NATURANCE

Nature for insurance, insurance for nature

(Grant Agreement 101060464)

Deliverable D3.1-
Governance/policy
enablers/barriers for scaling NbS

WP3 – Governance, policy & business models

Version 1.3.0 | October 2023

HORIZON-CL6-2021-BIODIV-01-06 - Nature-based solutions, prevention and reduction of risks and the insurance sector

This project has received funding from the European Union's Horizon Europe Research and Innovation Actions under grant agreement No 101060464

Deliverable Title	Governance/policy enablers/barriers for scaling NbS
Brief Description	This deliverable takes stock of the existing literature and practice of governance and policy for Nature-based Solutions, with a focus on the enablers and barriers, as well as financial approaches
WP number	WP3
Lead Beneficiary	IIASA
Author(s)	JoAnne Linnerooth-Bayer, Juliette Martin, Jenan Irshaid, Timothy Foreman, Laurine de Wolf
Deliverable Due Date	30/09/2023
Actual Delivery Date	30/11/2023
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Document History

Date	Ver.	Contributors	Comment
05/10/2023	1.0	JoAnne Linnerooth-Bayer, Juliette Martin, Jenan Irshaid, Timothy Foreman, Laurine de Wolf	D3.1 Outline
02/11/2023	1.1	JoAnne Linnerooth-Bayer, Juliette Martin, Jenan Irshaid, Timothy Foreman, Laurine de Wolf	D3.1 Draft
16/11/2023	1.2	Jamie Pollard, Sarah Conway, Simon Young, Constance Wong, Maya Dhanjal	D3.1 Internal Review
30/11/2023	1.3	JoAnne Linnerooth-Bayer, Juliette Martin, Jenan Irshaid, Timothy Foreman, Laurine de Wolf	D3.1 Final

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Executive Summary

Nature-based solutions (NbS) have emerged on the global and European Union agendas as essential for addressing the twin risks of climate change and biodiversity loss. Yet there is a huge gap in current and required NbS investments, which manifests in terms of their scale (typically small), financing (typically public), spatial diversity, and the profile of investors. The gap persists despite an increasing number of EU and national policy actions to advance NbS conceptualization and operationalization. Closing the gap is urgent. According to the World Wildlife Foundation (2023, p 3) "*Government and business leaders do not have decades to gradually get used to the problem and take action. Instead, nature-related risks are an issue that needs to be studied and addressed now.*" Responding to this urgency will require a multi-faceted understanding of the governance and financial arrangements driving NbS implementation.

This deliverable takes stock of NbS governance arrangements - enablers and barriers for NbS scaling - with particular focus on strategies and opportunities for NbS funding and financing, including insurance. We report on recent reviews of NbS across a range of urban, rural and marine contexts. We then turn to categorizing financing and funding arrangements across over 50 cases of NbS implementation. Finally, we take stock of standard and novel ways that insurers can support NbS through their underwriting and investment strategies. Throughout, we provide over 70 illustrative and good practice cases. Our analysis is based on a synthesis of the literature and experience, including H2020 case studies, NbS databases, demonstration projects, published reports and grey literature. In addition to stocktaking, we venture suggestions for 'ways forward' to scale NbS.

NbS enablers and barriers

At the top of the list of barriers to NbS implementation is the deficit in robust evidence on their performance and co-benefits under present and future environmental conditions. Lack of knowledge presents a formidable challenge for public authorities and private businesses when it comes to justifying NbS over their grey counterparts, especially given poorly staffed and siloed administrations with little NbS experience or expertise. Perceived lack of equity and resulting stakeholder conflicts constitute another highly concerning barrier to successful NbS implementation as was illustrated in the cancellation of an NbS to reduce flood risk in Norway due to opposition by stakeholders who benefitted from mining the gravel deposited by floods (illustrative case 6). In contrast to grey infrastructure, path dependency emerged prominently as a major limiting factor for NbS, i.e., the difficulty in changing the current legal and social norms that favor grey projects. As witnessed in Austria, grey solutions for flood risk were preferred to upstream water-absorption measures by authorities who had long experience with funding levees and other grey solutions (illustrative case 7).

Turning to enablers, stakeholder engagement and polycentric governance arrangements for overcoming siloed administrations in order to exploit multiple NbS co-benefits have proven to be especially valuable. As a good-practice case, we document the co-design of an NbS to reduce agricultural pollution and run off into a pristine Italian lake with farmers and residents in the Serchio river basin, which although originally opposed by farmers, ended with their enthusiastic cooperation in putting vegetation barriers on their fields (good practice case 1). A good-practice example of polycentric governance is the re-naturalization of the Isar river in Munich. Stakeholders agreed that this project would not have been possible without a

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polycentric arrangement in the form of an interdisciplinary working group across multiple organizations (good practice case 3).

Stakeholder engagement, the tendency of politicians to focus on short-term goals that bring voter support, and shortfalls of public budgets also plague grey infrastructure implementation, which presents learning opportunities for proposers of NbS. The NbS community can learn from how these barriers have been surmounted for grey infrastructure in the past. At the same time, three especially intransigent barriers differentiate NbS from traditional infrastructure, including the aforementioned lack of expertise and knowledge, lack of evidence on performance and co-benefits, and path dependency of 'grey' infrastructure. These barriers unique to NbS deserve special attention for moving forward.

New ideas are needed to overcome these particularly thorny barriers, especially the long timeframe often needed for cumulating evidence on NbS effectiveness and proof of concept.

One innovative idea is to shift the burden of proof from NbS to grey infrastructure projects by requiring proposers of conventional grey projects to prove 'no negative environmental impacts' rather than (or in addition to) requiring NbS proposers to prove their effectiveness, costs and benefits.

This could be accomplished by extending the scope of the EU Environmental Impact Assessment Directive to include smaller projects and at the same time exempting selected NbS in the same way as many renewable energy technologies have been exempted from the EIA Directive. Another idea is to require all infrastructure planning processes to include consideration of nature-based alternatives. A good practice case is the pioneering legislation in Norway that instructs public authorities to consider NbS when selecting strategies at municipal and regional levels (good practice case 4). Additionally, many reforms have been put forward by the NbS community, including whole-of-life contracts for long-term maintenance and monitoring, mandatory policy instruments for mainstreaming NbS, e.g., in landscape planning, self-certification schemes, linking NbS policies to wellbeing and preventative health care policies, and NbS project preparation facilities at different scales alongside accelerator programs for start-ups.

Financial instruments for NbS

Taking stock of over 50 cases of NbS, we find a rich array of public, private and hybrid financial and funding arrangements in place for their implementation, which can be classified across public-private spectrum including hybrid models as shown in figure 1.

Figure 1: A classification of funding/financing options for NbS

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By far the most dominant NbS financial arrangements are publicly funded projects paid for by local and national taxpayers and in some cases supplemented by users and donors.

According to UNEP (2022) around 83% of NbS are financed and funded by the public sector, and the European Investment Bank (2023) estimates that in the European Union funding meets up to 91% of NbS financing needs. It is notable that from our selected NbS cases, more than half are fully funded by present and future taxpayers and many more partially funded from public budgets, including from the European Union. The others are funded by donors, carbon credit investors, businesses, consumers and beneficiaries.

Co-financing can increase the available budget for NbS, but as highlighted above silo budgeting approaches hinder the development of these arrangements. As such, raising awareness among public authorities of the (often) multiple benefits NbS provide is of utmost importance to stimulate co-financing arrangements. A good practice example is the implementation of an NbS in Portugal's Porto mountain park, where multiple municipalities organized and successfully applied for a large grant from the European Union (good practice case 8).

Targeted user fees and philanthropic donations have the potential of greatly supplementing public financing. While the share of overall philanthropic donations to environmental causes remains small, less than 2% of giving in the European Union, it is among the fastest-growing philanthropic sectors (Gruby et al., 2023). It is important to flag that user fees and donations must take account of possible undesirable equity impacts, for example, payment for use of a public park or gentrifying neighborhoods. As a way of collecting user fees, the European Investment Bank (2023) has flagged utilities as being well positioned to allocate (user) capital to NbS. The Copenhagen Cloudburst Management Plan might serve as a model for EU Member States to finance NbS by enabling public utilities to impose user fees (good practice case 9).

Moving forward, it is critical to recognize the limits on both public budgets and private funding for scaling NbS. It appears prudent that innovative public and private funding sources are exploited, for example, taxes on nature-negative activities, targeted but equitable user fees and stepped-up philanthropic donations.

Turning to private NbS investing, it is notable that many if not most NbS are public goods in the sense that it is difficult or impossible to exclude users, and thus the NbS cannot be priced and sold to create a revenue stream. As emphasized by the European Investment Bank (2023), regulations (e.g. requiring offsets) and subsidies, among other instruments, can nudge private investors toward NbS. Good practice cases include the greening of housing projects in return for public land leases or investing in carbon mitigation projects to offset commercially viable investments (good practice case 23). While offsets are controversial with a questionable record of meeting their goals, a good practice case of private companies offsetting their carbon emissions is the Livelihoods-Yagasu project for planting mangrove forests (good practice case 11).

Given the public-good nature of NbS, private funding can be motivated by public subsidies and regulations that require NbS as an addition to already bankable ventures.

Many organizations, for example, the European Investment Bank (EIB, 2023) and The Geneva Association (Golnaraghi and Mellot, 2022) recommend exploiting multiple financing

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instruments, such as grants, equity arrangements, land easements and public-private partnerships. The European Union could also play a more prominent role in directing capital towards NbS. The U.S. Clean Water Revolving Fund, where the EPA capitalizes state banks for investing in NbS, might serve as a model for capitalizing NbS infrastructure banks set up by Member States (good practice case 12).

Yet the question remains whether hybrid funding is the magic bullet for filling the investment gap given that most require substantial public contributions, which in Europe come from already strapped municipal and national budgets or from the European Union. This is increasingly difficult in light of EU austerity requirements.

Insurance instruments for NbS

The insurance industry can enable the scaling of NbS with an array of products and strategies as shown in figure 2, which distinguishes two insurance pillars – underwriting and investment. The underwriting pillar can support NbS in at least five ways: underwriting NbS loss and damage, de-risking NbS, incentivizing NbS with insurance pricing, enabling NbS financing and declining cover for nature-negative projects. The insurance pillar can enable and finance NbS by engaging in transparency and disclosure of its asset portfolio, investing in and divesting from nature-positive and nature-negative assets, and with philanthropic activities.

