcomes, typically due to increased crop yields, or improved resilience of production to environmental change.

These negative outcomes and trade-offs can be mitigated through good design and management. The evidence suggests that positive outcomes can result from protection and restoration when they are accompanied by livelihood-focused interventions that support the most vulnerable resource users (i.e. a socially-differentiated approach), and when they are designed and implemented by or in partnership with the local community so that their needs and cultural preferences are integral to the NbS (Wright et al., 2015). This is reflected in the third of the four guidelines for successful, sustainable NbS (Box 1). Governance factors are critical, e.g. positive outcomes are often associated with provision of secure land tenure and negotiation of access for sustainable use.

Figure 4. Reported outcome directions for different intervention types: overall outcomes (left) and local economic outcomes (right)

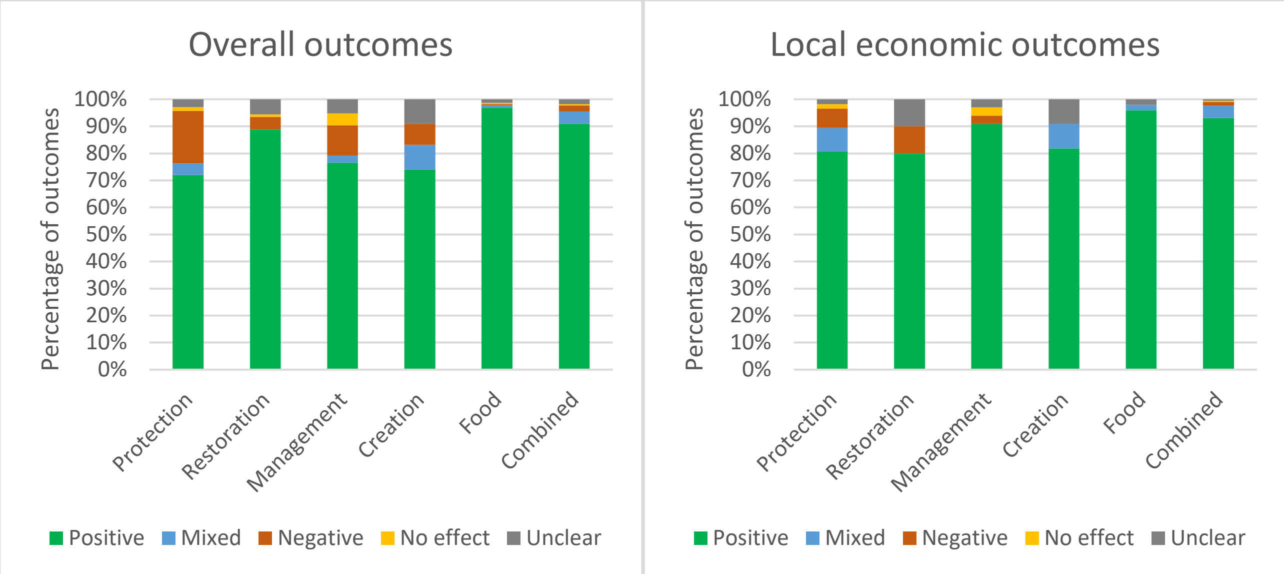


Table 2. Reported outcome direction for different intervention types: overall outcomes and local economic outcomes. Percentages reflect the split of each outcome type (column) into directions (positive, negative etc).

	Protection	Restoration	Management	Creation	Food	Combined	Total
Overall outcomes							
Positive	152 (72%)	95 (88.8%)	88 (76.5%)	57 (74%)	216 (96.9%)	911 (90.8%)	**1519**
Mixed	9 (4.3%)		3 (2.6%)	7 (9.1%)	2 (0.9%)	47 (4.7%)	**68**
Negative	41 (19.4%)	5 (4.7%)	13 (11.3%)	6 (7.8%)	1 (0.4%)	22 (2.2%)	**88**
No effect	3 (1.4%)	1 (0.9%)	5 (4.3%)		1 (0.4%)	5 (0.5%)	**15**
Unclear	6 (2.8%)	6 (5.6%)	6 (5.2%)	7 (9.1%)	3 (1.3%)	18 (1.8%)	**46**
Total	**211**	**107**	**115**	**77**	**223**	**1003**	**1736**
Local economic outcomes							
Positive	46 (80.7%)	16 (80%)	30 (90.9%)	9 (81.8%)	47 (95.9%)	190 (93.1%)	**338**
Mixed	5 (8.8%)	(0%)	(0%)	1 (9.1%)	1 (2%)	9 (4.4%)	**16**
Negative	4 (7%)	2 (10%)	1 (3%)			3 (1.5%)	**10**
No effect	1 (1.8%)		1 (3%)			1 (0.5%)	**3**
Unclear	1 (1.8%)	2 (10%)	1 (3%)	1 (9.1%)	1 (2%)	1 (0.5%)	**7**
Total	**57**	**20**	**33**	**11**	**49**	**204**	**374**

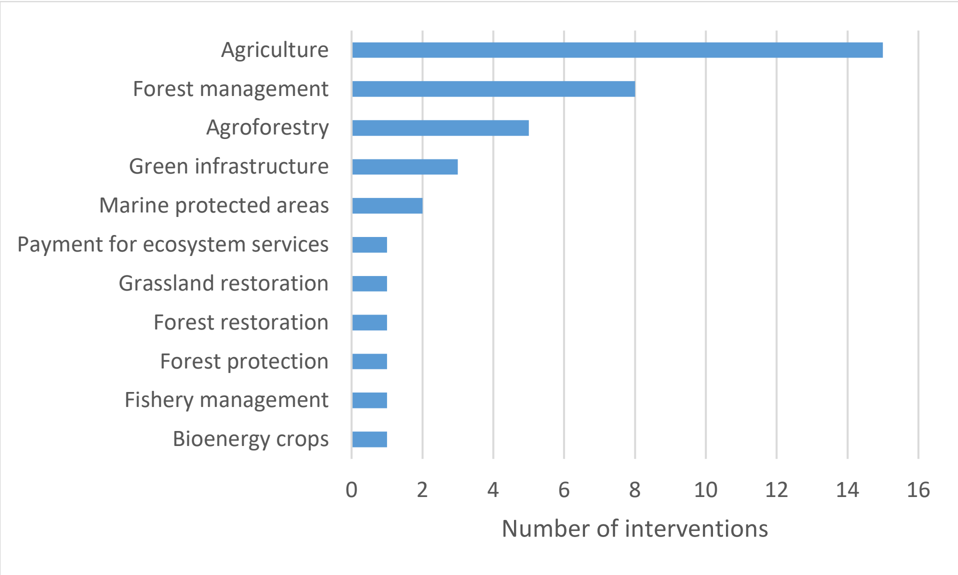
Much of the grey literature in the N4D database was self-reported evidence from the implementers or funders of the projects, and it may thus be subject to reporting bias (although note that bias can also apply to academic literature, which can be more likely to publish statistically significant positive results). In future work we will assess the quality of the evidence, e.g. whether the outcomes were reported with respect to a suitable baseline or counterfactual, and whether there was an attempt to account for confounding factors.

3.2 Review of reviews on economic recovery outcomes

The review of reviews was intended to provide a rapid overview of the evidence on conventional economic recovery indicators: jobs, incomes/ revenues, skills, GVA and economic multipliers. The search (see Annex 1 for search string) found 2,138 studies in Web of Science and 1,137 in Scopus, resulting in 2,818 after duplicate removal. Following screening of titles, abstracts and full texts, 199 studies remained. Of these, 37 were advertised as systematic reviews, and 25 of these explicitly aimed to address economic outcomes and were therefore coded in this initial phase of the work (see list in Annex 2). On coding, it became apparent that three of these reviews were not systematic; however, they contained relevant information and were therefore retained. Overall, 11 of the 25 reviews carried out a critical appraisal of the primary studies, and 10 checked whether the primary studies used a comparator (including counterfactuals or baselines); only 8 carried out both quality checks.

Reviews tended to focus on specific intervention types. The 25 reviews covered 39 interventions, dominated by production NbS: agriculture (15), forest management (8) and agroforestry (5) (Figure 5). This reflects the likelihood that these NbS tend to be designed with economic outcomes as a primary objective, and also because it is easier to assess their economic impacts as they produce goods with a market value such as crops, timber, livestock products and NTFPs. Some types of NbS were not covered at all by the reviews, e.g. restoration of inland wetlands (including peat bogs) or coastal ecosystems (dunes, mangroves, reefs).

Figure 5. Intervention types assessed by the systematic reviews



The 39 interventions reported on 66 conventional economic outcomes. Most of the evidence is for income or revenue (37 cases), followed by job creation (14). There was less evidence for the other conventional economic impact categories: skills / training, job security, GVA or multipliers (Figure 6, left-hand side). However, when considering the number of component studies covered by each review, the evidence base for job security outcomes (101 studies) was similar to that for the number of jobs (111 studies), with incomes / revenue still being the strongest evidence base at 629 studies (Figure 6, right-hand side; Table 3).

Although there are very few negative reported outcomes, there is a much higher proportion of mixed outcomes compared to the N4D database, mostly falling under income or revenue generation and job creation. Most (63%) of the outcomes for income and revenue are positive, but 29% are mixed, with 3% (one review) reporting only negative outcomes (Table 3).

Figure 6. Direction of outcomes for economic recovery indicators from the review of systematic reviews (left), and approximate strength of evidence as indicated by number of studies within reviews (right).

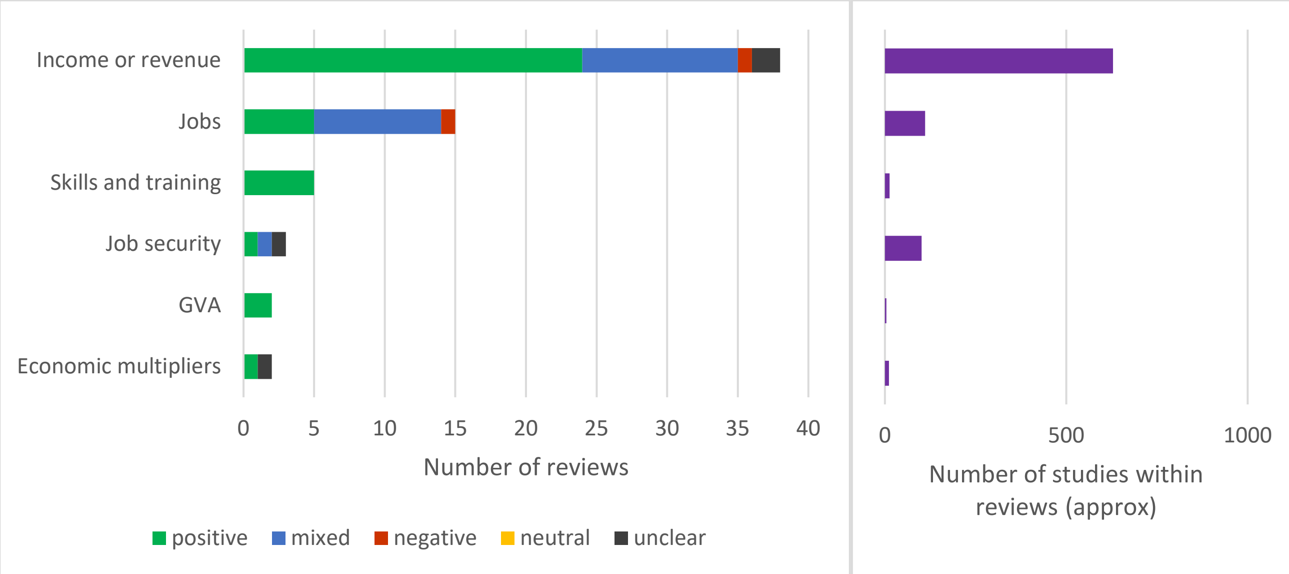


Table 3. Review of reviews: Direction of economic outcomes (number of reviews) and approximate number of underlying studies

Outcome	Positive	Mixed	Negative	Neutral	Unclear
Income or revenue	24 (63%)	11 (29%)	1 (3%)	(0%)	2 (5%)
Jobs	5 (33%)	9 (60%)	1 (7%)	(0%)	(0%)
Skills and training	5 (100%)	(0%)	(0%)	(0%)	(0%)
Job security	1 (33%)	1 (33%)	(0%)	(0%)	1 (33%)
Economic multipliers	1 (50%)	(0%)	(0%)	(0%)	1 (50%)
GVA	2 (100%)	(0%)	(0%)	(0%)	(0%)
% of total reviews	**58%**	**32%**	**3%**	**0%**	**6%**

The positive outcomes provide evidence that well-designed NbS can boost incomes, including by:

- providing opportunities for eco-tourism and outdoor recreation (e.g. BenDor et al., 2015b)
- saving energy and fertiliser costs and boosting crop yields (agro-ecology)
- saving energy and stormwater management costs (green roofs and walls)
- generating or sustaining incomes from sustainable agriculture, forestry or NTFPs.
- through payments from the generation of ecosystem services (e.g. through carbon credits, or PES mechanisms)

However, the negative and mixed outcomes show that incomes or revenues can fall in some cases. This can be for several reasons, including:

1. effects are dependent on the context (for example, the type of crops grown, access to market, household type);
2. income benefits materialize long term, after high opportunity costs short-term.
3. the NbS may not aim to generate more profits over alternatives, but rather to deliver higher levels of well-being (thus overall societal value increases, but income generation may decrease); or
4. impacts on income may differ across social groups.