Archetypal good-practice cases for pro-NbS underwriting include insurance cover for storm damage to the coral reefs along the Mesoamerican coastline as well as offering protection for catastrophe and political risk to enable a blue bond for financing the protection of 30 percent of Belize's oceans and an estimated USD 180 million towards conservation on the ground (good practice case 19) (The Nature Conservancy, 2021). Insurance coverage for innovative technologies has also played a role in de-risking NbS as seen in the case of mass timber (good practice case 14) or the Prins Hendrik Sand Dyke (good practice case 13). As these examples illustrate,

NbS underwriting products can be win-win in the sense that they are profitable ventures for insurance companies and at the same time they facilitate investments in nature.

However, in some cases, underwriters can choose to take a loss, for example, refusing cover in the case of the African crude oil pipeline (good practice case 24). This points to the need for new insurance business models.

Turning to the investment pillar, insurers hold large amounts of capital that, by factoring nature into their investment activities, can go a long way toward closing the financing gap highlighted earlier. Insurers are increasingly motivated to steer their investment portfolios toward nature-positive assets in order to reduce i) physical risks from rising insured losses, ii) transition and liability risks from rapid changes in regulations and policies, and iii) reputational risks from shifting societal expectations (ESG investing).

As illustrated on figure 2, the shift to nature-positive investing manifests in four ways: i) increasing transparency with respect to insurers' environmental footprint, ii) divesting from nature-negative assets, iii) contributing to philanthropic NbS projects, and iv) ii) pro-nature investing. The EU Task Force on Nature-related Financial Disclosures (TNFD) will potentially increase transparency by providing guidelines for the financial sector to disclose its impacts on nature. Implementation of the TNFD, however, faces difficult challenges such as data

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availability, which will need to be quickly addressed. Besides the TNFD, we document many other important initiatives, such as the UNEP FI Principles for Sustainable Insurance Initiative (PSI). Turning from principles to action, a good practice example of philanthropy and ESG investing is Aviva's support of rain forests in Britain (good practice case 25). On a negative note, it is still hard to find good-practice examples for pro-nature divestment and investment.

Insurers have lucrative opportunities to enhance their current business model and at the same time contribute to NbS scaling; however, many pro-NbS activities will require deviations from the current business model to take account of long-term developments – and some may be prohibitive in a competitive environment.

Figure 2: A classification of pro-NbS insurance activities

Insuring natural capital, like coral reefs, or enabling the financing of NbS, like ocean conservation, can greatly facilitate the implementation of NbS as well as provide business opportunities. As recently demonstrated by pioneering insurance products, these types of activities extend business-as-usual underwriting and fit comfortably with the insurance business model.

In contrast, insurer activities such as investing in NbS public goods - like mangrove forests or wetlands - that reduce losses from extreme weather can result in company losses. This contradicts optimism that insurers can be a leading force in confronting climate change and biodiversity loss by supporting and funding NbS, especially those that reduce disaster losses, since insurers and insureds stand to gain if property and asset losses, and consequently premiums, are reduced. This motivation should be examined closely since, in fact, insurers depend on risk for their core business. Except to assure insurability and their market in high-risk areas, insurers do not have a record of incentivizing or investing in DRR. If, for example, insurers fund the planting of mangrove trees to reduce storm losses, recovering their investment costs will be difficult with lowered premiums. Moreover, non-investing competitors can capitalize on the resulting market opportunities – the 'free rider' problem.

While many activities are constrained by insurers' fiduciary responsibility to their shareholders and by the competitive market in which insurers operate, a new business model that focuses on long-term benefits of a nature-positive economy and takes account of the emerging generation of impact investors may enable some steering of balance sheets toward nature-positive investments. To move the NbS agenda forward, it will be important to develop transformative governance regulations and strategies that can support, even require, nature-positive underwriting and investing as part of a new generation of insurance business models.

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1. Introduction

Nature-based solutions (NbS) have emerged on global and European agendas as essential for addressing the twin risks of climate change and biodiversity loss. A wide range of strategies can be implemented at different scales, including the management of river basins, conservation and restoration of forests, implementation of sustainable agricultural practices, and the creation of green urban spaces, among many others. Yet according to UNEP there is a huge gap in the current and required investments in NbS, a gap that can be closed only by tripling NbS investments in forests, peatlands, mangroves, coral reefs, disaster risk reduction, and more, by 2030 (UNEP, 2021). Similarly, according to the 2020 Financing Nature report (Deutz 2020), in order to conserve the natural environment, $845 billion is required for investment on an annual basis.

Reaching ambitious goals and closing the NbS investment gap will require a multi-faceted understanding of NbS governance – enablers, opportunities and barriers – and the necessity of significantly increasing public and private financing. Financial institutions recognize that nature risk and biodiversity loss pose serious threats to their operations. According to the European Commission (2022) roughly half of the world's GDP is moderately or highly dependent on nature. The World Bank (2023) estimates that the global economy could lose as much $2.7 trillion a year by 2030 if countries continue to destroy biodiversity, impacting wild pollination, food from fisheries and timber from forests. The sheer scale of this loss emphasizes the alarming need for investing in nature.

Despite growing recognition of the importance of NbS, the concept and its practical applications remain unclear. According to the European Commission, NbS are solutions *that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience* (European Commission, nd). Placing more emphasis on biodiversity, the International Union for Conservation for Nature (IUCN) defines NbS as *actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits* (IUCN, 2019). A recent review of 20 NbS definitions identified criteria that *dis*qualify projects as NbS, including, among others, negative or no impact on biodiversity, unfair distribution of benefits, top-down governance and financial expenses disproportionate to the benefits (Sowińska-Świerkosz and García, 2022). The concept of NbS thus extends beyond the conservation and protection of nature and underscores the utilization of nature's properties for solving societal challenges.

This deliverable takes stock of the enablers, opportunities and barriers for scaling NbS, with a particular focus on strategies for closing the financing gap. By taking stock, we appraise recent experience in terms of accomplishments and good practices. Our purpose is not to present an extensive literature review, but to provide a synthesis of the diffuse literature and experience, including H2020 case studies, NbS databases, demonstration projects, published reports and grey literature to render it relevant for the NATURANCE WP1 events and WP2 labs. For the most part,

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we rely on already documented cases, literature and reviews, as well as interviews that have been carried out to fill knowledge gaps.

Throughout we provide illustrative cases including good practice examples – all in all, a total of 25 cases. According to the European Commission, good practice implies "strategies, approaches and/or activities that have been shown through research and evaluation to be effective, efficient, sustainable and/or transferable, and to reliably lead to a desired result'' (European Commission, 2023b). Our focus is on both urban and rural NbS that support nature and biodiversity conservation, sustainable land use management, and sustainable forest management. Given the limited scope of this document, we give less attention to sustainable and nature-positive agriculture practices.

We begin in the next section by taking stock of the most recent evidence on how governance regimes enable or hinder the implementation of NbS across multiple scales and contexts. Governance can be thought of as a network of state and non-state actors (e.g., businesses, civil society, NGOs and expert communities) in the process of deciding on and implementing NbS and NbS policies. Since NbS have recently emerged on global and EU agendas, we begin by sketching out the main European Union policy frameworks that aim to drive action at the national and local scales. We then identify the enablers and barriers by expanding a literature review of over 250 enablers and 250 barriers extracted from workshop findings, grey- and peer-reviewed literature.

In the third section we take stock of financing arrangements in their current and potential role of enabling NbS. We catalog a large number of projects sorted by the extent to which they are publicly or privately financed and funded, also identifying hybrid solutions. This reveals a complex array of instruments for funding NbS including general taxes, user fees, payments for ecosystem services and donations; for financing NbS we document, among many other instruments, bank loans, green and resilience bonds, and underwriting arrangements. We examine the incidence of the instruments in terms of who ultimately pays for the NbS. One main message, repeated across the literature, is the near intractable problem of investing in a public good, which means that the large majority of NbS are publicly funded by taxpayers,

In the fourth section we turn specifically to taking stock of how insurance instruments and strategies can enable NbS and their scale-up. Our classification of activities distinguishes two insurance pillars – underwriting and investment. We identify five interrelated categories of pro-nature underwriting illustrated with good-practice cases for each, for example, insurers' recent role in insuring natural capital (e.g., coral reefs), facilitating NbS financing (e.g., Belize blue bonds) and refusing cover for nature-negative projects (e.g., the East African crude oil pipeline). We also identify three categories of how insurers' investment or asset management can support NbS, for example, the recent EU Task Force on Nature-related Financial Disclosures (TNFD) to encourage disclosure, and insurers' donations to NbS like Aviva's support of a rain forest in Britain. It is perhaps revealing that to date there are sparse examples of investment and divestment activities.

On scaling NbS and moving forward, we point out the opportunities insurers have in enhancing their current business model, like insuring natural capital, and those that will require deviations from it like divesting from profitable but nature-negative assets or funding loss prevention interventions as

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public goods. In the latter case, insurers are constrained by the competitive market in which they operate, although a new business model that focuses on long-term benefits of NbS and that takes account of the emerging generation of impact investors may enable some steering of balance sheets toward a nature-positive economy.

2. Governance and policy enablers, opportunities, and barriers

2.1 Nature-based solutions: European Union ambitions

In this section, we look at NbS governance in its broadest sense by encompassing all aspects related to collective and networked decision-making, including the social, ecological, political, and financial conditions through which NbS are implemented (Lemos & Agrawal, 2006; Steurer, 2013). While policy and governmental processes are a crucial part of governance, it has many more facets, including how and if stakeholders are involved in NbS decision-making and financing. Governance thus includes a network of state and non-state actors (e.g., businesses, civil society, NGOs and expert communities) in the process of deciding on and implementing NbS and NbS policies.

NbS are increasingly gaining political traction and recognition in Europe (European Commission, 2020; Davies et al., 2021; EEA, 2021; Faivre et al., 2018) and beyond (UNFCCC, 2022; CBD, 2022). They are embedded in a variety of cross-cutting European policy frameworks (EEA, 2021), such as the new EU Strategy on Adaptation to Climate Change in which they are considered essential for increasing climate resilience and sustaining healthy water, oceans, and soils (European Commission, 2021). In particular, the European Green Deal (European Commission, 2019) has set ambitious goals for NbS within its EU Biodiversity Strategy for 2030, new Common Agricultural Policy and Forest Strategy (European Commission, 2020). The EU Nature Restoration Law has recently been agreed with Member States. It sets a target for the EU to restore at least 20% of the EU's land and sea areas by 2030 and all ecosystems in need of restoration by 2050. Additionally, the 2021 EU Adaptation to Climate Change Strategy acknowledges the importance of ecosystems in climate change adaptation (European Commission, 2021) by emphasising NbS for carbon removal and incentivising and assisting member states in their rollout of NbS. From a financing perspective, the EU sustainable finance taxonomy (TNFD) intends to guide investment towards a green recovery and the deployment of nature-based solutions by providing a science-based classification system to assess financial decisions regarding their contribution to environmental objectives (EC, 2023). In parallel, an increasing number of funding opportunities have been put into place for supporting NbS in Europe (Trinomics & IUCN, 2019).

A non-exhaustive overview of policies currently addressing NbS (implicitly or explicitly) in European Union is provided in Appendix A. At the Member State policy level, multiple policy instruments explicitly acknowledge NbS and related concepts, sometimes even including them in their strategic objectives (e.g., German White Paper on Urban Green (BMUB, 2017), Spanish National Natural Heritage and Biodiversity Law (Ministerio de Medio Ambiente, 2007)). Although these multiple actions have advanced the conceptualisation and operationalisation of NbS in Europe, much wider adoption is needed to reach the goals of the Green Deal (Calliari et al., 2022). Additionally, the

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practice has shown that NbS implementation often fails because of governance barriers at the local or municipal level (Solheim et al., 2021).

Indeed, most NbS policies recommend non-binding measures – meaning that no sanctions are associated with failing to introduce them – and often lack quantitative and measurable targets for NbS deployment and quality evaluation (EEA, 2021). The complex mosaic of policy and financing instruments addressing NbS is not helping matters, sometimes resulting in fragmented governance and policy stalemates (Trémolet, 2019). Further alignment of sectoral policy instruments is also needed to facilitate cross-sectoral governance arrangements for NbS (EEA, 2021). The NbS landscape in Europe can be described as subject to an implementation gap (i.e., a mismatch between NbS ambitions and on-the-ground implementation).

It is, therefore, essential to advance our understanding of the governance drivers, frameworks, strategies and instruments that can help enable NbS. This section summarizes current research findings on governance enablers and barriers of NbS implementation across different governance settings and for different purposes. Our results are based on an expanded literature review of 264 barriers and 252 enablers extracted from workshop findings, grey- and peer-reviewed literature (N=26) (see Martin et al., 2023). Enablers and barriers were coded, classified and evaluated using NVIVO (Edwards-Jones, 2014), which resulted in the enabler and barrier clusters represented in Figures 1 and 2. Each cluster was composed of several enablers/barriers that shared common themes.

2.2 Enablers of NbS implementation

The NbS literature highlights diverse enablers considered critical for implementing NbS. In the analysed data, **stakeholder engagement and equity** emerged as the highest ranked enabling feature (Figure 1). This enabler relates to how and if stakeholders are involved in the NbS decision-making process, including such factors as social inclusion of stakeholder and citizen groups (Nesshöver et al., 2017; Schmalzbauer, 2018), trust emerging among stakeholders (Han & Kuhlicke, 2019) as well as trust in the local government (Frantzeskaki et al., 2019). This enabler also includes good practices with regards to identifying stakeholders, for instance by identifying the social networks that affect NbS governance (Albert et al., 2019).

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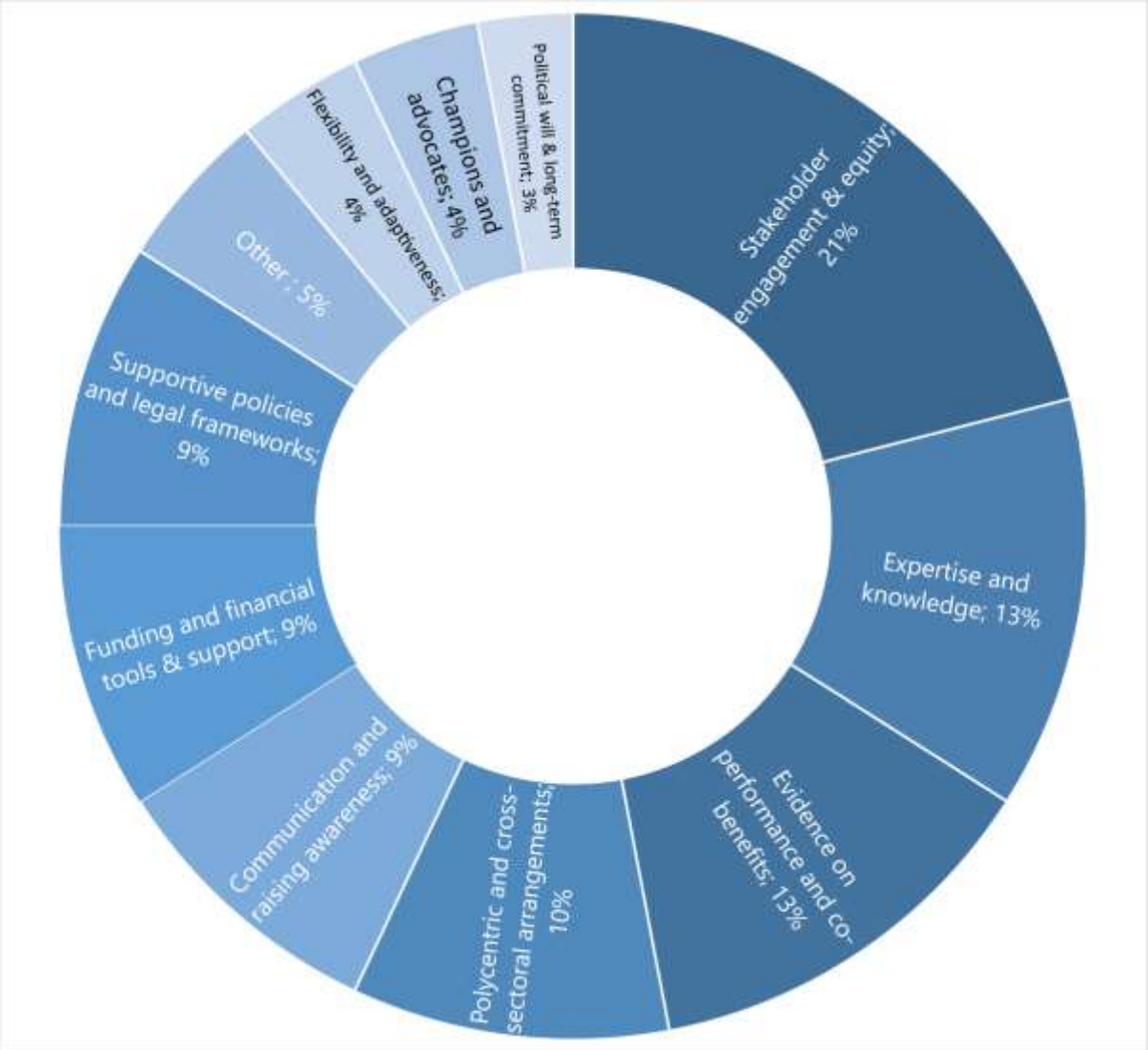

Figure 3: Enablers of nature-based solution implementation (Adapted from: Martin et al., 2023).

The concept of 'true' **co-creation and co-design** – meaning creatively engaging citizens and stakeholders to co-generate solutions to complex problems (Blomkamp, 2018) – was an important factor mentioned in the literature. Equity, which is fundamental to this enabler, includes comprehensive and just stakeholder involvement, all voices being heard, and fair NbS benefit sharing. The co-design of an NbS in the Serchio River Basin by farmers, administrators and researchers (good-practice case 1) is a successful example of co-designed and co-managed NbS measures.

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Good practice case 1: Co-design of a NbS in the Serchio River Basin (Italy)

NbS measures have been introduced in the Serchio River Basin in Italy to reduce sediment and pollutant runoff into Lake Massaciuccoli. The NbS were the result of a bottom-up participatory process in which farmers and local organisations closely collaborated with the responsible authority, the Autorita' di Bacino Distrettuale dell'Appennino Settentrionale (ADBS), to select the appropriate NbS interventions. The alignment between citizen and policymaker preferences facilitated the identification of the most suitable NbS for the area and established a relationship of trust. With a sense of involvement, the farmers were willing to participate actively. Local farmers from the watershed, who were paid for their services by the municipality, took responsibility for the vegetative buffer strips on their land by reshaping the canals and planting native species.

Interestingly, farmers were initially skeptical, possibly due to the more than 20 years of top-down policymaking, including about agricultural subsidies. Once the farmers were at the centre of implementing the measures, they fully supported the NbS co-design, and close cooperation will likely continue for monitoring and maintenance. The co-design process was fostered not only by the collaboration between farmers and public agencies but also between public agencies and research organisations. Indeed, researchers at Pisa University identified the specific characteristics of the seed species necessary for realising the buffer strips.

Photos by ADBS

Given the project's success, the ADBS intends to scale up these solutions as good practices at the regional (Region Toscana) and national level. For this to happen, however, it is necessary to increase NbS regional and national funding, e.g., by explicitly including NbS in rural development and water/flood risk management plans.

Evidence on performance and co-benefits ranked second as a critical enabler. Its counterpart, lack of evidence, was documented as an equally important barrier (see section 2.3), and the literature cited this enabler as an untested (rather than a proven) enabler, highlighting the need for further calculations and evidence of NbS' multiple co-benefits. Specifically, the need to enhance valuations of NbS versus grey alternatives was cited (Scolobig et al., 2020), as well as clear and harmonised quantitative targets and indicators to track NbS performance (Huthoff et al., 2018; Scolobig et al., 2021). The formulation of the 2020 IUCN global standard for NbS (IUCN 2020), which intends to help practitioners design effective and standardised NbS, represents an essential step in this direction.

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However, due to NbS novelty, on-the-ground experience on applying the standard across regions are still scarce (Châles et al., 2023).

As a closely related enabler, **expertise and knowledge** ranked prominently in the literature. This enabler manifests in overcoming NbS knowledge gaps, be it in terms of the functioning and dynamics of ecosystems (Fisher et al., 2019), the socio-economic systems and governance structures in which NbS are embedded (Albert et al., 2019) or in terms of specialised contractor skillsets (Bernardi et al., 2019). The good-practice case on accounting for multiple co-benefits of flood protection and habitat restoration in the Thornton Creek Watershed (good-practice case 2) illustrates practice in quantifying multiple values in the decisionmaking process of a nature-based solution.