Examples include:

- When governance (for protection or restoration) restricts access to or use of natural resources by local people, without adequate plans for sustainable livelihoods (as also found by the N4D review). For example, the one purely negative outcome was for a grassland restoration intervention in China that excluded pastoral communities from their grazing land and provided alternative livelihood options (polytunnel horticulture) that were not well aligned with cultural preferences, local knowledge or local climatic conditions (Li et al., 2016). This intervention would not be classed as a NbS because it was not designed by or with the local community. Similarly, mixed impacts were found for a review of Marine Protected Areas (MPAs), which concluded that it was important to provide suitable alternative livelihood options especially during the early years, while fish stocks recovered to a level where sustainable fishing could resume (Hassan et al., 2019b).
- Sustainable plantation management for certification schemes did not always deliver the expected crop price premiums, due to supply of certified produce exceeding demand from consumers, so that the costs of implementation sometimes exceeded the increased revenue (Burivalova et al., 2017; Garrett et al., 2021).
- Growing biofuels to rehabilitate degraded land also had mixed impacts on profitability, depending on local context including the type of crop, the sale price, soil type and water availability (Pulighe et al., 2019).
- Green roofs and walls can insulate buildings, thus reducing the cost of energy for heating or cooling, but these savings do not always pay back the initial investment costs for the building owner, even though there may be net benefits for society when all benefits are taken into account (e.g. from reduced stormwater runoff, biodiversity and aesthetic value). This is highly dependent on the local context, including the type of roof/wall, cost of energy, and local climatic conditions (Teotonio et al., 2021).

For jobs, 33% of outcomes are positive with 60% being mixed, and 7% (one review) negative. Where reported (8 cases) job creation was mostly direct (e.g. labour demands for NbS implementation or management) as opposed to indirect (due to multiplier effects, such as through increasing labour demands downstream in supply chains associated with NbS). Most of the evidence relates to sustainable agriculture, although job creation benefits were also found for community forest management (Pelletier et al., 2016), PES (Blundo-Canto et al., 2018) and Marine Protected Areas (Marcos et al., 2021). For sustainable agriculture the outcomes are mixed: it can involve replacing fossil fuel energy and agro-chemical use with human labour, but this varies depending on the exact mode of implementation (Rosa-Schleich et al., 2016). Intercropping, agroforestry and organic agriculture are generally found to increase labour demand (Reich et al., 2021), but conservation agriculture can either increase or decrease it for different cultivation stages (with crop residue retention reducing the need for pre-tilling, but reduced tillage potentially increasing the need for weeding unless herbicides are used; Wekesah et al., 2019). One complication is that increased agricultural labour hours are often classed as a negative effect, although they can also translate to employment opportunities for poor households. For example, the review that we have coded as a purely negative outcome for jobs showed that sustainable agriculture could result in labour savings (reduced working hours) that were viewed as a positive outcome, as this can reduce business costs and free up farmer's time for other economic activities (Rosa-Schleich et al., 2016).

NbS hold the potential to create both low and high-skilled jobs. There is evidence that some NbS practices can require more skill than non-NbS alternatives, e.g. to manage agroforestry systems while avoiding negative competition between trees and crops. Many interventions therefore provided training or outreach support (e.g. Castle et al., 2021), or harnessed local traditional knowledge (e.g. on suitable tree species to keep in farmer-managed natural regeneration; Chomba et al., 2019), thus building the skill and knowledge base of the workforce. However, not all jobs created are high skill. For example, implementing conservation agriculture without use of herbicides increases the amount of weeding needed, an arduous task which often falls on the women of the household, although it can also provide new job opportunities for poor households (Wekesah et al., 2019).

Few studies mentioned the other outcomes. Only two systematic reviews found a clear impact on job security. One review of agroforestry found that it could increase year-round income stability (Duffy et al., 2021), while a review of community forest management found that job security tended to improve in the forests that were community owned, but not necessarily in those owned by government or other agencies (Pelletier et al., 2016). For GVA, two reviews estimated the value of nature-based activities to national economies: one for resin-based agroforestry (Hassan et al., 2019a); and one for MPAs, which estimated average income generation and job creation per MPA, but found that the standard deviation was very high, showing the importance of local context (e.g. MPA size) (Marcos et al., 2021). For economic multipliers, a review of PES found that the payments generally resulted in greater household expenditure, and some of the revenue was used to build new infrastructure such as schools and clinics (Blundo-Canto et al., 2016); while the review of MPAs made a vague statement that the MPAs 'contributed to local economic development' (Marcos et al., 2021).

Several reviews considered the distribution of benefits between different groups. In some cases, it was found that the main benefits may flow to households with more capital, who can afford investment costs (e.g. for planting trees for agroforestry, or purchasing machinery for conservation agriculture) and have access to information and equipment. Similarly, farmers who can afford to apply for certification can reap the benefits of more sustainable commodity production, including via price premiums (DeFries et al., 2017). Even interventions targeting low-income households, such as community forest management, can exacerbate existing inequalities if there is weak governance, leading to elite capture (i.e. capture of benefits by those with more resources and power) (Burivalova et al., 2017).

A detailed summary of the findings for different types of NbS is presented in Annex 3. Overall, the review confirmed that economic outcomes are highly context-specific, and therefore it would not be meaningful to quantify ranges of economic outcomes for different types of NbS. However, the review provided a good understanding of the key factors governing economic outcomes, which we summarise in the Discussion.

3.3 Other key academic and grey literature

Our targeted search for additional relevant literature found seven academic papers and 19 grey literature reports and policy briefs collated from governmental, multi-lateral organizations, large international NGOs, stakeholder networks, consultancies, and one small non-profit (listed in Annex 2) that focus on the economic outcomes of investing in nature or shifting to a nature-positive economy, although not always specifically through NbS. We also explored some key references listed in these sources.

Some of these studies use economic modelling to provide evidence on jobs created per dollar of investment, GVA and economic multipliers, which was lacking in the evidence base for our two systematic reviews of the journal literature. Overall, the reports provide strong evidence for the potential of a range of nature-based solutions to generate jobs, through direct, indirect, and induced effects, across rich and poor nations and regions alike. Jobs can be created through government fiscal spending, or through the growth of nature-based enterprises, and can outweigh job creation potential across many traditional sectors (manufacturing, oil & gas). NbS hold the potential to create both low and high-skilled jobs, the former being particularly important for economic recoveries in vulnerable communities, and the latter for boosting innovation. There is good potential for NbS to be targeted at deprived communities and disadvantaged groups, and for spending to be retained within local economies. In addition, there is strong evidence that these interventions boost national and local economies through multiplier effects, and farmer incomes, while generating substantial biodiversity, climate change adaptation, and mitigation benefits. The supported ecosystem services can also mitigate job loss. Trade-offs were rarely mentioned, but one report did note opportunity costs in terms of job losses in traditional farming sectors, although this may be mitigated through added-value agricultural businesses.

Here we have categorised the evidence base under the following headings, although there is some overlap between categories as many reports address more than one issue:

- Economic dependence on nature
- Jobs per dollar of investment and economic multipliers
- Jobs per hectare of habitat, GVA and cost-benefit analysis
- Job diversity, job quality, skills and innovation
- New business opportunities
- Economic resilience and poverty reduction
- Wider economic impacts

3.3.1 Jobs per dollar of investment and economic multipliers

Three key academic studies on nature restoration in the US find good evidence that NbS can provide higher employment per dollar of public spending than other stimulus measures, and deliver high economic multipliers. Garrett-Peltier and Pollin (2010) used an economic multiplier model to estimate direct, indirect and induced job creation per $1 million investment for different sectors of the US economy. They found that nature-based investments are typically relatively labour-intensive, providing more jobs per dollar invested than other infrastructure such as fossil fuel power generation. The highest job creation potential was from "Reforestation, Land and Watershed Restoration, and Sustainable Forest Management", creating an estimated 40 jobs per $1 million investment, far higher than the next nearest sector (crop agriculture, at 23 jobs per $1 million). In contrast, coal, nuclear, oil and gas production generated only between 4 and 7 jobs per $1 million invested.

Similarly, Edwards et al. (2013) showed that the 2009 American Recovery and Reinvestment Act expenditure on 50 coastal habitat restoration projects generated on average 17 jobs per $1 million spent, similar to other conservation industries such as parks and land conservation, and much higher than other traditional industries including coal, gas, and nuclear energy generation. They pointed out that habitat restoration also has longer-term economic benefits, including future job creation in sustainable fisheries and eco-tourism, higher property values and better coastal water quality.

This was backed up by BenDor et al. (2015a), who showed how the 'Restoration economy' in the US supports economic growth and employment. They surveyed US businesses to parameterise an input-output model of the US restoration industry, and found that it supports 33 jobs per $1 million invested, with an employment multiplier of 1.48 to 3.8 (jobs supported by each restoration job) and an output multiplier of 1.6 to 2.59 (total economic output from each dollar invested). They also found a tendency for nature restoration projects to employ local labour and materials, ensuring that the benefits are delivered locally.

In line with these findings, WWF and ILO (2020) reported that the US urban forest programme delivered an estimated 24 full-time equivalent (FTE) jobs for every $1 million invested. There were also high fiscal and employment multipliers: for every dollar spent, two were created, and for every direct FTE job created, two more were created throughout the economy.

In Europe, a policy brief by the Institute for European Environmental Policy (IEEP) (Kopsieker et al., 2021) stated that the Natura 2000 network of 28,000 protected areas contribute to smart, sustainable and inclusive growth, providing an estimated 4.4 million direct, indirect and induced jobs. However, a more nuanced picture emerges from the underlying IEEP study (Mutafoglu et al., 2016). This clarifies that the total includes 52,000 direct jobs in management and conservation activities, which could double to 104,000 if the full proposed network was protected. Including indirect and induced jobs this would rise to 174,000, equating to 50 jobs per € billion invested, given that €5.8 billion is needed for the full implementation of the Natura 2000 network. The remaining 4.2 million jobs are linked to the role of protected areas in supporting forestry, agriculture, tourism and recreation, although these totals include both jobs in sustainable enterprises and those which do not support biodiversity. There may also be temporal trade-offs, e.g. short term reduction of grazing to enable long term recovery of the biodiversity underpinning sustainable livelihoods. The study also provides useful lessons for future economic assessments, including caveats on the limitations of input-output models for assessing job creation.

Similar estimates of 50 FTE/$million invested for forest landscape restoration come from an IUCN report (Raes et al., 2021). They show that more jobs per $ million invested in restoration are created than many of the other sectors that are usually targeted for economic stimulus spending. Unusually, they show the impact of jobs displaced in other economic activities, such as when restoration displaces other land uses. In fact, this can result in net job loss for some types of NbS involving natural regeneration rather than active restoration such as tree planting, although their report indicates that these NbS can have far higher carbon benefits. On the other hand, natural regeneration can restore far larger areas for the same investment. They suggest that additional livelihood measures, such as production of non-timber forest products, should be included in the design of such projects to offset any job losses. Citing a Vivid Economics study, they note that investing less than 5% of the total global stimulus package in a range of NbS would create an extra 7 million jobs, 7% more than a business-as-usual investment scenario. Finally, they recommend targeting NbS jobs at the most vulnerable groups, such as women and young people, by providing appropriate training (e.g. for tree planting).

Unusually large estimates of 281 to 458 jobs/ $ million for sustainable forest management come from the International Labour Organisation (ILO) report (Payen and Lieuw-Kie-Song, 2020, citing Nair and Rutt, 2009). However, they note that there is little information on the context underlying these estimates. Nevertheless, similar high estimates arise from other analyses. For example, the Emscher Landscape Park Programme in Germany (restoration of a former industrial area) created over 50,000 jobs, equivalent to 250 FTE/$ million invested (Raes et al., 2021; Box 2). Additionally, a WWF and ILO (2020) report exploring NbS job creation potential estimated a range of 24 to 750 FTE/$ million USD, depending on the intervention type and implementation context.

A global survey of economic experts by Hepburn et al. (2020) found that investment in natural capital was one of five policies with both high economic multipliers and positive climate impacts. This was backed up by a UNEP report which found that protecting natural capital can bring short-run recovery benefits while supporting long-run growth, with high economic multiplier potential and good job creation potential (O'Callaghan and Murdock, 2021). Subsequently, following the COVID-19 pandemic, O'Callaghan et al. (2022) used a machine learning approach to identify and analyse the evidence on the outcome of green recovery investments. They found evidence that green investments as a whole (including nature-based investments and other types such as green energy, energy efficiency and pollution reduction) can create more jobs and deliver higher fiscal multipliers than non-green investments, suggesting that policymakers should prioritise green spending in their economic recovery plans.

Box 2: Emscher Nature Park: regenerating an ex-industrial area, Germany

Nature was at the heart of the regeneration of the Emscher Landscape Park, in a deprived former coal and steel production area in Nord Rhine Westphalia (NRW) with high unemployment. Over 400 projects have been funded, restoring the polluted and canalised river and creating a network of green spaces connected by cycle paths, generating jobs and attracting new businesses into the area. The park now has 1500 plant species, 50 of them on the IUCN Red List.

Investment: 4.5 billion Euros
Jobs created from 1991-2007: 25,847 in NRW and 48,884 across Germany (direct, indirect and induced).
Jobs expected to be created by 2020: 55,892 in NRW and 101,687 across Germany.
Jobs per unit of investment: 250 FTE/$ million invested

Zollverein Coal Mine Industrial Complex
Zeche Zollverein, the most popular destination in the Emscher Landscape Park, is a 100 ha former coal mine that is now a UNESCO World Heritage Site. It celebrates the industrial heritage of the area, highlighting the unique biodiversity of the brownfield sites. One of the aims was to attract innovative companies and design firms to the green post-industrial setting. Eco-tourism and recreation opportunities have been created, with green walkways along the old railways, pocket parks, art and sculptures, and businesses offering nature tours. Biodiversity has increased, with over 800 plant and animal species including the return of the endangered peregrine falcon.