Polycentric and cross-sectoral arrangements emerged as another key enabler. Polycentric governing systems are those in which decisions are taken at different jurisdictional levels and scales (e.g., national, regional, global) and/or sectors through sometimes formally independent decision centres (Ostrom, 1999). While the concept is far from new, in the context of NbS, polycentrisity requires the cooperation and collaboration of actors across different scales and sectors (Martin et al., 2021). Similarly, the adaptiveness of governance systems is highlighted in the literature as fundamental to polycentricity (Carlisle & Gruby, 2019). Adaptiveness is needed to retain a level of flexibility of NbS in light of a changing climate (Kabisch et al., 2016; Suleiman, 2021) and rapidly evolving societal challenges (Nesshöver et al., 2017; Bernardi et al., 2019). While polycentricity is (re)surfacing as important for mainstreaming and upscaling NbS implementation (EEA, 2021), few examples of its practical application for NbS exist. As an exception, we highlight one notable case, the Isar Restoration or Isar Plan in Munich (good practice case 3). Stakeholders agree that the Isar restoration would not have been possible without an *ad hoc* working group across agencies and expertise.

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Good practice case 2: Combining flood protection and habitat restoration by accounting for multiple co-benefits in the Thornton Creek Watershed (USA)

Thornton Creek is a highly urbanized large watershed in Seattle, Washington, with most of its native habitats and vegetation being lost due to habitat conversion and pollution (Morley et al., 2013). Additionally, the area is prone to stormwater-related flooding. To remedy this, a project was launched in 2014 to restore habitats and to reduce flooding (Schmidt & Wittich, 2014).

A cost-benefit analysis incorporated ecosystem services values and suggested a policy option that reduced peak flows and provided habitat and floodplain restoration, including for Chinook salmon and other aquatic species. The economic analysis considered project capital costs as well as operational and maintenance costs. It evaluated three quantified benefits: reduction of living space flooding in the 25-year storm, improving the provision of ecosystem services by converting three acres from urban open space to wetland and reducing maintenance costs at Meadowbrook Pond (Schmidt & Wittich, 2014). The project also involved local communities in all stages and integrated indigenous ecological knowledge into the policy process (Murphy et al., 2022). Despite the project being carried out by Seattle Public Utilities, whose mandate usually only covers stormwater management, the organisation recognized the broader benefits of a more environmentally friendly option. Since 2018, Chinook salmon have returned to the watershed to spawn, and floods have been reported to be less frequent, providing evidence on the success of the project (Puget et al., 2020).

Photo 48409788 | Chinook Salmon © Justinhoffmanoutdoors

Supportive policies and legal frameworks are further pivotal enablers for implementing NbS although legal frameworks are predominantly mentioned as crucial for *potentially* enhancing NbS uptake instead of citing specific legal mechanisms that have proven to be effective. This can be attributed to the aforementioned lack of NbS-specific policies in Europe (Calliari et al., 2022) and sparse national NbS-specific action plans and guidelines. One precedent-setting case (good practice case 4) is recent legislation in Norway that provides guidance for public authorities to consider NbS as an alternative to grey solutions. This legislation addresses the mismatch between ambition and action regarding NbS, which has been a theme in several studies (Calliari et al., 2022; EEA, 2021).

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Financing and funding are prerequisites for implementing NbS, yet this enabler ranks relatively low in the reviewed literature, not surprisingly since the literature rarely documents experience and cases that do not enter the planning stages due to lack of prospective funding. As examples, funds for both the Isar restoration (good practice case 3) and the Prince Hendrik Sand Dyke restoration (good practice case 13) were assured by public authorities in advance of the planning process. Literature describing the cases did not therefore mention funding as a hurdle. The opportunities and challenges for funding NbS are discussed at length in sections 3 and 4.

Communication and awareness-raising emerged as a multi-faceted topic for scaling NbS. It includes, for instance, avoiding jargon (Bernardi et al., 2019) and adopting more clarity on NbS definitions (Scolobig et al., 2020). The need for awareness raising is highlighted in the literature with emphasis both on dissipating the 'fear of the unknown' that NbS often face (Schmalzbauer, 2018) and on their multiple socio-economic co-benefits (Chatzimentor et al., 2020).

Results show that **champions and advocates** are lower ranked but still salient enablers of NbS. While this enabler goes hand in hand with political will and long-term commitment, champions emerged as distinct in the barrier analysis (section 2.3). Here, the importance of forerunners and early adopters of NbS (Naumann et al., 2014; Bernardi et al., 2019; Martin et al., 2021), who can spearhead the NbS concept, was stressed, as well as agents of change that can transform institutions from within (Davies & Lafortezza, 2019).

Finally, the **aesthetics of NbS**, in contrast with grey solutions, was seen as a relatively minor enabler, followed by the **occurrence of a disaster** in triggering NbS actions. Not surprisingly, both only emerged in the enabler analysis, as they do not have counterparts as barriers.

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Good practice case 3: A polycentric working group to facilitate the Isar-Plan

From 2000–2011, an eight kilometre stretch of the Isar River in Munich (Germany) was restored using hybrid green and grey measures. It was widely acclaimed for having successfully turned a formerly concrete riverbank into a green/blue recreational space, which has since become an emblem of the city (Binder, 2010; Sartori, 2012; Düchs, 2014). The project's aims were threefold: flood protection, environmental restoration (both fulfilling the Munich Water Agency's central mandates) and creating an urban recreational space (fulfilling the City of Munich's mandate and the demand of local councils and Munich's inhabitants).

Source: Photo 62162600 | Isar Munich © Zyankarlo | Dreamstime.com

Indeed, the Isar River in Munich falls into several overlapping jurisdictions and legal mandates at the State (Bavaria) and City (Munich) scales, which created the need for a polycentric arrangement, bringing together different sectors and jurisdictional levels (Ostrom, 1999).

The collaboration was initiated by ecologically committed staff of the municipal government and the local water agency, who formed the multidisciplinary Isar Working Group. Creating such a working group was unprecedented for flood management (Zingraff-Hamed et al., 2019). It was seen as the main success factor for the eventual implementation of the project (Martin et al., 2021). While the working group was created ad-hoc, the same model has since inspired other flood mitigation projects in Germany (Martin et al., 2019).

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Good practice case 4: Pioneering NbS regulation in Norway

In 2018, Norway passed pioneering legislation in the form of guidelines instructing public authorities to consider nature-based solutions in planning, conservation, or restoration activities (Norwegian Environment Agency, 2018). The "National guidelines for climate and energy planning and climate adaptation" specifically state that public authorities must consider NbS when selecting strategies at municipal and regional levels. NbS are further explicitly mentioned as an alternative to be assessed along with any grey solution, and if dismissed, the decision must be substantiated. In 2022, the Norwegian Environment Agency published more detailed guidelines for climate adaptation that built strongly on this regulation (Norwegian Ministry of Climate and Environment, 2022).

Unfortunately, to date, the legislation has not been rigorously implemented, mainly due to its voluntary nature and novel approach.

Photo 5695732 © Serban Enache | Dreamstime.com

2.3 Barriers to NbS implementation

The manifold barriers to NbS implementation are shown in figure 2. Many are simply counterparts to the enablers highlighted above. For example, **NbS-specific expertise and knowledge** is both an enabler and (the lack of) a barrier for actors in both the public and private sectors. Interviews with NbS contractors emphasized their difficulties in recruiting trained staff and their need for legal guidelines to avoid liability (illustrative case 5). Possible solutions include creating educational and training programs specifically for nature-based enterprises responsible for NbS design (targeting landscape architects and designers) and implementation (targeting contractors). The further development of nationally (and ideally, internationally) agreed technical standards, guidelines and legal norms for NbS implementation can help surmount this challenge. However, it should be emphasized that a full assessment of the effectiveness and risks of NbS will take many years of

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operating experience. In many cases, this will not be possible in the time frame needed for their urgent implementation.

Figure 4: Barriers to nature-based solution implementation (Adapted from: Martin et al., forthcoming).

As would be expected, issues surrounding **equity** (both in stakeholder engagement and in NbS benefit distribution) emerged as a prominent barrier to successful NbS implementation. Stakeholder conflict often centers around views of distributive equity, especially 'winners and losers' of NbS projects. A classic case of conflicting stakeholder interestS is reported in illustrative case 6, where riparian stakeholders in Gudbrandsdalen, Norway, were opposed to a flood mitigation NbS because it reduced gravel flow into the river, which they removed and sold. The Norwegian case emphasizes the importance of not only inclusive engagement of stakeholders in the NbS design, planning and implementation process, but also the importance of conflict resolution often through facilitated compromise (Linnerooth-Bayer et al., 2016; Scolobig et al., 2016). One way to tackle this challenge is with genuine co-design and co-creation processes, which also emerged as key NBs enablers (good practice case 1).

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Illustrative case 5: A reality check from nature-based solutions contractors

Contractors play a crucial yet often overlooked role in designing and implementing NbS. They include a wide range of private sector companies, such as consultancy and engineering firms, construction firms, landscape architects and material suppliers. If contractors are to expand or increase their market share in nature-based solutions, it is important to understand the challenges that they might face in this endeavor. Interviewees with 20 contractors revealed that knowledge-related factors are the most important barrier. This included lack of solid information, practical experience, training, and concrete data to demonstrate the effectiveness of NbS (see Linnerooth-Bayer et al., 2023, for more detailed results).

People are not used to it [NbS] because they don't have any training in this field. Unless it is someone with an environmental background or a forestry engineer, they have not had any of this in their training. (Quote from construction company)

Still today our main problem is having people that can work with us and sometimes we need to tell our customers that we cannot do the work because we do not have [the right] people. (Quote from design/construction company)

One problem is that nature-based solutions are very multidisciplinary projects. All the different partners must work in areas that are outside their comfort zone, that are new to them, which causes them a little bit of hesitation. (Quote from design/construction company)

Territorial strategy for public spaces in wetland areas in Rennes. Source: Agence Ter

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Illustrative case 6: Conflicting stakeholder interests stalling a NbS in Norway

Stakeholder economic interests played a pivotal role in the flood-mitigation NbS proposed in the Norwegian valley of Gudbrandsdalen. The catchment of the river, Gudbrandsdalslågen, and its tributaries drain large areas of glacial tills. This results in severe erosion, leading to transport and deposition of large amounts of sand and gravel downstream.

Contrary to most European countries, where rivers are the property of the public, in Norway they are the property of the riparian landowners. This enables private property owners to have great influence on measures that impact the river. Gravel out-take after flooding events represents an important additional income for landowners along the river, which gave rise to opposition to implementing flood-reduction measures of any type in this area and ultimately caused the NbS to stall (Solheim et al., 2021).