Investment: Over 4 million Euros
Jobs created: over 1,300 permanent and 680 temporary (direct, indirect and induced) in 2016, plus 760 tourism jobs from visitors to the World Heritage Site in Essen.
Visitors: 1.5 million per year (note that it is not possible to separate the role of nature restoration from the museums, galleries and other tourist attractions)

Sources: EGC (2017); Kopseiker et al. (2021); Raes et al. (2021); Stiftung Zollverein (2018); Urban Nature Atlas (2021); WWF and ILO (2020)

3.3.2 Jobs per hectare of habitat restoration and GVA

In the UK, input-output modelling by Cambridge Econometrics for the RSPB (Dicks et al., 2020) estimated the jobs and GVA created through habitat restoration (Table 4). They showed that as NbS often have large up-front costs from buying the equipment, materials and services needed to create or restore ecosystems, they also have high multiplier effects and generate high gross value added for the economy.

Table 4. Summary of Cambridge Econometrics modelling of jobs and GVA per ha of restored habitat in the UK (Dicks et al., 2020)

	Peatland	Woodland	Saltmarsh
Temporary jobs	3	25	14-74
Job years for operation over 100 years	7	6	-
GVA from capital investment (£ '000)	48,000	1222	880-4802
GVA from operational investment (£ '000)	112,000	314	-

The findings from this work, together with other sources, informed a report by the Green Alliance (2021). They estimated that jobs created per 100 ha range from 22-114 for woodland restoration in the UK (with estimates clustered towards the lower end of this range), 1-4 for peatland and 30-56 for coastal habitats.

This means that planting an extra 20,000 ha of woodland per year could create 5,000 jobs, restoring 55% of peatland by 2050 (50,000 ha/year) could create 500-2,000 jobs between 2021 and 2050, and restoring 13,550 ha of coastal habitat over 10 years (1355 ha/y) in priority locations identified by the RSPB could create a further 400-750 jobs.

In Africa, the ILO estimates an average of 0.58 FTE per ha based on 8 reforestation projects in Rwanda, Burundi and Cape Verde, equivalent to 58 jobs per 100 ha, approximately twice the UK estimates above. However, there was a wide range from 42 FTE per 100 ha in Burundi to 111 in Cape Verde, showing the importance of local context. The WWF and ILO (2020) 'Nature Hires' report also cites a wide range, depending on the type of NbS, of 0.02 to 500 jobs per 100 ha.

A report by the IUCN (Raes et al., 2021) presents case studies to demonstrate that investments in nature can be an effective policy to create jobs and support positive economic outcomes. Direct jobs created (FTE/ha/year) are highest for mangrove restoration, agroforestry with perennial crops, silvo-pastoral systems and soil conservation on cropland. Job demand is highest during the implementation phase, as opposed to the maintenance phase, making NbS particularly suitable for providing an economic recovery stimulus, e.g. for countering short term job losses in tourism and hospitality during the pandemic.

World Resources Institute research shows that restoring 160 million hectares of degraded agricultural land could generate $84 billion per year for national and local economies, boosting smallholder farmers' incomes in developing countries by $35 billion to $40 billion per year (Cook and Taylor, 2020; citing a New Climate Economy report from 2018).

3.3.3 Cost-benefit analysis

Dicks et al. (2019) carried out cost-benefit analysis (CBA) that showed positive cost-benefit ratios for peatland (4.32) and woodland (2.79) restoration in the UK, and for saltmarsh restoration for the low end of the estimated range of restoration costs (1.31) but not the high end (0.24) (Table 5). However, they emphasised that only a very limited number of the benefits of habitat restoration were able to be valued and included in the CBA, so it is likely that the true return on investment would be much higher if all benefits were considered.

Table 5. Summary of Cambridge Econometrics modelling of return on investment from habitat restoration in the UK (Dicks et al., 2020)

	Peatland	Woodland	Saltmarsh
Return on £1 investment (from CBA)	£4.62	£2.79	£0.24 to £1.31 (high to low cost estimates)
Included in CBA	carbon, recreation	carbon, recreation, air quality	carbon
Not valued in CBA	water quality, flood alleviation, biodiversity	water quality, flood alleviation, biodiversity, noise regulation, cooling	recreation, water quality, flood alleviation, biodiversity, fish production

A WRI report found even higher returns on investment for forest and landscape restoration, estimating $US 7 to 30 in benefits for every dollar spent (Ding et al., 2017).

3.3.4 Job security and economic dependence on nature

Several grey literature reports stress the dependence of our economies on healthy ecosystems, as highlighted recently by the Dasgupta report (2021). For example, 1.2 billion jobs in sectors such as farming, fisheries, forestry, and tourism are highly dependent on the effective management and sustainability of ecosystems, mainly in the Asia Pacific and Africa regions (ILO, 2018). Water dependence is particularly important: as well as the obvious necessity of clean water to sustain life, over half of the world's workers (1.4 billion people) worked in heavily water-dependent jobs and most of the rest (1.2 billion) in moderately water-dependent jobs in 2016 (cited in Payen and Lieuw-Kie-Song, 2020). The World Economic Forum (WEF) 'Nature Risk Rising' report (WEF, 2020a) showed that over half of global GDP ($44 trillion of economic value) is dependent on nature and its services, which is alarming given that biodiversity loss and ecosystem collapse was one of the top five threats to humanity in WEF's 2020 Global Risks Report.

The ILO study of jobs in Natural Resource Management highlights the particularly strong potential of agro-ecology and soil-water conservation to contribute to sustaining livelihoods in the long term, as well as creating jobs in the short term (Payen and Lieuw-Kie-Song, 2020).

3.3.5 Job diversity, job quality, skills and innovation

NbS have been found to create a wide range of different types of jobs at different skill levels. For example, Dicks et al. (2020) found that restoration created jobs in different sectors (e.g. tree nursery staff, countryside rangers, farm workers, forestry workers and managers and environmental and conservation professionals). These jobs ranged from entry-level low skilled jobs that could be quickly taken up by people with few qualifications, to high-skilled jobs requiring training and education, with increasing use of remote sensing, robotics and data analytics. They also cited a survey of 23 rewilding sites in Britain which found that full-time equivalent jobs increased by 47%, and income sources diversified to include nature-based tourism, monitoring, restoration activities, informal recreation and education (Rewilding Britain, 2021).

Similarly, an academic paper by Consoli et al. (2016) also found that green jobs in the US used more high-level cognitive and interpersonal skills than non-green jobs, and that they involved higher levels of formal education, work experience and on-the-job training.

The European Commission (2022) emphasise the role of NbS for innovation and upskilling. They show that Nature-based enterprises in Europe hold potential for both low and high-skilled jobs, while supporting the growth of several sectors: computation, IT, artificial intelligence and robotics, multi-modal sensing systems, and blockchain, generating both direct and indirect jobs. For example, they found that retrofitting buildings with green roofs in Austria had a value chain of Eur 90.5 million in 2018; with a compound annual sectoral growth rate of 9% (2014-2018), and could generate 33, 000 new green jobs. The IEEP study of EU protected areas also emphasised their role in supporting innovation and growth, including through research, bio-mimicry and bioprospecting (Mutafoglu et al. 2016).

The ILO also highlight that NbS such as agro-ecology and agroforestry are knowledge-intensive, and supporting policies should build capacity through extension approaches such as farmer field schools, and facilitate local production of specialized farm tools. This would also be likely to create better and more productive jobs (Payen and Lieuw-Kie-Song, 2020).

However, the capacity to innovate may be limited by a skills shortage. In the UK, both the Environmental Audit Committee and the Chartered Institute of Ecologists and Environmental Managers (CIEEM) have warned of a shortage of trained ecologists, and advocated for training and skills in chartered ecology as part of the Green Jobs Agenda (House of Commons Environmental Audit Committee, 2021).

If NbS are designed in accordance with the IUCN standard (IUCN, 2020) and the NbS guidelines (nbsguidelines.info), they should provide good quality jobs that meet the ILO definition of decent work: "Work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men" (Payen and Lieuw-Kie-Song, 2020). However, these criteria rely on sufficient resources being allocated to employment and training. Some protected areas are understaffed, e.g. in Brazil there is only one employee per 18,000 ha of protected land, and often shortfalls are made up through a reliance on volunteer labour (Payen and Lieuw-Kie-Song, 2020).

The ILO points out that tree planting often follows employment norms prevalent in the forestry industry, which is dominated by seasonal, contract work. Tree planting is therefore often low-paid and based on piece wages which leads to rushed work and long hours. There are few social benefits and migrant workers are often used. Strong regulations and supervision by relevant agencies are therefore needed to ensure that NbS provide decent jobs (Payen and Lieuw-Kie-Song, 2020).

Certification schemes for forest and agricultural products can help to ensure not only environmental sustainability but also decent wages, good working conditions, and inclusive decision making. However, these schemes are often voluntary and not legally binding; and most forest certification schemes (such as FSC) are in the Global North, with only 2% of tropical forests being covered (Payen and Lieuw-Kie-Song, 2020).

Nature-based jobs can also be used as a pathway towards employment in different sectors, such as for a training programme targeting long-term unemployed people in Zagreb (Box 3).

Box 3: Zagreb public space greening: targeting long term unemployment

In Zagreb, Croatia, there were high levels of long-term unemployed people in 2005. A scheme was set up to train them maintain green spaces and remove waste dumped in forests, lawns and waterbodies, while receiving unemployment benefits. In return, they could choose from a range of free training courses to help them obtain jobs in areas which were in high demand locally, such as health, retail, construction, office administration and catering. The programme is said to have had a positive effect on poverty reduction and has decreased pressure on the social budget and social services.

Training provided: 3000 long term unemployed people (300 per year for 10 years)
Success rate: One third of the participants found full time employment after their training, and others found seasonal employment.

Source: Kopsieker et al., 2021; Eurocities (undated)

3.3.6 New business opportunities

The 'New Nature Economy' report by the WEF (2020b) envisaged a 'Great Reset' to a nature-positive economy. They estimated that NbS can create 395 million jobs in 2030 and unlock an estimated $10 trillion of business opportunities by transforming the three economic systems that are responsible for almost 80% of nature loss: food, land and ocean use; built environment and infrastructure; and energy and extractive industries. They state that it will be essential to gain the support of citizens and governments by a focus on inclusive growth and improved jobs and livelihoods.

A 2022 WEF report estimates that making investments with nature-positive outcomes can create new business opportunities worth $10 trillion annually and create 395 million jobs by 2030 (WEF, 2022).

3.3.7 Economic resilience and poverty reduction

As well as jobs and GVA, a report by Conservation International (2020) argues that ecosystem-based adaptation can help to build resilience to economic shocks, including from pandemics. For example, agroforestry systems, farmer managed natural regeneration, and ecosystem restoration and protection can build resilience by supporting diversified incomes and revenue streams.

NbS can also alleviate poverty, but only if the intervention is well designed. A review of 339 studies of showed that reforestation by smallholders could alleviate poverty if it was designed to be complementary to livelihoods, not competitive, and if any local limitations on capacity to carry out the reforestation were addressed promptly (Ota et al., 2020).

NbS can also be targeted at areas of greatest need. In the UK, the Green Alliance (2021) report found that NbS had a high potential for 'levelling up', i.e. tackling inequalities across the UK. They found a high overlap between areas with labour market challenges and areas suitable for tree planting, urban green space enhancement, and restoration of coastal habitats, seagrass and peatland. For example, improving green infrastructure in neighbourhoods with little green space could create 10,800 jobs in the most deprived areas. Similarly, a report for the National Trust in the UK shows how investing £5.5bn into greenspace interventions in the most deprived urban areas would help to tackle health inequalities and support struggling local economies, with £200bn in physical health and wellbeing benefits to disadvantaged communities, as well as delivering active travel, biodiversity, carbon capture and air quality enhancements to support the UK's journey towards net zero (Vivid Economics and Barton Wilmore, 2020).

The ILO report emphasises the synergies between job creation and protection of natural capital to ensure sustainable natural resource management and protect livelihoods. They prioritise five areas: protection of biodiversity, restoration of water bodies, soil and water conservation, afforestation and forest protection, and coastal management, with soil and water conservation being the most critical for livelihood protection (Payen and Lieuw-Kie-Song, 2020).

3.3.8 Wider economic impacts

In addition to these papers that specifically address economic impacts, wider evidence shows the value of NbS for climate change adaptation (Chausson, Turner et al., 2020), mitigation (e.g. Girardin et al., 2021) and biodiversity (Key et al., 2022), all of which will reduce the economic costs of climate change (Stern, 2006) and biodiversity loss (Dasgupta, 2021) and lead to a stronger and more resilient global economy in the long term. It appears that many countries are increasingly recognising the critical role of NbS for climate change adaptation, as there has been an 89% increase in inclusion of NbS in the revised Nationally Determined Contributions (NDCs) between submission rounds (Adaptation Action Coalition, 2022).

4 Discussion

Here we first present the key findings of the review, discussing the evidence for positive and negative economic outcomes, distribution of outcomes between beneficiaries, trade-offs, and best practice pathways for maximising benefits and mitigating trade-offs. We then discuss the strength of the evidence and the need to improve future assessments of economic outcomes. Finally, we suggest next steps for research.

4.1 NbS generate predominantly positive outcomes for economic recovery

By synthesising three complementary datasets, we have found strong evidence that NbS provide powerful mechanisms to drive economic recovery as well as tackling climate change, biodiversity loss and the food and fuel price crises, both in the Global South and the Global North. NbS can deliver positive economic outcomes through the following mechanisms:

- **Direct jobs and incomes.** NbS are typically relatively labour-intensive, providing high numbers of jobs per £1 invested that typically exceed those created by investing in other sectors such as fossil fuels or nuclear power (BenDor et al., 2015a; Mutafoglu et al. 2016; Raes et al., 2021; WWF and ILO, 2020). Outcomes include:

- **Short term jobs for establishing NbS,** and associated incomes.
    - **Long term jobs for managing and monitoring NbS,** and associated incomes.
    - **New jobs from new business opportunities**, e.g. eco-tourism, and associated incomes.
    - **Job and income security and economic resilience.** NbS protect and restore the natural capital stocks that underpin livelihoods in fishing, forestry, agriculture, outdoor recreation and tourism, making them more resilient to environmental change. Resilience also arises from more stable yields, and diversified income sources (e.g. aromatic resin from agroforestry trees; Hassan et al., 2019a), that can reduce vulnerability to volatile markets (e.g. Huang et al. 2022 on agroforestry rubber systems). They can also protect from natural hazards and climate change (e.g. Chausson, Turner et al., 2020; Roe et al., 2021). For example, NbS can remediate areas affected by soil salinity, allowing profitable crop production to continue (Mukhopadhyay et al. 2021).
    - **Increased incomes** due to improved yields (e.g. Chimsah et al. 2020; Rosa-Schleich et al. 2019) or sale of additional products (e.g. fruit or nuts from agroforestry trees). Yields can also decrease for some interventions, such as due to reduced use of inputs or competition between trees and crops in agroforestry (e.g. Garrett et al., 2021), but this is often offset by reduced costs (see below).
    - **Reduced costs.** For example, sustainable agriculture can reduce the need for fuels, fertilisers and biocides (Box 4; Rosa-Schleich et al., 2019). Chimsah et al. 2020 found production cost reductions of 35-44% for conservation tillage in China, leading to a doubling of profit margins. Green roofs and walls can reduce energy consumption for heating and cooling in buildings (Teotonio et al., 2021). These benefits are expected to grow as resource costs continue to be affected by global environmental stresses and geopolitical shocks.

- **High multipliers and GVA, leading to indirect and induced jobs and incomes.** NbS often have large up-front costs, from buying the equipment, materials and services needed to create or restore ecosystems, so they also have high multiplier effects and generate high gross value added (GVA) for the economy (BenDor et al., 2015a; Dicks et al., 2020; Hepburn et al., 2020; Mutafoglu et al. 2016; O’Callaghan and Murdock, 2021; O’Callaghan et al., 2022; Raes et al., 2021; WWF and ILO, 2020).
- **Increased innovation, skills and knowledge.** NbS often involve learning new skills or making better use of traditional and local knowledge. Good practice therefore involves provision of appropriate training, outreach and demonstration services, leading to creation of new knowledge bases and upskilling of employees.
- **Rapid, targeted support for disadvantaged groups**. NbS can be designed to deliver a range of high-quality jobs and training opportunities at different skill levels, targeted on the most deprived communities and disadvantaged groups.
- **Resilience to future shocks.** NbS can diversify income sources and boost resilience to economic and environmental shocks, including climate change and pandemics (Roe et al., 2021).
- **Wider benefits for development and the economy**, including through improved climate change adaptation (Chausson, Turner et al., 2020) and mitigation, food security and dietary diversity (Panneerselvam et al., 2011), water security, capacity building and empowerment (Roe et al., 2021) and improved health and well-being, leading to reduced costs of damage from climate change and reduced healthcare costs.

Box 4: Agro-ecology in India can reduce costs and increase profits

Agro-ecological methods such as conservation agriculture or organic agriculture have become increasingly popular in India over the last few decades, to reduce the use of expensive inputs and halt the environmental degradation caused by intensive farming. Evidence shows that yields per ha may either increase or decrease, depending on the crop type, methods applied and local conditions, but production costs typically decrease due to lower dependence on expensive fuel, fertilizer and agro-chemicals. This generally leads to increased income and profits (especially if price premiums are obtained for certified organic products) and a reduction in farmer debts (Panneerselvam et al., 2011).

One example is the concept of 'Zero Budget Natural Farming' (ZBNF), which is designed to reduce the costs of external inputs by using local resources. Farmers apply the principles of agro-ecology to attract beneficial pest predators and pollinators, and manage soil fertility. They reduce tilling, apply mulch, make their own seed treatments and soil inoculants from cow manure and other inputs, while making pesticides from local plants such as neem, chili, garlic and tobacco. Up to 12 different types of trees, vines and crops of different heights are grown in a system of five canopy layers designed to allow each plant to access the right amount of sunlight, intercropped with leguminous plants to fix nitrogen from the air into the soil. Fields are surrounded by live fences and trenches for water harvesting. ZBNF initially grew as a grassroots farmer-led movement where farmers experimented and learned from each other, adopting different elements of the system, but in Andhra Pradesh the state government is now aiming to roll it out to all 6 million farmers.

A study in Himachal Pradesh found that a vegetable-based ZBNF cropping system reduced costs by over 30% in the Kharif season and almost 12% in the Rabi season compared to conventional vegetable monoculture, and increased net returns by 20% in the Kharif season and 15% in the Rabi season, as well as reducing the chance of crop yield loss (Laishram et al., 2022). In Andhra Pradesh, crop-cutting experiments on 1531 paired plots found that yields increased by an average 17%, costs fell by 24%, gross incomes increased by 14% and net incomes by 50%. The number of earthworms, increased by a factor of 7 (from 32 to 232 worms per square metre) and farmers reported greater crop resilience to dry spells and other climate shocks and greater dietary diversity (Bharucha et al., 2020). Another study also suggests that livelihoods are more resilient, social networks are strengthened and farmer wellbeing is improved, and that ZBNF could play a key role in reducing the increasing crisis of farmer suicides, as these are linked to debts (usually related to high input costs) in 99% of cases (Meek and Khadse, 2022).

Source: WEF (2022); Bharucha et al., 2020 ; Laishram et al. (2022), Panneerselvam et al., 2011.

4.2 NbS can also generate negative or mixed economic outcomes

Although the predominant outcomes are positive, there can also be negative and mixed outcomes, which can arise through the following mechanisms:

1. **Loss of access to or use of protected areas** for dependent communities (see section 3.1).
2. **High up-front costs** for options such as agroforestry (e.g. Reich et al., 2021) or green roofs (Teotonio et al., 2019), which were not always recovered through resource savings and other benefits.
3. **Short term losses.** The benefits of NbS may take a few years to materialize, e.g. while trees grow, soil health recovers or certification is achieved, so there can be short term losses (e.g. Reich et al. 2021). These are often recovered via long term benefits, so long term monitoring is needed to accurately assess the outcome.
4. **Failure for projected benefits to materialise,** e.g. if certified products could not be sold at a premium because supply exceeded demand (e.g. DeFries et al., 2017), if reduced sustainable harvest volume or crop yield is not offset by the certification price premium (Burivalova et al., 2017; Garrett et al., 2021) or if projected yield increases from sustainable agriculture or agroforestry are not delivered.

5. **Distributional impacts,** typically if marginalised or low-income groups lack access to the land, knowledge, machinery, credit, and other resources needed to implement some types of NbS such as agroforestry or conservation agriculture, or when revenue streams are not equitably distributed (see Box 5).

Box 5: Distribution of economic benefits from NbS

Evidence shows that the costs and benefits of NbS are not always equitably distributed. This can be for several reasons.

1. **Investment costs**. Households with more capital can afford high up-front investment costs and have better access to credit, information and equipment (e.g. for planting trees for agroforestry, or purchasing machinery for conservation agriculture).
2. **Certification costs.** Farmers who can afford to apply for certification can reap the benefits of more sustainable commodity production, including via price premiums (DeFries et al., 2017; Garrett et al., 2021). Also, certification may not be an option for communities and small holders that do not produce volumes large enough to enter international markets (Burivalova et al., 2017). However, Maier et al. (2021) argue that systematic monitoring based on pre-set indicators is worth the high transaction costs, as it enables transparent decision-making processes and builds trust among the actors involved.
3. **Elite capture** i.e. capture of benefits by those with more resources and power. This can happen even when interventions are specifically targeted at poor households, e.g. for community forest or fishery management (Burivalova et al., 2017; Hassan et al. 2019b).
4. **Exclusion from resources.** Poor households tend to rely more on wild resources, including through both legal and illegal logging, fishing, grazing and hunting, and thus face greater losses when those resources are protected (Blundo-Canto et al., 2018; Burivalova et al., 2017; Li et al., 2016).
5. **Non-market benefits**. Sometimes costs fall on NbS implementers but some or all of the benefits flow to wider society, e.g. for installation of green roofs and walls (Teotonio et al., 2021).

Gender differences. 1-4 above can apply disproportionately to women (Goncalves et al., 2021). For example, Wekesah et al. (2019) showed that lack of capital prevented women from accessing the benefits of conservation agriculture (CA). Even where they were able to adopt it, they faced higher risks of land and crop dispossession by men when farming becomes more lucrative, especially where they had insecure tenure. CA also increased workloads and health risks for women from extra weeding using heavy overhead hoes to break up hard ground. Women farmers also had more difficulties defending their mulch and crop residue against theft and use by men or individuals from more powerful households. On the other hand, CA boosted women's participation in agricultural decision-making at the household level. Strategies to combat these effects included deliberately enlisting women as beneficiaries; working with men to advance their understanding of women's needs in agriculture; and offering agricultural inputs directly to women.

Positive outcomes. Despite the challenges described above, well-designed NbS can also help to reduce inequality. For example, smallholder farmers experienced the most positive effects from agroforestry interventions (Castle et al., 2021), and engagement of local farmers in conservation efforts increased equitable distribution of land holdings, leading to greater social stability (Duffy et al., 2021). A study of community forest management in Nepal found that it diverted profits from individual households to the community, benefitting poor households, although 60% of the studies reported in this review have negative outcomes for equity (Pelletier et al., 2016).

Most of these negative outcomes can be addressed through good design of NbS and supporting interventions (see section 4.4).

4.3 Synergies and trade-offs

A key strength of NbS is that they generally offer very strong synergies between multiple objectives. Numerous sources cite strong evidence that NbS can deliver a wide range of positive outcomes as well as economic recovery, including food and water security, climate change mitigation and adaptation, social cohesion and human health and wellbeing (e.g. Chausson, Turner et al., 2020; Girardin et al., 2021; Key et al., 2022; Seddon, Smith et al., 2021). For example, agroforestry provides food security, income generation, and medicines (Goncalves et al., 2021) while contributing to environmental health (especially soil, water and microclimate) and carbon sequestration (Hassan et al. 2019a), and bioremediation of saline soils has co-benefits for food security, carbon storage, conservation and recycling of natural resources (Mukhopadhyay et al., 2021). Evidence from agroecological surveys also shows that diverse, organic small-holder farming systems support biodiversity without sacrificing autonomy and food security, whereas farmers devoting most of their production to one crop (e.g. coffee) were vulnerable to economic to market price fluctuations (Altieri & Nicholls, 2020).

However potential trade-offs must be recognized, understood, and managed through careful design. Several types of trade-offs emerged from the evidence review, often related to the negative outcomes listed above. Two main themes are trade-offs between short term losses and longer-term gains, and trade-offs between livelihoods and biodiversity.

1. **Short term losses vs long term gains,** e.g.:
    a. **Reduced resource use to allow ecosystems to recover** and thus enable long term sustainable use. For example, lower harvest intensities or better enforcement of bans on illegal logging will help sustain forest resources but also reduce short-term profits or community access to forest resources. Longer term studies are needed to determine whether the marginalization of poor households persists, or if long-term profits outweigh any immediate increases in poverty (Burivalova et al., 2020).
    b. **Reduced yields in short term** during transition to conservation agriculture or agroforestry, eventually offset as trees mature, soil fertility increases, price premiums are obtained or resilience to climate change confers an economic advantage (Castle et al., 2021; Rosa-Schleich et al., 2019).
2. **Livelihoods vs biodiversity,** e.g.:
    a. **Opportunity costs** of using land for nature conservation vs livelihoods, e.g. income losses due to reduced timber harvesting and loss of protein sources for communities that depend on bushmeat (Blundo-Canto et al., 2018; Burivalova et al., 2020), although these impacts can be offset by PES (Blundo-Canto et al., 2018), or sustainable use in protected area buffer zones.
    b. **Human-wildlife conflicts** related to protected areas or hunting bans, e.g. crop damage by elephants (Burivalova et al., 2020).
    c. **Yield reductions** in some cases, e.g. for transition to a certified coffee or cocoa system with greater shade and tree diversity, where price premiums are insufficient to compensate for productivity loss (Garrett et al., 2018); and for organic agriculture where this is not offset by the reduced cost of inputs (Rosa-Schleich et al., 2019).
    d. **Use of herbicides in conservation tillage** has adverse biodiversity and human health impacts but can increase yield or reduce the arduous task of hand weeding, although conversely manual weeding can also create jobs for poor households (Rosa-Schleich et al., 2019).

e. **Competing demand for crop residue** for conservation agriculture and for use as livestock feed, fuel, or house construction material, leading to damaging alternatives such as deforestation. (Wekesah et al., 2019).
f. **Short term job creation** of active restoration (e.g. tree planting) vs potential long term biodiversity and climate impacts for the alternative of natural regeneration, where this is viable (Raes et al., 2021; Holl and Brancalion, 2020).
g. **Leakage of impacts into other areas.** Restrictions on use of some areas can result in increased use of adjacent areas. For example, shifting livestock off degraded rangeland in China led to more intensive animal production and spillover impacts on land outside the project area (Li et al., 2016); and reduced logging in FSC certified areas in Tanzania led to increased logging in nearby areas (Burivalova et al., 2020).

4.4 Enabling factors for securing economic benefits

To secure sustainable and equitable economic benefits while maximising synergies and managing trade-offs, NbS should be developed in accordance with best practice guidelines and standards, including the four NbS guidelines (Seddon, Smith et al., 2021) and the detailed IUCN global standard (IUCN, 2020). More specifically, the review suggested two groups of enabling factors to tackle some of the challenges listed above, related to local stakeholder participation and provision of targeted support.