Source: Photo 208987890 | Gravel Norway © Wirestock | Dreamstime.com

Enablers and barriers differed in several aspects. Most prominently, factors limiting NbS implementation are **path dependency** and institutional lock-in, i.e., the difficulty in breaking away from current legal and social norms (Hanger-Kopp et al., 2022). In general, legal frameworks favour grey infrastructure (Linnerooth-Bayer et al., 2023). In Austria, as a case in point, the authorities and other stakeholders prioritized grey measures for preventing flood losses (illlustrative case 7), which might be explained in part by the reluctance of the (mostly senior) authorities in moving away from their long-standing experience and competence with levies and other grey measures.

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Illustrative case 7: Path dependency in flood risk management in Austria

The Ennstal valley in the province of Styria in Austria is prone to regular floods, and a torrential flood event in 2017 resulted in several million euros in damage (Clar et al., 2021). In response, structural and non-structural measures were considered by the region. Yet, interviews showed a preference for grey infrastructure, such as channeling of river courses and flood dykes, which are still perceived as a more reliable and long-lasting option by local authorities (Seebauer et al., 2023). Indeed, classic infrastructure was still prioritized by decisionmakers due to its well-established design, implementation, and maintenance processes.

Photo 205416130 | Ennstal © Aron M | Dreamstime.com

Path dependency was also influenced by elderly employees who were trained decades ago, indicating that public bodies may lack the capacities to move away from long-tread paths. The role of EU directives in driving institutional shifts (e.g., towards integrated water management), as well as regular training in novel methods and information (e.g., on nature-based solutions), were highlighted as potential pathways to change.

In synch with NbS barriers, the literature stresses the importance for NbS projects to be embedded in broader agendas that bring together different sectors and environmental issues. Novel governance arrangements, including polycentric arrangements to include NbS co-benefits, are again emphasized as transforming policy for NbS uptake and contribution to transformative agendas (see good practice case 3).

As would be expected from the extensive discussion on the importance of an **evidence base on NbS performance and co-benefits**, this emerged strongly as an NbS enabler. While significant progress has been made in advancing valuation methods of NbS co-benefits (Ommer et al., 2022; Watkin et al., 2019; Stroud et al., 2023; Kumar et al., 2021) (see good practice case 2), further long-term studies will be needed to account for benefits beyond the lifespan of NbS projects. Additionally, poorly staffed and financially constrained public authorities with little experience or expertise with

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NbS (who remain the leading implementors of NbS in Europe) (Mayor et al., 2021; Sekulova & Anguelovski, 2017) cannot be expected to carry out the monitoring required to compile this evidence.

Lack of capacity and knowledge is compounded by the **lack and complexity of financing**, among the top five NbS barriers. There is a fundamental problem in attracting private financing given the public-good nature of NbS benefits, which fail to produce tangible cash flows as necessary for business survival. This results in a shortage of bankable NbS projects and business models. As will be discussed in sections 3 and 4, most NbS (around 83%, according to UNEP) (Sekulova & Anguelovski, 2017; Davis et al., 2018; UNEP, 2022) are publicly financed, creating a heavy load for public authorities and finances. This is exacerbated by often limited municipal spending autonomy on budgets (Toxopeus & Polzin, 2021), recent austerity policies (Mell, 2020), and the incapacity to co-finance NbS (Bernardi et al., 2019). Public bodies thus have high demands on their budgets, and politicians are typically attracted to highly visible projects with short-term benefits (Coelho et al., 2014) that award them credit and votes; yet, infrastructure governance is very much about long-term investments that remain difficult to sell politically.

2.4 Summary and reflections on overcoming barriers

For NbS to meet their promise of helping to achieve biodiversity and climate targets, it is vital to advance our understanding of the (often overlapping) governance drivers that can enable or hamper their implementation. Taking stock of governance enablers and barriers as reported in the literature has yielded important insights on scaling NbS. At the top of the barrier list is lack of equity (mainly in stakeholder engagement) and resulting stakeholder conflicts, which suggests investing in inclusive participatory processes in all phases of NbS implementation, from project initiation to maintenance. Although knowledge of NbS has greatly advanced in the last decades, the literature still suggests a lack of NbS-specific expertise and knowledge (particularly for practitioners), combined with a dearth of evidence on their effectiveness and co-benefits. This represents a formidable challenge for public authorities and private businesses when justifying NbS over their grey counterparts. Overcoming this hurdle will require further development of an evidence base on NbS performance over longer timescales, as well as more quantitative cost-benefit analyses capturing their multiple co-benefits. Since this will require a long history of operating experience, a major challenge is urgently implementing NbS in the time scale needed to reverse biodiversity loss and contribute to climate change mitigation.

Limited capacity and knowledge of NbS is compounded by a lack of earmarked funds. This barrier is addressed in more detail in section 3. Finally, the current lack of supportive policies, standards and frameworks, including those that legally mandate NbS (at the risk of being otherwise sanctioned) also emerged as a critical policy bottleneck.

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Enablers and barriers differed in several aspects. Most prominently, a significant factor limiting NbS implementation is path dependency, i.e., the difficulty in changing the current legal and social norms that favour grey infrastructure. Moreover, polycentric governance arrangements to overcome siloed administrations present a unique enabler to NbS implementation since they foster cross-sectoral and cross-scale cooperation needed in a complex environment of stakeholders, sectors and jurisdictional scales.

It is also noteworthy that many (if not most) detailed barriers and enablers characterize grey solutions or traditional infrastructure as well as NbS (Linnerooth-Bayer et al., 2023). For example, stakeholder opposition has historically plagued both types of infrastructure. The lack and complexity of financing also remain a key challenge for grey infrastructure, which largely relies on public funding. Furthermore, the lack of political will and long-term commitment is a hurdle faced by both NbS and grey infrastructure, exacerbated by the tendency of politicians to focus on short-term goals that bring voter support - even more so for NbS, which have longer gestation cycles. The NbS community can learn from how these barriers have been surmounted for grey infrastructure in the past. At the same time, three especially intransigent barriers differentiate NbS from traditional infrastructure, including the aforementioned lack of expertise and knowledge, lack of evidence on performance and co-benefits, and path dependency of 'grey' infrastructure. These barriers unique to NbS deserve special attention for moving forward.

To respond to the distinctive challenges, recommendations have been put forward in the literature. These include extending the scope of the EU Environmental Impact Assessment (EIA) Directive, coupled with the requirement that proposers of grey solutions consider NbS as an alternative (Linnerooth-Bayer et al., 2023). This would effectively switch the burden of proof (currently on NbS) by assuming NbS to be the preferred option unless the grey solution is proven superior. Switching the burden of proof would help overcome the currently near-intractable challenge of estimating NbS effectiveness and co-benefits, given the lack of experience and data. In addition, exempting those NbS that are considered low risk from EIAs or subjecting them to a streamlined approval process could help break grey path dependency (*ibidem*).

Based on a series of Policy Business Fora, NbS experts and practitioners identified lessons from current NbS shortfalls, summarized in a policy brief (Scolobig et al., 2023). They emphasized the importance of innovative co-generation stakeholder processes to avoid stakeholder conflicts, as well as intelligent uses of cost-benefit analyses that account not only for the long-term impacts of NbS but also their diverse co-benefits (Scolobig et al., 2023). Additionally, whole-of-life contracts that include long-term maintenance and monitoring were mentioned to enhance long-term accountability and evidence gathering (*ibidem*). To overcome the lack of supportive policies and legal frameworks for NbS, mandatory policy instruments making NbS compulsory elements of, e.g., landscape planning or the introduction of self-certification schemes were recommended. Increasing policy synergies and cross-sectoral integration of NbS was also suggested, for instance, by linking

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NbS policies to wellbeing and preventative health care policies or green infrastructure, transport, and mobility policies. Finally, building capacity on NbS was emphasized as a critical way forward. Creating an NbS project preparation facility at different scales, alongside accelerator programs for start-ups and training courses and seminars based on past experiences, were put forward as possible solutions.

3. Financing and funding NbS

Nature-based solutions depend on financing and funding sources for their implementation; yet, there is a formidable gap in securing the requisite funds from both private and public sources at the scale needed. UNEP (2022) estimates that the world needs to triple NbS investments by 2030. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability (Deutz et al., 2020) suggest that to reverse the decline in biodiversity by 2030, globally, we need to spend between US$ 722-967 billion each year. The financing challenge at the global scale manifests at local and national levels. As illustrated in Figure 2, the complexity of financing/funding ranks among the top five NbS barriers as reported in the literature.

This section provides an overview of selected financial and funding approaches used to deliver NbS, each with a good practice case, and examines their associated barriers and limiting factors. It also takes a careful look at who ultimately pays for the NbS. Before proceeding, it is useful to distinguish between financiers and funders (den Heijer and Coppens, 2023). The former refers to the provision of resources needed to implement a project, while the latter refers to the ultimate payment of the implementation, operation, and capital costs. We interpret “funding” to address the question of ''who pays?'' whereas ''financing'' addresses the question of how the funding providers raise the necessary capital. Financial agents include banks, insurance companies, asset managers and multilateral development banks.

In all cases, a distinction is made between public and private funders and financiers. Public actors refer to governments and government-affiliated entities, whereas private actors refer to any institution that does not directly associate with a government setting. As such, private actors include, inter alia, insurance companies, insurance brokers, banks, institutional investors, enterprises, NGOs, non-profit organizations, and citizens. Public actors include municipal, national and other governments, and publicly owned banks and insurance providers. As one case in point, the European Investment Bank (EIB), the largest multilateral bank in the world operates as a public entity. As another example, the National Flood Insurance Program (NFIP) in the U.S. is a publicly underwritten insurance program administered by private insurers.

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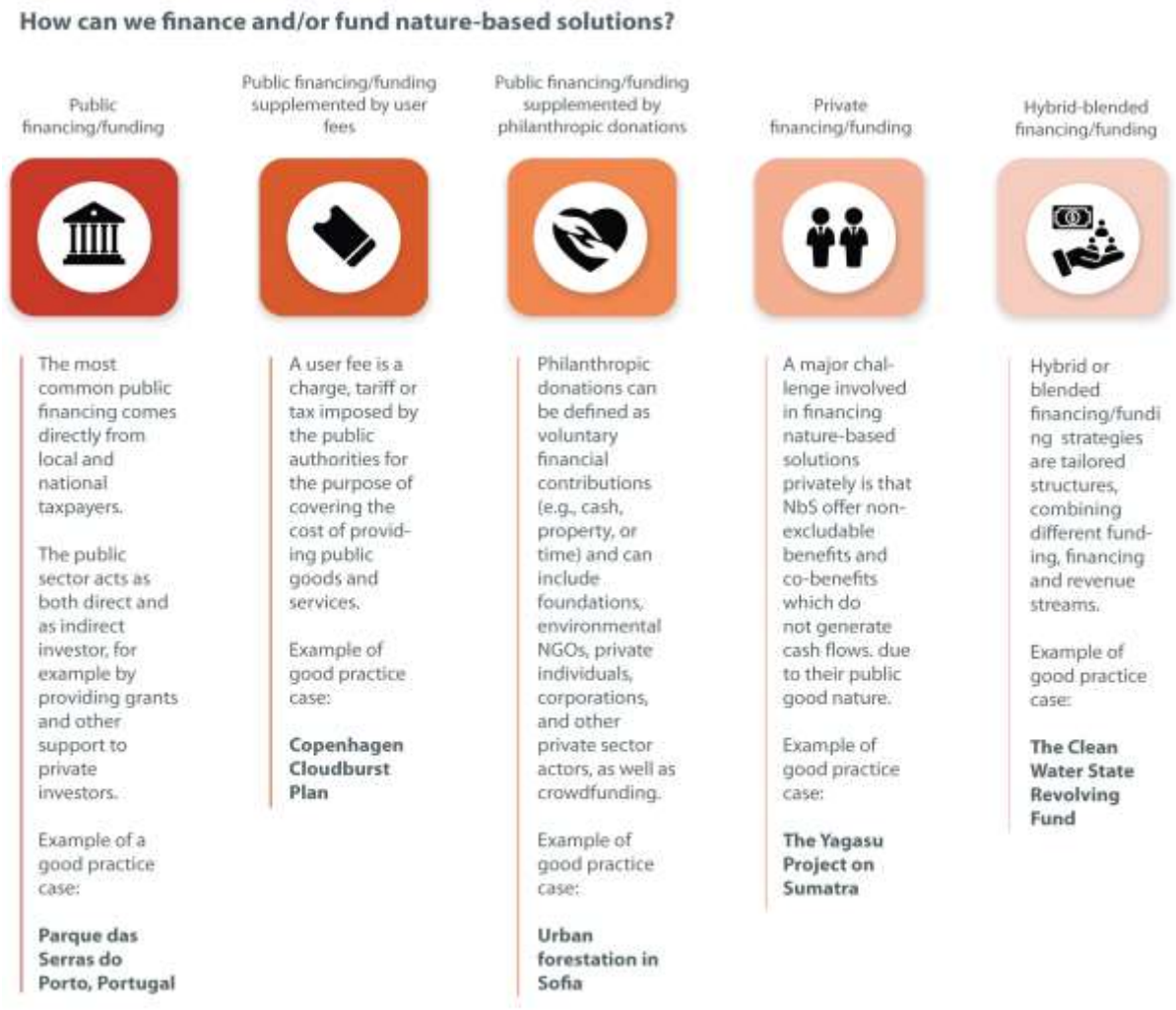

Figure 3: A classification of funding/financing mechanisms available for NbS with good practice cases

In table 3(a-e), we provide 51 separate cases of NbS funding and financing, and we briefly illustrate each with a good-practice case. We did not aim for a representative selection of cases but rather for those that illustrate a range of financing and funding arrangements. The majority of selected cases are European (61%) followed by the United States (14%), and most NbS are implemented in an urban context (65%). This may demonstrate a lack of funding for NbS outside of Europe and a lack of data regarding NbS projects elsewhere (Giam & Wilcove, 2012). In relation to scale, the NbS identified are typically small, ranging from the micro- to the meso-scale (67%). This result can be explained by the large number of projects located in urban regions.

Of the 51 reported cases, only twelve or about 24% are entirely privately funded. Although the cases are not representative, we should point out that this is in line with the literature as confirmed by a recent analysis by Papari et al. (2024) that explored the investment landscape of urban NbS in

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Europe. In synch with other studies reported below, they conclude that public budgets currently finance the overwhelming majority of urban NbS and lack investment from profit-seeking financial instruments (Figure 4).

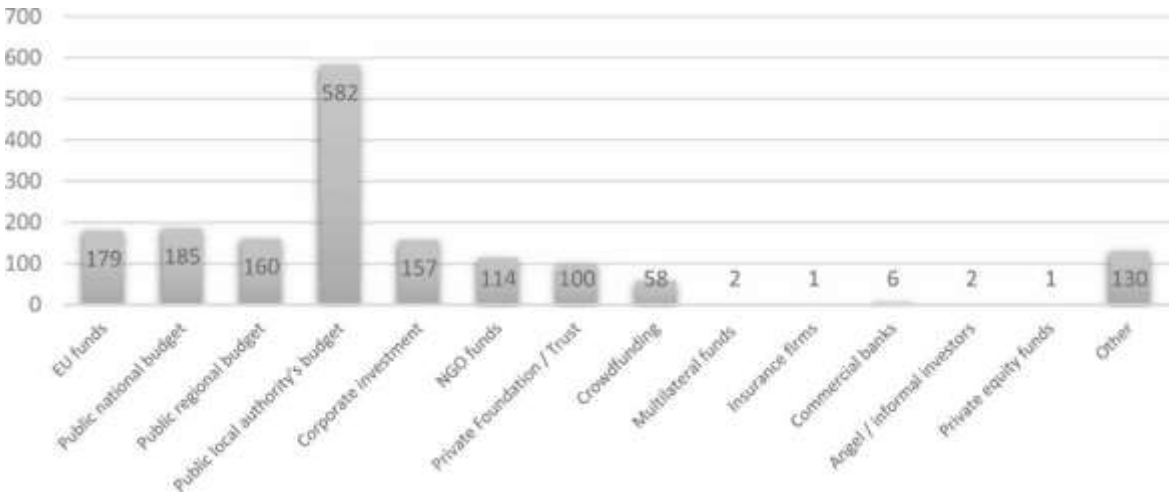

Figure 4: Financing sources of urban NbS in Europe. Source: Papari et al., 2024

We exclude cases from the agricultural/forestry sector since they would expand the scope of this document beyond our resources. As noted by the European Investment Bank (EIB, 2023), the agricultural landscape/ecosystem is unique in funding and financing given the large budget of the Common Agricultural Policy (CAP), which offers vast opportunities for NbS. There is already extensive literature discussing NbS opportunities in the agricultural sector and corresponding questions about the efficiency and effectiveness of current NbS expenditure from CAP (European Commission, 2022).

The selected cases described in Table 3 (a-e) are distinguished into the following five categories on the public-private spectrum, including mixed and hybrid arrangements (Figure 5):

a) Public (18 cases)
b) Public supplemented by user fees (7 cases)
c) Public supplemented by philanthropic donations (6 cases)
d) Private (13 cases)
e) Hybrid (10 cases)

In what follows, we discuss the five categories of NbS, each illustrated with a selected case to highlight good practice. We also discuss barriers to the financing/funding instruments and point out who ultimately pays – taxpayers of national, regional and local governments, users, donors, future

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generations, private persons, EU agencies, multilateral development banks (such as the EIB), or others.

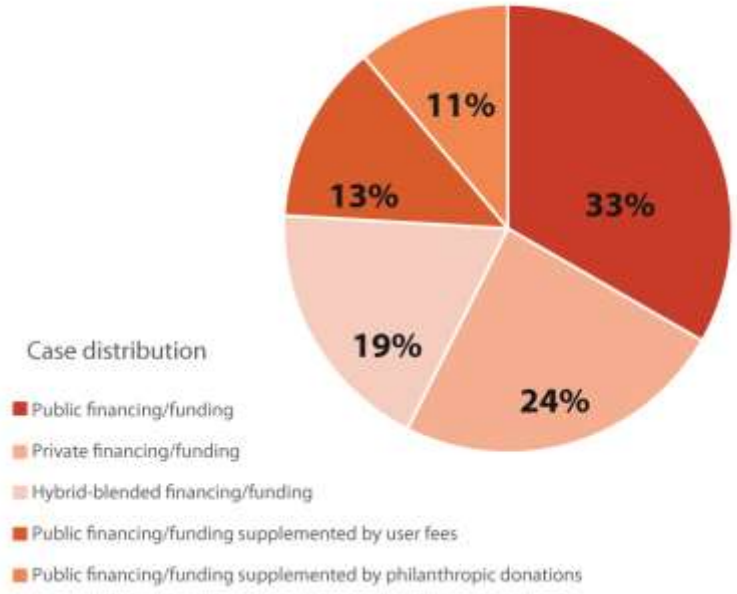

Figure 5: Distribution of NbS financing/funding across the 51 selected cases

3.1 Public financing and/or funding

Public financing and funding dominate the financial arrangements for implementing NbS at all scales. According to UNEP (2022), around 83% of NbS are financed and funded by the public sector (see also Sekulova and Anguelovski, 2017; Davis et al., 2018). A similar conclusion was reached by the European Investment Bank (EIB), which has recently carried out an extensive review of the current state and diversity of nature-based solutions in the European Union and the United Kingdom, covering a total of 1,364 implemented NbS projects. Only 3% of the projects received private sector financing that covers more than 50% of a project's total cost (EIB, 2023). The report found that public funding meets up to 91% of the current financing needs of projects at the EU level, consisting of contributions by EU agencies, EU-based multilateral development banks (such as the EIB), and national, regional and local governments. This broadly corresponds to global figures where it is estimated by CrossBoundary (2021) that 83% of nature-based projects, respectively, are publicly funded (see also Sekulova and Anguelovski, 2017; Davis et al., 2018). A primary reason for the dearth of private funding is the public-good nature of NbS. It is usually difficult or impossible to exclude people from the enjoyment or utilization of their benefits. Thus, they cannot be priced and sold to create a revenue stream.