Ensure that NbS are led-by or designed and implemented in close partnership with local stakeholders

In accordance with the IUCN standard and NbS guidelines, NbS should be designed and delivered by or with the full participation of local communities, including indigenous peoples. This in turn will help to enable several key success factors:

- **Facilitate acceptance and long-term stewardship** of NbS by the local community, and reduce the risk of non-compliance (e.g. illegal resource extraction) (e.g. community forest management, Box 6).
- **Enable the use of local, traditional and indigenous knowledge** to ensure that NbS are tailored to the local social and ecological context, which has a huge impact on NbS outcomes. For example, a study of sustainable agriculture in Africa found that there were often opposite responses from adjacent farms in terms of yield, economics, and resource quality, due variations in educational backgrounds, farmer goals, market access, and agro-ecological conditions (Reich et al. 2021).
- **Help promote equitable benefit distribution** within the community and targeted at those most in need of support.
- **Help secure decent and sustainable jobs**, with potential for greater job satisfaction compared to conventional jobs.
- **Build trust** between providers and investors, with clear governance mechanisms, transparent decision-making processes, and good communication.
- **Build capacity towards generating financially sustainable NbS,** e.g. how to make a business case, access markets, secure funding and monitor and demonstrate return on investment.

Provide targeted support

- **Increase the investment directed towards NbS** in economic recovery, climate and development programmes. Directing subsidies and investment towards NbS rather than environmentally damaging activities will deliver more jobs per unit of investment and higher multipliers, together with multiple co-benefits for innovation, climate mitigation and adaptation, biodiversity, food security and health (Koplow and Steenblik, 2022).
- **Support NbS with livelihood-focused interventions where necessary.** Even for well-designed NbS there can sometimes be trade-offs for livelihoods, especially in the short term (see section 4.3).

These may be associated with time lags in delivering benefits, or foregone opportunity costs of alternative income-generating land use activities. NbS should therefore be delivered together with suitable livelihood-focused interventions, carefully designed in partnership with local communities and other stakeholders, to take account of local needs and cultures (Wright et al., 2016).

- **Target benefits at the most vulnerable,** such as through deliberate targeting of financial support, outreach, equipment, training or capacity building at vulnerable households (Duffy et al., 2021) or women (Wekesah et al., 2019). Even where unequal distribution of benefits is rooted in wider societal inequalities and corruption, carefully designed NbS can help to empower vulnerable stakeholders. For example, engagement of local farmers in conservation efforts increased equitable distribution of land holdings and rehabilitation of degraded lands, leading to greater social stability (Duffy et al., 2021).
- **Minimise transaction and entry costs** (e.g. for obtaining information, credit, setting up PES (Maier et al., 2022), or obtaining certification for sustainable products) **or provide start-up funding** to overcome opportunity costs and reduce barriers to uptake of NbS by low income households.
- **Support diversified NbS-based production.** NbS that increase the diversity of crops produced or income sources provide multiple benefits, e.g. diversified income sources for more resilient livelihoods (Hassan et al. 2019a); reduced vulnerability to volatile markets (e.g. agroforestry rubber systems, Huang et al. 2022); and health benefits from dietary diversity in traditional homegardens (Duffy et al. 2021).
- **Consider the use of public environmental works programmes.** These can avoid trade-offs between livelihoods and biodiversity as they are specifically designed to provide livelihoods through environmental improvement, such as the well-established and successful Working for Water programme in South Africa (Payen and Lieuw-Kie-Song, 2020).
- **Ensure long term sustainability of NbS.** We have described many ways in which NbS can generate incomes and employment, but ecosystem services must be used sustainably in a way that conserves biodiversity, such as through low impact eco-tourism or well-managed sustainable harvesting of wild produce, so that benefits can be delivered over the long term.

Box 6: Empowering community forest management in Guatemala

In the 1980s, the highly biodiverse forests in northern Guatemala were being rapidly degraded due to illegal logging and burning as the population expanded. In response, in 1990 the government designated 2.1 million ha of forests in northern Petén as the Maya Biosphere Reserve: a core protected zone of 767,000 ha, a multiple use zone of 848,440 ha for sustainable harvesting, and a buffer zone of 497,500 ha. However, many local people resented the central government control of the forests. Despite the presence of guards and checkpoints, illegal logging continued at an estimated rate of three times the permitted amount, fueled by lack of land tenure, corruption, and under-resourced law enforcement.

In 1994, a new approach was suggested: giving communities harvesting rights in the multiple use zone, to promote community support of the reserve system. Starting with a 25-year 4,800 ha concession awarded to one village, community-owned forestry enterprises now steward more than 420,000 ha, supervised by NGOs, donors, and government agencies: the world's largest tract of sustainably certified and community-managed forest.

Community management has reduced illegal deforestation and improved local economies. In 2007, forest enterprises employed over 10,000 people directly and had created 60,000 indirect jobs. Employees were also paid more than double their normal wage. Community-owned enterprises received US$4.75 million in revenue from FSC certified timber sales and US$150,000 from sales of non-timber forest products such as palm leaves. Biodiversity has flourished and forest fires, illegal logging, and hunting are much lower than in neighbouring national parks.

This "transformation of fragmented communities of farmers and illegal loggers into eco-entrepreneurs" was enabled by well-designed government decentralization policies, which awarded communities tenure rights and resource management responsibilities and provided an enabling environment and motivation for communities to protect their forests, plus substantial funding and technical assistance from donors and intermediary support organizations. Progress has been slow and challenging, and not all enterprises succeed. However, strong financial and social incentives have encouraged communities to persist, learning through trial and error and gaining valuable business experience.

Source: WWF and ILO (2020); WRI (2008).

4.5 The evidence strength is mixed and better assessment protocols are needed

The strength of the evidence varied between datasets. There were marked differences in the proportion of positive and mixed outcomes between our reanalysis of the N4D database and our systematic review of reviews (93% positive and 3% mixed, vs 53% positive and 32% mixed, respectively). This could be because the N4D database included many grey literature project reports, many of which were written by project implementers, which may have taken a less critical approach to evaluating outcomes. However, it is also true that many of these projects were specifically designed to deliver positive socio-economic outcomes, for example through participatory approaches that aimed to build local capacities and support livelihoods.

The grey literature and selected additional academic literature (Section 3.3) was very useful for filling a gap in the other two reviews, as it contained several major economic modelling assessments that specifically targeted key economic indicators including jobs created per unit of investment and per hectare; GVA; economic multipliers and cost-benefit analysis. However, the quality of this evidence base also varied considerably, ranging from detailed and robust economic modelling approaches to policy briefs and commentaries that appeared to recycle evidence from other sources or synthesised selected case study examples. Most of the evidence synthesised in the grey literature showed positive economic outcomes, with less discussion of trade-offs and negative effects than the other datasets.

4.5.1 Evidence gaps and knowledge barriers

Many of the reviews concluded that there were evidence gaps that required more research. Some examples include:

- Lack of data on PES impacts on household expenditure and choice; lack of understanding of equity and power relations within and between ES providers and users. There is a need for better monitoring and evaluation of outcomes, including disaggregated assessments of costs and benefits within local communities (Blundo-Canto et al. 2018)
- Lack of data on how governance arrangements influence NbS economic impacts and synergies/trade-offs with environmental and social outcomes.
- Lack of holistic assessments covering multiple outcomes, so that assessing trade-offs and synergies is difficult, e.g. between different livelihood dimensions (Blundo-Canto et al. 2018), or between social, environmental and economic outcomes (Pelletier et al. 2016; Castle et al. 2021).
- Lack of data on disaggregation of costs and benefits between social groups (Blundo-Canto et al. 2018; Castle et al. 2021).
- Lack of robust effectiveness assessments based on comparators, due to lack of evidence on forest protection outcomes (Miller & Nakamura, 2018).

- A research gap on the long-term impacts on conservation agriculture for gender relations, incomes for men and women, and women's empowerment (Wekesah et al. 2019).
- A lack of data on water use and biodiversity outcomes of biofuels, which are proposed as a solution for restoration of degraded land (Pulighe et al., 2019).

4.5.2 Need for better measurement of economic outcomes

To tackle evidence gaps and ensure that assessments can be compared across different NbS projects, several reviews suggested how the evidence base could be improved.

- Reich et al. (2021) in their review of sustainable agriculture called for:
    - **basic estimates for indicators such as labour hours or net income**, even where economic models could not be used
    - **more participatory action research** involving farmers and other stakeholders
    - **more research on the local context**, as there were examples of negative impacts in some areas depending on factors such as soil type, meaning that it was not possible to make blanket recommendations
    - **longer term assessments**. 70% of the reviewed studies were short term (less than five years), but up to ten years are needed to deliver economic returns from some NbS such as conservation agriculture and agroforestry. Note that this would also require longer term funding cycles.
- DeFries et al. (2017) in their review of certification schemes called for:
    - **shared evaluation criteria and procedures** for the future success of certification programs, with consistent response variables (e.g. reported as percentages or absolute differences between treatment and control groups). Inconsistency made it hard to conduct a rigorous meta-analysis with pooled data from different studies.
    - **rigorous matching procedures and construction of counterfactuals**.
- Chomba et al. (2020) in their review of Farmer-managed natural regeneration called for:
    - **More rigorous and unbiased evidence**, as many studies "make claims based on perceptions, proxy values, unpublished data, internal project reports and views of a few farmers not systematically collected or analysed, mainly derived from project officers or authors involved in promoting FMNR"
    - **Accounting for the value of farmer's labour and the opportunity cost of land** that could have other uses, which were both routinely ignored.
- Hassan et al (2019b) in their review of protected and community-managed forests and fisheries called for:
    - **baseline information** on the status of the resource and people's livelihoods prior to implementation of policy reforms. Most studies had to use cross-sectional data for sites with and without the intervention rather than data before and after the intervention.
    - **Consistent measures** of livelihood (e.g., income, revenue, net benefits, consumption expenditure, livelihood dependence, equity) and conservation impacts (e.g., extent and density of vegetation cover, species counts and diversity, volume of trees) and **standardized and contextually sound indicators** (both biophysical and socioeconomic) to allow for more meaningful comparative assessments and to derive generalizable results.
    - **Information about the differentiated impacts on various social groups**, particularly the poor and vulnerable.
    - **Effects of confounding factors**
    - **Cross-validated survey methods** (e.g., remote sensing and vegetation surveys)

    - **Less reliance on subjective self-assessments** of survey respondents (although we note that self-assessments do have a role to play, e.g. for evaluating outcomes such as well-being).
    - **Increased collaboration between natural scientists, social scientists and economists**. Only 29.1 percent of the studies they reviewed were joint assessments of conservation and livelihood (i.e., socioeconomic) outcomes.
    - They cited impact evaluation studies (Ferraro and Hanauer 2014; Ferraro and Pressey 2015) for guidance concerning study designs that are likely to generate scientific evidence that can be used to conduct more rigorous comparative impact assessments.
- Teotonio et al. (2021) in their review of economic assessments of green roofs and walls call for:
    - Consistent and transparent assumptions about the costs and benefits included or excluded and the discount rate (which are normative, and political decisions), as variation in these have marked effects on assessments.
    - Efforts to reduce uncertainties in estimates of installation costs, energy consumption, property value and tax reduction. However, they noted that the performance of green roofs and green walls is very case-sensitive, making it difficult to report comparable outcomes, and it is hard to estimate the influence of other factors such as building layout, climate conditions and the urban environment.
    - Better consideration of ecosystem services that are difficult to quantify and monetise. Further efforts should set a consistent, transversal and all-inclusive methodology considering all potential costs, benefits and co-benefits of green roofs and walls.

We recommend that researchers and economists work with practitioners to develop a ‘gold standard’ protocol for robust assessments of the economic impact outcomes of NbS, similar to the guidance on social impact evaluation for conservation interventions developed by Woodhouse et al. (2016). This could include criteria such as:

1. Use of a suitable baseline or counterfactual. Before-After Control-Intervention (BACI) methodologies can be useful (Woodhouse et al. 2016), although these although have shortcomings (e.g. where the control and intervention sites evolve in different ways between sampling periods).
2. Accounting for potential displacement of jobs or incomes in other sectors
3. Standardised economic indicators such as Full Time Equivalent (FTE) job years per unit of investment and per hectare of land where the intervention takes place. Note that holistic assessments of livelihoods and ecological impacts need to combine standardisation of key indicators with a broader range of context-specific approaches and indicators.
4. Identification of whether jobs created are full time or part time, and temporary, seasonal or permanent
5. Measurement of direct, indirect and induced jobs and GVA, and economic multipliers, e.g. using input-output models (Raes et al., 2021)
6. Information on distribution of benefits between different groups
7. Information on any trade-offs between outcomes (e.g. short term job creation of tree planting vs long term biodiversity impacts for the alternative of natural regeneration).

However, we recognise that use of a ‘gold standard’ may be challenging for some projects, especially small projects run by non-profit organisations, especially elements such as assessment of multipliers that require use of economic models. It will therefore be important to work with practitioners to identify protocols aligned with organizational capacities and resources, and ways of streamlining through provision of suitable tools and guidance.

4.6 Next steps

This research will continue with co-funding from the Oxford Martin School programme on Biodiversity and Society. We plan to focus on the following objectives and activities.