The statistics for privately and publicly funded NbS mirror the statistics for biodiversity spending. It is estimated that from 2014 to 2019, all public sector actors (EU funds, Member State public expenditure) domestically spent an estimated EUR 129 billion on biodiversity protection

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(approximately EUR 70 billion from the EU and EUR 59 billion from Member States). This can be compared to only EUR 738 million in private purchases of green bonds and EUR 608 million from philanthropic institutions. (Nesbit, M, Whiteoak, K, et al. 2020)

As shown in table 3(a), the public sector acts as both a direct investor in NbS (e.g., natural playgrounds in Poznań, Poland) and as an indirect investor by providing grants and other support to private investors (e.g., tax rebates in the form of Natura 2000 Management Agreements in France). As investors, the most common financing comes directly from local and national taxpayers. The public sector can also borrow from local or European banks (e.g., financing from the EIB to restore peatlands and boreal forests in Finland). Bonds are a typical source of public financing for NbS investment. As documented in a recent report by the European Commission (2023 a), there has been a steep increase at a global level in green bond annual issuance, from USD 37 billion in 2014 to USD 168 billion in 2018. Cumulatively, the EU's green bond issuance over the past decade has reached 569 billion USD, while globally, it surpassed 1 trillion USD in 2014-2020. However, as the EC report highlights, green bonds have focused principally on climate change and have rarely included concrete biodiversity finance.

Also, as documented in table 3(a), there are many ways municipalities and other responsible authorities can enable financing. These include polycentric arrangements that diversify the funding sources across administrative bodies, and participatory budgeting to prioritize NbS outlays and cost-sharing with the national, federal or regional governments (e.g., through grant programs). As described in section 2.2, polycentric arrangements are an almost essential enabler for those NbS that have multiple benefits spread over different funding agencies. As we see in good practice case 8, the NbS in the Porto mountain park were enabled by collaboration among several municipalities.

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Good practicec case 8: Parque das Serras do Porto, Portugal

The Parque das Serras do Porto represents an area spanning nearly 6000 hectares in the municipalities of Gondomar, Paredes, and Valongo. The Association of the Municipalities of the Porto Mountain Park were awarded 2.1 million Euros by the European Climate Infrastructure and Environment Executive Agency for the implementation of climate change adaptation measures. These measures include a number of ecological and social activities as well as the implementation of NbS to increase soil water retention capacities and to improve river banks. Additionally the projects aims to restore native vegetation to the area, control exotic and invasive species, and further includes a 12 hectare agricultural demonstration site for adaptation actions. The project puts specific emphasis on awareness raising, capacity building activities, and stakeholder inclusion (Serrasdoporto, 2023).

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As witnessed in the Isar case, co-financing can increase the available budget for NbS, while silo budgeting approaches can hinder the development of these arrangements (Bernadi et al., 2019). As such, raising awareness among public authorities of the (often) multiple benefits NbS is of utmost importance to stimulate co-financing arrangements (Drayson, 2014). In addition, a lack of knowledge and skills may prevent the development of alternative financing/funding approaches, such as green bonds and participatory budgeting (Climate-ADAPT, 2016d; Rutherfoord et al., 2013). Finally, high administrative and transaction costs pose a limiting factor to the development of these approaches, for example, for community asset transfer, tax rebates, and payment for ecosystem services (PES) (Drayson, 2014; Hein et al., 2013; Trinomics & IUCN, 2019).

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Table 3(a): Public NbS financing/funding (18 cases)

Financing instrument/ arrangements	Barriers & limiting factors	Good Practice examples	Who pays for the NbS?
Polycentric financing	Sectoral siloes and 'silo budgeting' (Bernardi et al., 2019) Awareness needs to be raised among public authorities of the benefits of NbS in order to convince them to fund from their public budget (Drayson, 2014). Budgets of departments who are most suitable for NbS, for example health and education, are often also quite limited (Drayson, 2014). The pressure on public finances is intense with often limited municipal spending autonomy on budgets (Toxopeus and Polzin, 2021) and the incapacity to co-finance NbS (Bernardi et al., 2019). The challenges facing public finances are compounded by the long-term nature of most NbS, which are often then difficult to sell politically (Coelho, Ratnoo, and Dellepiane, 2014).	**Natural playgrounds in Poznań (Poland)** The recognition of the co-benefits of NbS allowed for the facilitation of co-financing nature-oriented playgrounds, implemented by the Department of Education of Poznań City Hall and the Poznań Civil Budget (Collier et al., 2023). Each year the renovation of up to 10 pre-school gardens is funded by the Department of Education (Trinomics & IUCN, 2019). There are currently 46 kindergartens with eco-demonstrators (e.g., insect houses, garden wooden pots/flower beds filled with compost soil for planting, live willow huts) that also include ecological education classes and 21 nature-oriented playgrounds in kindergartens (Collier et al., 2023). **Isar-Plan, Munich (Germany)** The Isar-Plan project was launched in 1995 by the State Office of Water Management Munich and the City of Munich to improve flood control, biodiversity, and recreational quality by redesigning the riverbanks to give them a more natural character. The total budget was 35 million euros, which was financed by a Bavarian scheme for big water sources, shared by the Bavarian State (55%) and the city of Munich (45%) (See case 3). **Green Exercise Partnership (Scotland)** The Green Exercise Partnership is a joint venture between the Forestry Commission Scotland, Scottish Natural Heritage and Health Scotland. Projects are funded by the partnership to demonstrate the health	State and municipal taxpayers

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		benefits that can be derived from investment and management of greenspace around hospitals and healthcare centres. They have included tree planting, pathway improvement and active woodland management in order to provide hospital staff, patients and local residents with areas in which they can exercise and spend time in nature (Forestry Commission Scotland, 2015). **Natural Choices for Health and Wellbeing, Liverpool (United Kingdom)** The Natural Choices for Health and Wellbeing is funded by the Liverpool Primary Care Trust (PCT). The aim of the programme is to increase engagement with the natural environment and to reduce inequality in health and wellbeing in the city of Liverpool. Those who live in disadvantaged areas lacking green space could apply for grants to improve their neighbourhoods, in order to increase wellbeing in these areas. In total, £380,000 was spent divided over 38 projects, with each project awarded between £1000 and £38,000. After the programme was completed, an evaluation study showed an increase in wellbeing up to 18 per cent in areas that had implemented green projects (Dryson, 2014; Wood et al., 2013).	
Participatory budgeting to allocate municipal budget	Areas need to have access to skills and methods related, in particular, to community engagement and business case development (Rutherfoord et al., 2013).	**Participatory budgeting in Chicago's 49th ward (United States)** The first participatory budgeting process in the US was launched in Chicago in 2009. Since then, every year each alderman in the city is allocated $1.3 million to spend on infrastructure improvements in their ward. The community members of the 49th ward can send in ideas for projects as well as vote on the final selected projects. Various green space projects have been implemented as a result of the participatory budgeting process, including a playground replacement, tree planting, path creation, and community gardens (Drayson, 2014).	Chicago taxpayers

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Green bonds	The establishment of green bonds can be a complex and long-term process, requiring knowledge of what is expected or valued by investors (Climate-ADAPT, 2016b). Due to the relatively recent development of green bonds, there is no single standard or certification process to obtain the label (Peterson et al., 2020). If the green bond is perceived as greenwashing projects the reputation of the issuer could be damaged (Doronz et al., 2011)	**Climate adaptation bonds, Paris (France)** In 2015 a climate bond was issued by the City of Paris to finance climate and energy projects. The bond was issued for €300 million with an annual interest rate of 1.75%. Two adaptation projects currently included in the bond involve planting 20,000 trees and creating 30 hectares of park. The objective of both adaptation projects is to reduce the urban heat island effect and increase thermal comfort within the city (Climate-ADAPT, 2016d). **Central Arkansas Water (CAW) green bond protecting watershed forest (United States)** In 2020, CAW, the local water utility in Arkansas, posted a $31.8 billion bond. The bond is certified under the Climate Bond Initiative and aims to enhance clean drinking water services (Brears, 2022). Proceeds from the green bond will be used to finance the costs of design, construction, property acquisition, and other expenses for eligible green projects. CAW earmarked 35% of the green bond proceeds to support nature-based filtration services (Central Arkansas Water, n.d.).	Present and future taxpayers
European Union grant funding	Regarding Horizon 2020, only suitable for projects with an innovation or research focus (Trinomics & IUCN, 2019). Calls for proposals are highly competitive. Only a few projects per priority area receive funding each year (Trinomics & IUCN, 2019).	**GrowGreen project, Wroclaw (Poland)** The GrowGreen project, which is financed by Horizon 2020 with matching funds from the Wroclaw municipality, focusses on developing NbS to meet the city's development challenges, including pluvial flooding, heat island effect and air quality. NbS include but are not limited to rain gardens, flower beds, and the integration of trees in public places (MCR2030, 2022). **Bratislava is preparing for climate change, Bratislava (Slovakia)** *Bratislava is preparing for climate change* is a projectthat aims to enhance the resilience of the city to the impacts of climate change, with a focus on intense rainfall and urban heat island effect. Measures include tree planting, green roofs and rainwater retention facilities. 85% of the	Member state contributions and municipal taxpayers

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		€3.3 million project is funded by EEA and Norway Grants. The remaining 15% is funded by the city office and two participating city districts (Climate-ADAPT, 2016c). **Adapting Park Serra Do Porto to Climate Change (Portugal)** The main objective of the project is to make the park more resilient to the impacts of climate change, especially increased temperatures and heatwaves, and increased extreme precipitation events. The aim is to diversify forest land together with nature-based solutions directed at water retention, soil improvement and erosion control. Total costs are estimated over €3 million, with a total of €2 million funded by LIFE (European Commission, n.d.).	
Community asset transfer	The administrative costs of such transfers may be high (Drayson, 2014). The community organisation receiving the transfer may lack, over the long term, the expertise and staff required to manage the site in such a way that it delivers the intended benefits (Trinomics & IUCN, 2019).	**The Bristol Community Asset Transfer, Bristol (United Kingdom)** Through the Bristol Community Asset Transfer leases for 150-publicy owned properties are provided to various voluntary and community organization, at a reduced or zero cost. In order to show eligibility for a lease, plans for the properties must generate social, economic or environmental benefits. The asset transfer can take multiple forms, such as management agreement, license to occupy, short lease or long lease (Interlace Hub, n.d.-b).	Bristol taxpayers
Loans from the European Investment Bank	The NCFF targets projects of at least €2 million, hence it is not suitable for smaller-scale interventions (European Investment Bank, n.d.). There is a risk that the beneficiaries will be unable to make regular repayments on the loan. (EIB, 2023)	**Athens Resilient City and Natural Capital, Athens (Greece)** The European Investment Bank provided a €55 million loan to the City of Athens to support investments in transport, waste, energy efficiency, culture and urban rehabilitation schemes across Athens. Regarding NbS, investments in improving green and water related infrastructure totalling €5 million will be provided under the new financing programme (Willis, 2018). Restoring peatlands and boreal forest (Finland)	