1. Produce a peer-reviewed journal publication.
2. **Produce a policy brief** to support the development of economic recovery plans and the revision of associated climate and development policies, to share with key decision-makers during critical policy windows in 2022-2023. Opportunities could include the National Adaptation Plan and Mujib Climate Prosperity Plan in Bangladesh; National Adaptation Plan and National Climate Change Strategy 2050 in Peru; National Medium Term Growth Plan in Indonesia; Africa Green Stimulus Program via the African Union, in partnership with UNECA; UK & OST Adaptation Communication, and NbS Accelerator (International Climate Finance team, Defra) in the UK.
3. **Continue to check the lower priority reviews** retrieved by our search: those that are not systematic or which do not explicitly address economic outcomes.
4. **Consider the potential to use a machine learning approach** to identify gaps in the evidence base on economic benefits of NbS projects and programmes, including the wider economic impacts.
5. Continue to review emerging **grey literature**
6. **Identify high quality case studies** to form part of an evidence base for policymakers
7. **Develop a robust 'gold standard' protocol for assessing and monitoring economic outcomes** of NbS investments, in partnership with economic experts and practitioners, and test its feasibility.

5 Conclusions and recommendations

By synthesising three complementary datasets, we have found strong evidence that NbS provide powerful mechanisms to drive economic recovery, both in the Global South and the Global North. NbS have predominantly positive economic outcomes for directly generated jobs and incomes; they can generate high gross value added and higher returns per unit of investment than other sectors; and they have high economic multipliers which can spread further indirect and induced benefits throughout the national economy. They can also deliver a range of high-quality jobs and training opportunities at different skill levels, which can be rapidly targeted on the most deprived communities and disadvantaged groups in response to economic shocks. In addition, they can diversify income sources and boost resilience to future economic and environmental shocks, including those arising from climate change, conflicts and pandemics. By making use of new digital technologies as well as bringing together traditional, local and scientific knowledge, they can be key drivers of smart sectoral growth and eco-innovation and accelerate the transition to a clean, efficient, low carbon, circular economy.

NbS also have a far wider range of potential economic benefits, beyond these conventional indicators. By simultaneously protecting and restoring natural capital stocks, tackling climate change and biodiversity loss, reducing dependence on costly fossil fuels and agricultural inputs and improving human health and well-being, they can avoid costs of climate damage to property, infrastructure and crops, reduce healthcare costs, and thus make economies stronger, more prosperous and more resilient to future change.

However, there can also be negative and mixed outcomes from poorly designed interventions, highlighting the importance of developing NbS in accordance with best practice guidelines and standards. Even for well-designed interventions there can sometimes be trade-offs for some livelihoods, especially in the short term, and NbS should therefore be delivered together with suitable livelihood-focused interventions carefully designed in partnership with local communities and other stakeholders. Also, the quality of the evidence base was mixed and there is a need to improve evidence collection for monitoring future investments. We therefore make the following recommendations for policymakers, funders, landowners and practitioners:

1. NbS should form a central and large component of investment in national and regional programmes aimed at economic recovery, international development and climate action, due to their ability to tackle multiple economic, environmental and social problems simultaneously.
2. NbS should be led by or designed and implemented in partnership with local communities and indigenous groups, in accordance with the four NbS guidelines and the detailed IUCN global standard, to ensure maximisation and equitable delivery of economic benefits.
3. Appropriate levels of training and capacity building should be provided, especially for disadvantaged groups.
4. Jobs created should meet the ILO definition of decent work.
5. Any potential short or long-term trade-offs with livelihoods should be made transparent, negotiated, and addressed through suitable livelihood-focused interventions designed in line with local stakeholder needs, culture and preferences.
6. Relevant government agencies should be provided with adequate resources to oversee the implementation and design of high quality NbS, and monitor the environmental, social and economic outcomes
7. As well as the conventional economic outcomes for jobs, incomes, GVA and multipliers, economic assessments should incorporate wider economic outcomes to consider the full benefits of NbS compared to alternatives, as well as any trade-offs. This demands a reconsideration of conventional economic theory.
8. Funding should be provided for researchers to work with practitioners and economic experts to develop and test a protocol for robust assessment of the economic outcomes of NbS interventions, ensuring attention to the correct use of counterfactuals and a comprehensive set of standardised indicators.

We have shown how NbS provide clear economic benefits and potential for strong economic output and employment stimulation, but we also stress the need for governments and other investors in NbS to recognize their broader, long-term societal benefits, beyond market-based considerations. First, the consideration of plural market and non-market values is crucial to stimulate policies that are inclusive and respond to human well-being (IPBES, 2022). Valuation methods accounting for diverse values of nature are needed, to complement economic outcomes of NbS, as stressed by Dicks et al. (2020) in their valuation of NbS in the UK. Second, it is crucial to not constrain evaluations and appraisals to short-term objectives, as this can undermine the long-term resilience of the solution, leading to maladaptation and reduced benefits for society (Haider et al. 2021). Ultimately, this requires transitioning towards a new economic paradigm, placing a focus on sustaining regenerative human-nature relations, shifting away from capital growth and accumulation as the prime economic objective. This sits at the core of sustainable, circular economies that sustain both human well-being and the biosphere (Raworth, 2017).

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Annex 1: Protocol for systematic review of reviews

Table 1. Study scope.

Subject/Population	Intervention	Comparators	Outcomes
Human individuals, groups, communities and economic sectors (e.g. agriculture, water, forestry, transport, energy).	Interventions managing, restoring, rehabilitating, creating, or protecting biodiversity, ecosystems (semi-natural or natural), or ecosystem services, including in working landscapes (agriculture, forestry, farms, fishing grounds) and urban green infrastructure.	As we are focusing on reviews rather than primary studies. Articles will not be excluded according to comparators. We will however indicate whether relevant reviews report consider or restrict their analyses to comparators, and if so which types.	Reported direct, or indirect effects on economies, including employment, income, multiplier effects, GVA, and GDP.

Table 2. Study selection criteria.

Inclusion criteria:
Population: Human individuals, groups, communities and economic sectors (e.g. agriculture, water, forestry, transport, energy). **Intervention**: Interventions falling under the scope of nature-based solutions (sustainably managing, restoring, or protecting biodiversity, ecosystems, or ecosystem services, for any societal outcome, including biodiversity conservation), as well as afforestation[1]. **Outcomes**: Intervention outcomes relevant to economic impact: direct/indirect/induced effects on employment, income, revenue, and GVA. **Comparators**: no restrictions on comparators **Article type**: Articles categorized as reviews, or 'grey literature' reports of evidence from implemented programs, or across case studies.
Exclusion criteria: Non-review article types where the intent is not to describe / review / summarize the state of knowledge Reviews which do not report evidence of intervention outcomes on the economic dimensions (as defined by the scope) Reviews which do not report the outcomes of investments in nature/NbS (as defined by the scope) Reviews which focus on the economic impact of intensive agriculture, or aquaculture (i.e. types of agriculture/aquaculture that are not 'nature-based' as per the guidelines for nbs, and iucn standard). This includes commercial forestry with non-native species, or felling of native forest, or forestry.

[1] Even though afforestation does not necessarily constitute a nature-based solution (as per the NbS guidelines & IUCN standard), some stakeholders include afforestation as an NbS or NCS, and these are included as 'negative emission technologies' in pathways to meet the Paris agreement.

Table 3. Search string to search Web of Science CORE index collections (adapted for SCOPUS).

Category	Terms
Intervention terms	TS=("nature-based solution*" OR "nature-based approach" OR (natur* NEAR/1 (solution* OR approach*)) OR "ecosystem approach*" OR "ecosystem-based" OR "community-based" OR "disaster risk reduction" OR (integrated NEAR/2 management) OR "natural resource management" OR (management NEAR/1 (traditional OR protected OR coast* OR river OR riparian OR wetland* OR flood* OR catchment OR watershed OR vegetation OR forest OR woodland OR landscape OR "dry-land" OR dryland OR rangeland OR grassland OR ecosystem OR sustainable OR environment*)) OR "land management" OR restor* OR protect* OR conserv* OR (agriculture NEAR/1 (conservation OR resilient OR sustainable OR ecolog*)) OR agroecolog* OR agro-ecolog* OR agroforest* OR "agro-pastur*" OR agropastur* OR agropastor* OR agro-pastor* OR silvo-past* OR silvopast* OR "re-vegetat*" OR revegetat* OR afforest* OR reforest* OR rewild* OR "climate-smart" OR "adaptation services" OR (engineering NEAR/1 (ecological OR ecosystem OR natur*)) OR "rainwater harvesting" OR "floating garden*" OR (infrastructure NEAR/1 (green OR natural OR blue OR ecological))
Ecosystem type and related terms	TS=(ecosystem* OR habitat* OR vegetation OR soil OR *biodiversity OR wildlife OR "natural capital" OR "ecosystem service*" OR *forest* OR woodland* OR tree* OR shrub* OR hedgerow OR *grass* OR meadow* OR heath* OR savanna*OR dryland* OR "dry-field*" OR dryfield* OR wetland* OR peatland* OR *marsh* OR swamp* OR bog* OR mountain* OR river OR riparian OR lake* OR stream* OR aquifer* OR catchment* OR watershed* OR floodplain* OR "flood plain*" OR estuar* OR intertidal OR mangrove* OR reef* OR seagrass* OR kelp* OR farmland OR arable OR *pasture OR rangeland* OR livestock OR cropland OR "agro-ecosystem*" OR agroecosystem* OR park* OR "green roof*" OR "green wall" OR "sustainable drainage" OR "natural flood management" OR (infrastructure NEAR/1 (green OR blue OR "green-blue" OR "blue-green" OR natural OR ecological)) OR "sustainable drainage" OR "sustainable urban drainage" OR "natural resource*")
Outcomes	TS=(GVA OR "gross value added" OR job* OR employment OR wage* OR labo$r OR "value-added" OR income OR hiring OR earning* OR profit* OR salary OR salaries OR revenue* OR livelihood* OR monetary OR moneti?ed OR valuation))

Coding framework.

A. Meta-data
    a. Article ID
    b. Title
    c. Author(s)
    d. Year
    e. Journal
    f. Abstract
    g. Do we want the full ref (incl vol / pages and/or DOI and/or hyperlink) as well?
B. Basic information about the intervention(s) (Note: reviews will include a range of interventions; here we should record the types included)
    a. intervention description (what the intervention(s) were called, what was done on the ground)
        i. (as described in the text)
        ii. Including how it/they were financed, if available
    b. type of intervention(s) included (tick all that apply)
        i. (protection, management, restoration, nature-based food production, combined)
    c. Instigator (who drove the intervention(s))
        i. (as described in the text)
    d. local stakeholder involvement (mode of engagement)
        i. (as described in the text)
    e. Stated aim of the intervention(s)

f. Location(s)
g. Country(s)
h. Geographical region(s) (could be global for reviews)
i. Ecosystem type(s)

C. Geographical scale of the evidence reported on economic impact in the review
  a. Local, national, regional, global
  b. not applicable (e.g. synthesis of experimental evidence)

D. Reported outcomes
  a. Economic impact outcome types. For each outcome, capture:
    - If reported (categorical, yes/no)
    - Direction of effect (positive, neutral, negative, mixed, unclear)
    - The outcome variable(s) (What was measured)
    - Type of data (per outcome category; i.e. whether the synthesis presents evidence that is quantitative, qualitative, or mixed)
      i. Qualitative
      ii. Quantitative
      iii. Mixed
      iv. Unclear
    - Text description as reported
    - Number of studies reporting this outcome direction

  Outcome types
    i. Jobs: number, job years, proportional change, jobs/$ economic output or job retention. Also capture the following additional categorical variables (additional info for all these can be recorded in the Jobs text field, no need to have separate text fields):
      1. if direct, indirect, induced, mixed, unclear /not reported (categorical)
      2. type of contract: formal, informal, mixed, unclear / not reported (categorical)
      3. Type of employment: seasonal, year-round, mixed, unclear / not reported (categorical)
      4. Length of employment: long term, short term (i.e. only implementation phase), mixed, unclear / not reported (categorical)
    ii. Skill level (skilled, unskilled); training provided (qual / text)
    iii. Job security (qual/text). How vulnerable is the job to changing climate and other socio-economic or political factors?
    iv. Income or revenue generation, e.g. measured as average or % change in wage/income/revenue
    v. Economic multipliers associated with NbS investment: Indirect (net additional purchases of goods and services from companies in other sectors by the companies carrying out the NbS; cost of labour (= incomes)), land purchases, Induced (additional expenditure by employees related to incomes from jobs.)
    vi. GROSS VALUE ADDED
    vii. Impact on 'economic growth' or GDP

  b. 'Level' at which economic impact was measured
    i. Individual (e.g. individual farmer profits)
    ii. Household
    iii. Enterprise
    iv. Community
    v. Sub-national region (e.g. a province)
    vi. Nation

  c. Distributional effects (i.e. whether distribution of economic costs, benefits across stakeholder/rightholder groups is considered)
    i. Yes/no

        ii. Qual / text (record gender dimensions)
    d. Reports on avoided economic costs (e.g. avoided storm damage, reduced health expenditures)
        i. Yes/no
    e. Other ecosystem service valuation
        i. Yes/no
    f. Other livelihood impacts (e.g. also reports measures of yield, or reports on livelihood diversification)
        i. Yes/no
    g. Reports outcomes for biodiversity or ecosystems
        i. Yes/no
    h. Reports climate change mitigation outcomes
        i. Yes/no
    i. Reports climate change adaptation or DRR outcomes
        i. Yes/no
    j. Trade-off and synergies: any trade-offs or synergies with biodiversity, climate mitigation, climate change adaptation or any other outcomes for people)
        i. Yes/no
        ii. Qual / text description

E. Outcome pathways
    a. Provides information on *how economic* outcomes are delivered (pathways) and any mediating factors
        i. Yes/no
        ii. Text description

F. The review compares economic impact outcomes between different types of NbS
        i. Yes/no
        ii. Text description

G. The review compares economic impact outcomes between NbS and alternative interventions
        i. Yes/no
        ii. Text description

H. Methodology
    a. Type of article
        i. Systematic review/map
        ii. Other review
        iii. Not a review (but does include 'reviewed' material)
    b. critical appraisal of primary studies conducted
        i. Yes/no
    c. Review restricted to primary studies with comparators, or counterfactuals
        i. Yes/no

Annex 2: List of literature reviewed

Note: this Annex does not include the N4D database.

Systematic review of reviews

Badini, O. S., Hajjar, R., Kozak, R. (2018) Critical success factors for small and medium forest enterprises: A review. Forest Policy and Economics.

Blundo-Canto, G., Bax, V., Quintero, M., Cruz-Garcia, G. S., Groeneveld, R. A., Perez-Marul, a, L. (2018) The Different Dimensions of Livelihood Impacts of Payments for Environmental Services (PES) Schemes: A Systematic Review. Ecological Economics.

Burivalova, Z., Hua, F. Y., Koh, L. P., Garcia, C., Putz, F. (2017) A Critical Comparison of Conventional, Certified, and Community Management of Tropical Forests for Timber in Terms of Environmental, Economic, and Social Variables. Conservation Letters.

Castle, S. E., Miller, D. C., Ordonez, P. J., Baylis, K., Hughes, K. (2021) The impacts of agroforestry interventions on agricultural productivity, ecosystem services, and human well-being in low- and middle-income countries: A systematic review. Campbell Systematic Reviews.

Chimsah, F. A., Cai, L., Wu, J., Zhang, R. (2020) Outcomes of long-term conservation tillage research in Northern China. Sustainability (Switzerland).

Chomba, S., Sinclair, F., Savadogo, P., Bourne, M., Lohbeck, M. (2020) Opportunities and Constraints for Using Farmer Managed Natural Regeneration for Land Restoration in Sub-Saharan Africa. Frontiers in Forests and Global Change.

DeFries, R. S., Fanzo, J., Mondal, P., Remans, R., Wood, S. A. (2017) Is voluntary certification of tropical agricultural commodities achieving sustainability goals for small-scale producers? A review of the evidence. Environmental Research Letters.

Duffy, C., Toth, G. G., Hagan, R. P. O., McKeown, P. C., Rahman, S. A., Widyaningsih, Y., Sunderl, , T. C. H., Spillane, C. (2021) Agroforestry contributions to smallholder farmer food security in Indonesia. Agroforestry Systems.

Garrett, R. D., Levy, S. A., Gollnow, F., Hodel, L., Rueda, X. (2021) Have food supply chain policies improved forest conservation and rural livelihoods? A systematic review. Environmental Research Letters.

Goncalves, C. D. Q., Schlindwein, M. M., Martinelli, G. D. (2021) Agroforestry Systems: A Systematic Review Focusing on Traditional Indigenous Practices, Food and Nutrition Security, Economic Viability, and the Role of Women. Sustainability.

Haider, L.J., Schlüter, M., Folke, C. and Reyers, B., 2021. Rethinking resilience and development: A coevolutionary perspective. *Ambio*, *50*(7), pp.1304-1312

Haq, S. M. A., Islam, M. N., Siddhanta, A., Ahmed, K. J., Chowdhury, M. T. A. (2021) Public Perceptions of Urban Green Spaces: Convergences and Divergences. Frontiers in Sustainable Cities.

Hassan, B. A., Glover, E. K., Luukkanen, O., Kanninen, M., Jamnadass, R. (2019a) Boswellia and Commiphora species as a resource base for rural livelihood security in the horn of Africa: A systematic review. Forests.

Hassan, R., Mungatana, E., Akpalu, W. (2019b) Strategies for managing common pool natural resources in Sub-Saharan Africa: A review of past experience and future challenges. Review of Environmental Economics and Policy.

Huang, I. Y., James, K., Thamthanakoon, N., Pinitjitsamut, P., Rattanamanee, N., Pinitjitsamut, M., Yamklin, S., Lowenberg-DeBoer, J. (2022) Economic outcomes of rubber-based agroforestry systems: a systematic review and narrative synthesis. Agroforestry Systems.

Li, W. J., Li, Y. B., Gongbuzeren, Behnke, R. H., Mortimore, M. (2016) Rangeland Degradation Control in China: A Policy Review. End of Desertification?: Disputing Environmental Change in the Drylands.

Maier, C., Hebermehl, W., Grossmann, C. M., Loft, L., Mann, C., Hern, ez-Morcillo, M. (2021) Innovations for securing forest ecosystem service provision in Europe-A systematic literature review. Ecosystem Services.

Marcos, C., Diaz, D., Fietz, K., Forcada, A., Ford, A., Garcia-Charton, J. A., Goni, R., Lenfant, P., Mallol, S., Mouillot, D., Perez-Marcos, M., Puebla, O., Manel, S., Perez-Ruzafa, A. (2021) Reviewing the Ecosystem Services, Societal Goods, and Benefits of Marine Protected Areas. Frontiers in Marine Science.

Miller, D. C., Nakamura, K. S. (2018) Protected areas and the sustainable governance of forest resources. Current Opinion in Environmental Sustainability.

Mukhopadhyay, R., Sarkar, B., Jat, H. S., Sharma, P. C., Bolan, N. S. (2021) Soil salinity under climate change: Challenges for sustainable agriculture and food security. Journal of Environmental Management.

Panneerselvam, P., Hermansen, J. E., & Halberg, N. (2010). Food Security of Small Holding Farmers: Comparing Organic and Conventional Systems in India. *Journal of Sustainable Agriculture*, *35*(1), 48–68. https://doi.org/10.1080/10440046.2011.530506

Pelletier, J., Gelinas, N., Skutsch, M. (2016) The Place of Community Forest Management in the REDD plus Landscape. Forests.

Pulighe, G., Bonati, G., Colangeli, M., Morese, M. M., Traverso, L., Lupia, F., Khawaja, C., Janssen, R., Fava, F. (2019) Ongoing and emerging issues for sustainable bioenergy production on marginal lands in the Mediterranean regions. Renewable and Sustainable Energy Reviews.

Reich, J., Paul, S. S., Snapp, S. S. (2021) Highly variable performance of sustainable intensification on smallholder farms: A systematic review. Global Food Security-Agriculture Policy Economics and Environment.

Rosa-Schleich, J., Loos, J., Musshoff, O., Tscharntke, T. (2019) Ecological-economic trade-offs of Diversified Farming Systems - A review. Ecological Economics.

Teotonio, I., Silva, C. M., Cruz, C. O. (2021) Economics of green roofs and green walls: A literature review. Sustainable Cities and Society.

Wekesah, F. M., Mutua, E. N., Izugbara, C. O. (2019) Gender and conservation agriculture in sub-Saharan Africa: a systematic review. International Journal of Agricultural Sustainability.

Additional selected academic literature

BenDor, T., Lester, T. W., Livengood, A., Davis, A., & Yonavjak, L. (2015a). Estimating the Size and Impact of the Ecological Restoration Economy. *PLOS ONE*, *10*(6), e0128339. https://doi.org/10.1371/journal.pone.0128339

Edwards, P.E.T., A.E. Sutton-Grier, G.E. Coyle (2013), Investing in nature: Restoring coastal habitat blue infrastructure and green job creation. Marine Policy 38, 65-71. https://doi.org/10.1016/j.marpol.2012.05.020

Garrett-Peltier, H. & Pollin, R. (2010) Job creation for investment. Based on methodology presented in Heintz, J., Pollin, R. and Garrett-Peltier, H. (2009) How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth, Political Economy Research Institute.

Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J., & Zenghelis, D. (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? *Oxford Review of Economic Policy*, *36*. https://doi.org/10.1093/oxrep/graa015

O'Callaghan, B., Yau, N. and Hepburn, C. (in review) How stimulating is a green stimulus? The economic attributes of green fiscal spending.

O'Callaghan, B. and Murdock, E. (2021). Are We Building Back Better: Evidence from 2020 and pathways to inclusive green recovery spending. United Nations Environment Program.

Ota, L., Herbohn, J.L., Gregorio, N.O. and Harrison, S.R. (2020) Reforestation and smallholder livelihoods in the humid tropics. Land Use Policy 92, 104455.

Additional selected grey literature reports and policy briefs

Source	Year	Title
Cambridge Econometrics (Dicks et al., 2020)	2020	Economic costs and benefits of nature-based solutions to mitigate climate change
Commonland	2020	Calculating the Value of Four Returns of Large-scale Holistic Landscape Restoration
Conservation International	2020	Pandemics prevention and recovery through ecosystem-based adaptation
Conservation International	2020	The Business Case for Natural Climate Solutions: Insights and Opportunities for Southeast Asia
European Commission	2022	The vital role of Nature-based Solutions in a nature-positive economy
Global Goal for Nature Group	2020	COVID-19 Response and Recovery: Nature-based Solutions for People, Planet, and Prosperity
Green Alliance	2021	Jobs for a green recovery: Levelling up through nature
Green Jobs Task Force	2021	Green jobs task force report to the Government: Industry and the Skills Sector
IEEP (Kopsieker et al., 2021)	2017	Natura 2000 and jobs
IEEP (Mutafoglu et al., 2021)	2021	Nature-based Solutions and their socio-economic benefits for Europe's recovery
ILO (Payen and Lieuw-Kie-Song, 2020)	2020	Desk Review Study on Employment Impact Assessment (EmpIA): Potential of Natural Resource Management (NRM) Investments on Employment Creation
IUCN (Raes et al., 2021)	2021	Nature-based Recovery can create jobs, deliver growth and provide value for nature
UNCCD	2020	The Great Green Wall: Implementation Status and Way Ahead to 2030
UNEP	2021	Are we building back better? Evidence from 2020 and Pathways to Inclusive Green Recovery Spending
WEF	2020	New Nature Economy Report II: The Future Of Nature And Business
WEF	2022	Scaling Investments in Nature: The Next Critical Frontier for Private Sector Leadership
WRI	2017	Roots of Prosperity - The economics and finance of restoring land
WRI (Cook & Taylor, 2020)	2020	Nature Is An Economic Winner for COVID-19 Recovery
WWF, ILO	2020	NATURE HIRES: How Nature-based Solutions can power a green jobs recovery

Annex 3: Systematic review of reviews: findings for different intervention types

Note: For references see the list after the main report text. The individual studies cited by the reviews (*shown in italics*) are not included in the reference list.

A3.1 Agriculture

A global review of 241 studies on sustainable intensification in smallholder agriculture **(Reich et al., 2021)** found that measures to improve soil health (conservation tillage, residue retention, compost, mulch) had more uniformly positive economic benefits than diversification (agroforestry, intercropping, mixed crop-livestock) perhaps because diversification measures often involved high upfront costs.

For soil health interventions, studies reported a broad range of economic outcomes from no effect to a significant effect (at least a 50% improvement compared to the control). There were strong regional variations: no overall effect was reported in the Americas, but there were positive effects in Asia and West Africa. Only one study showed a negative effect (not statistically significant). Surprisingly, the productivity and economic benefits of technologies under low intensity (no synthetic fertilizer) systems were equivalent to those under high intensity system, relative to controls. This contradicts the prevailing drive towards intensification to meet food security goals. There were mixed outcomes for labour hours. Increased hours are classed as a negative effect in the review because they can be seen as an additional cost or burden on smallholder farmers.

For diversity interventions, the average economic effect was positive with a broad spread of outcomes from no effect to a significant effect. A few studies showed both significant and non-significant negative effects, especially for agroforestry and crop-livestock integration where profits could be negative or uncertain. The review notes that this could be due to steep upfront and opportunity costs, and long time horizons before benefits are delivered, but also that these findings contrast with the highly positive outcomes reported in a global agroforestry meta-analysis (citing *Kuyah et al., 2019*). However they point out that 70% of the reviewed studies were short term (i.e. <5 years), while up to ten years are often required before economic returns arise from conservation agriculture and agroforestry. There was a broad spread of outcomes from a large increase to a large decrease in labour hours, with an overall average small increase in hours compared to conventional practice, particularly for mixed tree-crop systems that require intensive management to minimize competition. This was classed as a negative effect. There was also evidence that sustainable farming technologies are knowledge-intensive, requiring support for hyper-local adaptation. They called for investment in extension education, innovation and participatory research to address this need.

Rosa-Schleich et al. (2019) compared diversified farming (DF) methods such as conservation agriculture, mixed crop-livestock systems and organic agriculture with intensive agriculture, showing that DF could lead to higher and more stable yields, increase profitability and reduce risks in the long-term. Reduced physical crop yields in the short term led to equivalent or better yields in the long term, as soil quality, pollination and pest control services improved. Profits increased mainly due to reduced costs of mechanisation, seeds, chemicals, machinery, and to some extent labour, as well as price premiums for product quality, or extra income streams. Overall ecological and economic benefits thus outweighed small yield losses. Combined DF practices outperformed single DF practices. They called for financial instruments to increase uptake and reward the ecological benefits. However there were some trade-offs between ecological and economic outcomes, including the trade-off between weed control and herbicide application for conservation tillage, and between biodiversity benefits and yield, and between weed control and yield, for organic agriculture. They reported key factors affecting outcomes for different interventions:

1. Cover crops that are locally adapted perform better

2. Diverse crop rotations are discouraged by high grain prices
3. No-till opportunity costs are highly dependent on soil and climate conditions
4. Intercropping system profitability depends strongly on the crop choice
5. Hedge and field margin impacts on beneficial species for pest control and pollination are determined by habitat quality, field:boundary ratio, field size and dispersal ability
6. Conservation agriculture is often, but not always, profitable. Yield and yield stability depend on soil structure, precipitation, fertility and application of manure. Farm level benefits also depend on how well CA technologies are adapted to the local environment, socioeconomic, cultural conditions.
7. Integrated diversified crop-livestock system benefits are highly dependent on the local biophysical, socioeconomic and cultural conditions.
8. Organic farming may deliver greatest biodiversity benefits per unit output in lower-productivity landscapes because of a smaller yield difference between organic and conventional farms. The trend towards simplified, large-scale organic farming may reduce its ecological benefits.

Chimsah et al. (2020) found that conservation tillage in dry regions of northern China improved crop yield by 4-6% depending on the cropping system, by improving soil physical properties and quality, while reducing GHG emissions. Production costs fell by 35.6–44.4%, equivalent to US$ 65.5–106 per ha, for all except one study, and farmer profit margins doubled at some sites. However there wan an initial reduction of crop yields in the early years. They also note that different technologies are required for reduced tillage compared to conventional tillage, which can be a barrier to uptake.

Mukhopadhyay et al. (2021) carried out a global review that concluded that a suite of NbS (conservation agriculture, phytoremediation, agroforestry) can be used alongside other measures to address the problem of soil salinization due to increasing ground water abstraction, in regions like Bangladesh. This can lead to improved crop productivity and therefore improved socioeconomic conditions for rural farming communities.

Wekesah et al. (2019) found that conservation agriculture (CA) can increase crop yields and therefore incomes and revenues, but these benefits can flow mainly to men and to large commercial farms, due to the lower access of women and smallholders to land, machinery, knowledge and resources. CA reduces labour demand, but only where it is displaced by use of inputs (herbicide and machinery). Otherwise, it increases labour demand. This can provide low skilled job opportunities for poor workers, weeding and preparing planting basins, but it can also fall as an extra burden on unpaid female household members, reducing their ability to take up other employment opportunities.

Pulighe et al. (2019) proposed bioenergy crops as a solution for restoring degraded land, to provide environmental and socio-economic benefits while supporting ecosystem services, compared to intensive monocropping systems. They frame this as an economic opportunity for marginalized land in the Mediterranean region that is not suitable for crop production in a warming world**.** However they suggest that fiscal incentives are needed to overcome risks of uncertain investment. They also note a lack of data on water use and biodiversity outcomes.

A3.2 Agroforestry

A systematic review of 92 studies of agroforestry in Brazil by **Goncalves et al. (2021)** concluded that agroforestry can generate income and be economically viable, and that the total income of agroforestry systems is higher when compared to monoculture. **Huang et al. (2022)** showed that agroforestry rubber systems are more diverse (reducing vulnerability to volatile markets through diversified income), and profitable, although when rubber prices are high monoculture rubber may produce higher income. Key barriers included labour availability, investment and management capacity, and access to market for secondary products.

Castle et al. (2021) showed that agroforestry has a large effect on yield but a smaller effect on income due to high implementation costs. They highlighted mixed results for equity, and the need for more attention to ensure equitable outcomes for women and poor households.

Duffy et al. (2021) found that traditional agroforestry or homegardens in Indonesia increased dietary diversity by 20% and provided medicinal benefits compared to commercial agroforestry, but produced lower income. Agroforestry systems overall freed up time for off-farm labour, compared to other forms of agriculture, and reduced pressure on surrounding forest for fuel wood collection. This contradicts Reich et al. (2021) that associated agroforestry with higher labour requirements overall, although they found a broad spread.

A3.3 Forest management

Badini et al. (2018) point out that small to medium forest enterprises employ up to 30 million people worldwide in the formal economy and an additional 140 million people work in informal forest micro enterprises, generating up to $100 billion US per year. They identify 12 critical success factors for small to medium forest enterprises, including sustaining natural capital, forest law enforcement, tenure and ownership rights, management and land use planning rights, forest management capacities, access to market, and a transparent, positive, stable macroeconomic setting with sound and consistent policies. They found that strong regulations are needed but overly complex regulations can be "barriers to legality" that prevent informal SMFEs from entering the formal sector, increasing the shadow economy and illegal sector.

Pelletier et al. (2016) show that Community Forest Management supports livelihoods but has a limited effect on poverty reduction, due to equity issues (distribution of benefits in user groups). Mechanisms are needed to ensure equitable distribution of benefits to the poor, as there is no guarantee that revenue from carbon payments will benefit those most in need.

Hassan et al. (2019a) showed that harvesting Frankincense and Myrhh from wild aromatic resin trees in the Horn of Africa provides a vital source of income for poor households and also contributes significantly to national incomes and exports. These trees, which grow on steep slopes in poor, dry soil, also play a key role in soil protection, water flow regulation and microclimate regulation as well as contributing to carbon sequestration. However they are threatened by over-harvesting of the resins, which can reduce seed production and germination and increase tree mortality, highlighting the need for sustainable forest management, restoration or agroforestry interventions to grow the trees on farms.

Hassan et al. (2019b) cite seven papers reporting positive impacts of participatory forest management on livelihoods in sub-Saharan Africa, with one finding it was 'poverty-neutral' and one unclear. Note that this is not a systematic review, and no overall totals are reported, with evidence only presented as citations in the text. They report that decentralization results in higher forest revenues, mainly because collective action at the village level is stronger that the weak ability of government agencies to monitor and enforce resource restrictions and regulations. When local communities are given rights to some or all the proceeds of forest sales, they "have an incentive to enforce regulations, at least on outsiders, either by excluding them or ensuring the collection of taxes on harvests".

A3.4 Forest protection

Miller & Nakamura (2018) find that forest protection benefits biodiversity conservation but has mixed impacts on human well-being, depending on the context. For example, there can be a positive impact on wages from eco-tourism but negative economic impacts to households in other protected areas.

Hassan et al. (2019b) find that monitoring and enforcement of protected areas is challenging in sub-Saharan Africa due to inadequate funding. They promote community forest management as a better option than central government control by forest departments, citing a meta-analysis of 129 case studies (*Yami, Vogel,* *and Hauser, 2009*) which found that decentralization enabled informal institutions (e.g., local leaders, religious groups, community organizations) to play a critical role in achieving sustainable forest management. There is a need for a genuine shift of authority to—and empowerment of—local communities, but the transition toward decentralization is slow, due to the focus on providing use rather than ownership rights, lack of government support to enable local institutions to govern and manage their forests, and continued emphasis on large industrial concessions. They suggest a need for "innovative bottom-up governance approaches and policy reforms that foster local institutions and knowledge and improve the ability of local communities to manage the natural commons and prevent illicit harvesting and trade of timber, wildlife, and fisheries." They also emphasize the importance of political stability in ensuring the effective management of common pool resources, as political unrest encourages illegal harvesting and trade of natural resources. Income support (livelihood projects) is important to encourage local stakeholders to participate in the enforcement of regulations and enhances the welfare impacts of conservation efforts.

A3.5 Forest restoration

Chomba et al. (2020) find that farmer-managed natural regeneration (FMNR), where farmers decide which naturally regenerating trees to retain on their land, is cheaper than tree planting, provided that soils are not too degraded and there is forest vegetation nearby. Most regenerating species (93%) were native and are likely to be in their ecological niche, in contrast to plantations. FMNR can also promote species diversity, while most tree planting campaigns rely on a few species amenable to rapid multiplication in nurseries. Various examples are cited but they note the potential for publication bias (positive results more likely to be reported). For example, *Binam et al. (2015)* found a 72 USD per household increase in four countries in the Sahel and a 34–38% increase in the value of products. But they note that most other studies make claims based on perceptions, proxy values, unpublished data, internal project reports and the views of a few farmers not systematically collected or analyzed, mainly derived from project officers or authors involved in promoting FMNR. E.g. *Reij and Garrity (2016)* suggested an annual value of 127–154 USD per household in Niger from the firewood from FMNR, with tree-based revenue contributing around 10% of household revenue. FMNR in Niger increased gross annual household income by 46–56 USD (or 18–24%) per capita, mostly from increases in crop and wood production. However they note that many studies completely ignore or undervalue farmer's labour and the opportunity cost of land that could have other uses.

A3.6 MPAs and fishery co-management

Marcos et al. (2021) found that Marine Protected Areas support biodiversity, including for economically important species.

Hassan et al. (2019b) reported mixed economic outcomes from MPAs and positive outcomes from fishery co-management. Some negative outcomes from MPAs arose from weak governance and enforcement of regulations. They find that it is important to empower local resource users and address poverty through complementary income-generating activities (livelihood projects) but these must provide sufficient income to offset the costs of the restrictions on local people who are highly dependent on fishing, particularly during the early years of a MPA (i.e., before the fishery has recovered). They highlight the importance of aligning fishery co-management programs with existing institutional arrangements, including values, beliefs, and norms. Compliance can be significantly higher in villages formed their own co-management committees. However they found evidence that decentralization of power and responsibilities to local users has had limited success, because local government agencies and political elites retained control of key decision-making processes. Most studies raised concerns about decentralization leading to increased inequity, with elites appearing to capture most of the benefits from forest management. One study found that although co-management had little conservation impact (Note: hence not NbS), it had a strong positive impact on livelihoods, but mainly for wealthier users.

A3.7 Green infrastructure

Teotonio et al. (2021) reviewed 53 cost-benefit studies on green roofs and 31 on green walls. Green roofs and walls insulate buildings and therefore save energy costs for heating and cooling. They can also attract fee discounts due to avoided stormwater in drainage systems, and provide marketing advantages and increased property value.

Intensive green roofs (with thick substrates, garden-type vegetation including trees and shrubs, and often seating areas) have wide ranges of values because they are complex and variable systems. They have higher costs than extensive green roofs (which have thinner substrates and usually sedum and/or wildflower vegetation) but also deliver increased benefits such as improved aesthetics and recreational space. They are generally not cost-effective as private investments because the energy savings and other benefits are not offset by the high installation and maintenance costs. However the private costs are offset by wider benefits to society, i.e. the total economic value when all monetised benefits are considered is often positive, with a high benefit-cost ratio. Extensive green roofs are cheaper, require little maintenance and can be more cost-effective, although they may produce fewer benefits (depending on the exact design of the roof).

For green walls, financial costs to the investor are often negative (more often than with green roofs), but more often positive when full economic costs / benefits included, with high benefit/cost ratios. Economic incentives such as tax reductions play a crucial role in the feasibility of investing in living walls. However one study showed that annual electricity savings were offset by the costs of property tax increments imposed by local authorities due to increased building value. Living walls show lower NPV than green façades because they require a high initial investment and have significant maintenance costs. However they have higher benefits, not all of which are evaluated so the true value of living walls to society is expected to be higher than shown. Living walls are unattractive investments for building owners and will only become feasible if the government provides incentives. Green façades show lower burdens to investors (similar to intensive green roofs), but the social and environmental contribution is also less. Comparisons with grey alternatives are generally negative because most studies do not include the full range of benefits. One study that did include the full range showed high benefits to society.

The authors note that different indicators (NPV, B/C ratio, payback period, life cycle costs) can give contradictory values, but one of the main factors is the number of benefits that are included. Policy and financial support is needed to transfer social equities to private investors and reduce the life-cycle burden, through subsidies and awards (e.g., governments pay a share of the costs, reduction of interest loans or abatement of taxes to reduce personal costs, etc.), or even legislation and mandatory regulation.

A3.8 PES

Maier et al. (2021) review the potential for businesses based on forest ecosystem services (FES). They highlight the need for participant involvement, network building and trust building by intermediary actors connecting those providing the FES (e.g. shepherds) and those monitoring the PS and paying for the provision of FES (e.g. public administration). They see a key role for public administrations, such as environmental and forest administrations, managing the PS because the FES is a public good and because they have the expertise and institutional capacity needed to implement transparent decision-making, payment procedures, and monitoring systems. Personal values play a role: forest owners who care about conservation will accept lower compensation rates for delivering the service. Success factors for income generation from FES include clear understanding of the cause-effect relationships, proper stakeholder involvement, positive entrepreneurial attitude and networking capacity, capacity building, minimization of transaction costs, clear governance mechanisms and transparent decision-making processes, soft government interventions, communication and green and territorial marketing initiatives.

A3.9 Certification

Burivalova et al. (2019) note short term trade-offs for tropical forest certification schemes (e.g. FSC) with profitability but these can be offset in the long term, e.g. due to the higher profitability of reduced impact logging after the first logging cycle (as more of the forest remains for subsequent cycles). They found that certified or reduced-impact logging management had higher economic benefits than conventional logging in 44%, no different in 14%, and worse in 42% of comparisons. Price premiums for certified products were obtained in most cases but rarely met the expectations of forest managers.

DeFries et al. (2017) reviewed certification for coffee, tea and bananas. The studies reviewed reported a wide range of economic variables related to yield, revenue or household income. On average, 36% of the economic variables included within each study had a positive response to certification, 59% had no effect and 5% had a negative effect. For variables categorized as 'revenue from commodity,' 56% had positive outcomes compared with 24% for 'household income.' This could reflect the relative success of certification in providing premiums but less success with improving smallholders' overall economic situation. Some of the negative impacts could be from cases where the product cannot be sold at a premium rate because of lack of market demand for certified products. For example, 40% of coffee produced is certified but only 12% is sold as certified, due to lack of market demand.

They found that smallholders who cannot afford the transaction costs associated with certification or do not have access to information can be further marginalized. Therefore certification programs need stronger mechanisms to ensure that poorer farmers can benefit and that the market is not further concentrated in the hands of large plantations and wealthier farmers.

Garrett et al. (2021) found that certification schemes aimed at reducing deforestation (including various certifications and codes of conduct for coffee, RA-UTZ certification for cocoa, and RSPO certification for oil palm, but not including organic or fair trade) increased incomes from the commodity in 65% of the cases and improved farm or household income in 53% of the cases, but often this was achieved by increased use of inputs to increase crop yields (i.e. not NbS). However, farmers may then specialise more in the commodity, leading to vulnerability to drops in global prices, and they may have to spend more on food to replace food previously grown on the farm.

Maeir et al. (2021) report one study arguing that systematic monitoring based on pre-set indicators is well worth high transaction costs as it also enables transparent decision-making processes and thus builds trust among the actors involved. This provides a complementary point of view to **Garrett et al. (2021)** which argued that transaction costs led to inequitable outcomes.