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		In 2017 the Landscape Rewilding Program was initiated by Snowchange, a non-profit co-operative. The program aims to purchase, secure and restore new peatlands and forest pilot sites, including the lake Kuivasjärvi catchment area in western Finland (Rewilding Europe, 2022). Rewilding Europe Capital (REC) provides a commercial loan to the restoration of ecosystem project, backed by the Natural Capital Financing Facility (NCFF), an initiative of the European Investment Bank and the European Commission (Rewilding Europe, 2019). **Alzette River Renaturalisation (Luxembourg)** The restoration works of the Alzette River include renaturalisation along a 20km stretch of the river between Luxembourg City and Mersch. By re-establishing natural conditions the project aims to reduce flood risk, improve water quality and enhance biodiversity. The State of Luxembourg received a loan of €9 million by the European Investment Bank, granted under the NCFF, to fund the project (European Investment Bank, 2017).	
Loans from public development banks	If the additional risk to development banks (compared to purely commercial banks) is not accurately compensated or priced the development bank may face long-term losses (Griffith-Jones, 2022).	**Making Bolivia Resilient to Climate Change (Bolivia)** Bolivia is predicted to experience increasing floods and droughts in the future because of climate change. To build resilience to these risks, the Government of Bolivia sought support from the Inter-American Development Bank in 2017 to implement projects to mitigate climate-related hazards, including reforestation and riparian stabilization. In total a €40 million loan was provided by the Inter-American Development Bank (Olivier et al., 2021). **Vihn River Rehabilitation Project (Vietnam)** In 2021, the Vietnamese government, with the support of the World Bank, initiated the Vinh City Priority Infrastructure and Urban Resilience Development Project (VPIUR) (Urban Nature Atlas, 2023). The project aims to implements a range of structural and non-structural	Bolivian taxpayers

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		interventions, including flood control systems and NbS, to combat flood risk and developed green public spaces along the Vihn riverbank. The World Bank provided a loan of $130 million, with counterpart funding totalling $65 million (The World Bank, 2022).	
Tax rebates	Monitoring is required to ensure that those receiving the rebate are indeed contributing to NbS (Trinomics & IUCN, 2019). Involves administrative costs (Trinomics & IUCN, 2019).	**Natura 2000 Management Agreements (France)** Management agreements are one example of contractual tools linked to Natura 2000 sites that have been introduced in France to incentivise biodiversity conservation. Landowners who commit to these agreements can benefit from various tax reliefs, including an exemption from property tax for undeveloped property on Natura 2000 sites, reduction of inheritance tax if the recipient enters an 18-year management agreement conforming to the site objectives, and reduction of income tax for Natura 2000 management. The national government pays a yearly compensation to local authorities to account for the loss of earnings due to, for example, the unbuilt property tax exemption (Kettunen & Illes, 2017).	French taxpayers
Public budget pays for private provision of ecosystem services (PES)	Transaction costs (project design, distribution of funds, monitoring and reporting are often relatively high (Hein et al., 2013) PES mechanisms are often not well aligned with the supply of multiple services by NbS (Hein & van der Meer, 2012).	**England Woodland Creation Offer (United Kingdom)** Landowner, land managers, and public bodies who have full management control of the land are remunerated to create new woodland. Addition contributions can be claimed if the woodland's location and design deliver public benefits such as the reduction of flood risk and providing access to woodlands for the public to enjoy. Grants are administered by the Forestry Commission (Forest Commission, 2021).	UK taxpayers

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3.2 Public financing and/or funding supplemented by user fees

A *user fee* is a charge, tariff or tax imposed by the public authorities to cover the cost of providing public goods and services. One form of a user fee is a betterment levy, a tax the state collects on property or land that the state has somehow improved. The idea is to directly raise financing, not from taxpayers, but from the people who benefit. User fees have been extensively used to provide grey infrastructure, for instance, highway tolls or parking garage fees. In the case of NbS, a user fee is akin to a payment for an ecosystem service. Although by no means exhaustive, different ways users can contribute to nature-based solutions are described in Table 3(b) and include charges on healthcare budgets, wastewater emitters, users of urban plots, water users, and urban park users. In all cases, the public sector plays a significant role in the financial arrangements.

As another instrument, the public authorities can grant easements to use public land for NbS. An easement is the right to use someone else's land for a specified purpose. A recent recommendation by the EIB encourages the acquisition/resale of public land to create easements for nature-based projects and the establishment of land trusts and/or nature restoration developers (EIB, 2023, p.4). An example is the Pla Buits scheme in Barcelona, where the City Council allows public entities or non-profit associations to develop temporary uses and activities on small plots of unused public land.

One case from Table 3(b) deserves special mention, the **Copenhagen Cloudburst Plan,** given its potential as a replicable good practice example. This case illustrates how public utilities can be enabled to charge user fees (water tariffs) for the purpose of investing in NbS.

While these financing mechanisms can contribute to NbS, many associated barriers can make them difficult to implement. Betterment levies and utility fees face the challenge of accurately calculating the project costs to recover (Infrastructure Victoria, 2016; Trinomics & IUCN, 2019). Furthermore, user fees and taxes may be met with public resistance, while betterment levies can lead to gentrification if poorer individuals are priced out of the neighbourhood (Infrastructure Victoria, 2016; Mullin et al., 2019).

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Good practice case 9: The Copenhagen Cloudburst Plan

As described in Table 3(b), the City's Cloudburst Management Plan was empowered by a 2013 revision of the water sector law that enables corporatized utilities to co-finance privately and municipally owned projects using water tariffs. This enabled the utility to invest in NbS and cover its costs with user fees. In its recent report, the EIB (2023, p.4) flagged utilities as being well-positioned to allocate capital to NbS:

"Under the right conditions, public utilities (especially water utilities) and corporations would be well positioned to allocate capital to nature-based solutions. In most cases, their incentives align, as they have long investment timeframes in their core business and significant amounts of capital to deploy. Direct land ownership or significant influence over land would enable them to operate directly in the target areas. Importantly, the adoption of nature-based solutions can be justified through alignment with their long-term strategic considerations, for instance, resilient supply chains reliant on natural systems or a social licence to operate and their capacity to leverage customers' ability and willingness to pay on a regulatory or voluntary basis."

This example illustrates the importance of institutional change, in this case, changing legislation to enable NbS. It also illustrates the potential of positioning utilities to invest in NbS.

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Table 3(b) Public NbS financing/funding supplemented by user fees/taxes (8 cases)

Type of instrument	Barriers & limiting factors	Good practice example	Who pays for the NbS?
Public grant matched by user fees		**Food for Good, Utrecht (Netherlands)** "Food for Good" is an urban vegetable garden project that supports and connects vulnerable people from different backgrounds, such as refugees, the elderly and disabled people. The urban gardens receive income from the healthcare budgets of the people who use the service, in exchange for providing activities and day care. In addition, the garden receives support from the municipality in the form of a 1-year urban agriculture grant and the allocation of land (Toxopeus, 2019).	Utrecht taxpayers and user fees
EU funds and earmarked wastewater taxes	The competence of municipalities regarding taxes is usually limited (Trinomics & IUCN, 2019). Tax revenues may compete with other projects requiring funding from local budgets if not raised specifically for NBS (Drayson, 2014). New taxes can be met with stakeholder resistance, especially since NBS often represent local public goods, benefitting some citizens groups more than others (Mullin et al., 2019).	**Renaturation of the Weser river coast, Bremen (Germany)** The renaturation of the right shore of the Weser river in Bremen-Hemelingen was planned and implemented as part of the project "Lebensader Weser" (WFD) on behalf of the Bremen Dike Association (Bremischen Deichverband), which is financed by the state of Bremen and Association fees paid by members. The project aimed to increase biodiversity, increase the river shore protection and water management. In addition, public access to the recreation area and the attractiveness of the river landscape were improved (Urban Nature Atlas, 2021a). The project was financed in equal parts from EU funds and the wastewater tax (Janz, 2012).	EU grant, members of the WFD association and residents/businesses paying wastewater taxes.

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Publicly provided land	Land uses are short-term solutions to funding as they draw on a finite source of resources (Mell, 2018).	**Pla Buits, Barcelona (Spain)** The Pla Buits scheme in Barcelona is a participatory intervention fostered by the City Council of Barcelona that gives the opportunity to public entities or non-profit associations to develop temporary uses and activities (1-3 years) on small plots of unused land. Most activities are social urban gardens (Toxopeus, 2019). The Barcelona City Council assumed part of the expenditure of adapting the plots and installing the necessary services. The rest was self-financed by the initiatives managing the plots (Interlace Hub, n.d. -b).	Barcelona taxpayers and users of the green plots
Utility fees	Accurate calculations of the tariffs are required in order to cover the cost of the project (Trinomics & IUCN, 2019).	**Cloudburst Plan, Copenhagen (Denmark)** The City of Copenhagen developed the Cloudburst Management Plan in 2012 to combat the impacts of extreme rainfall in the city. The strategy involves the repurposing of existing public spaces and parks to allow for water infiltration and retention using a blue-green approach. In 2013, national legislation of the water sector law was revised in order to enable corporatized utilities to co-finance privately and municipally owned projects using water-tariffs (Tubridy, 2021).	Municipal taxpayers and water users
Betterment levies	There is a risk of gentrification if the instrument leads to poorer individuals being priced out of a neighbourhood (Infrastructure Victoria, 2016). Appropriate percentage of project costs to recover, or the amount of value uplift to target, needs to be determined (Infrastructure Victoria, 2016).	**Melbourne Metropolitan Park Charge (Australia)** Every year the Melbourne Metropolitan Park Charge is collected. The funds raised go to Parks Victoria, Zoos Victoria, the Royal Botanic Gardens and the Shrine of Remembrance for the development, management and maintenance of these locations. The charge is determined by the valuation of the local council, which tries to capture the value Melbourne's parks provide to residents and businesses (Infrastructure Victoria, 2016).	Melbourne taxpayers and users of the park

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User fees	Revenues raised from events can be controversial as they can generate noise, litter, damage, and exclude local residents from all or part of the green space. Introducing new charges for existing facilities, for example parks, can raise strong public reaction (Drayson, 2014).	**Botanic Gardens and Parks Authority, Perth (Australia)** The Botanic Gardens and Parks Authority received 7% of their revenues from fees and user charges from events and functions in 2011-2012 (Searle, 2013). **Royal Botanic Gardens and Domain Trust, Sydney (Australia)** In 2011-2012, the Royal Botanic Gardens and Domain Trust got 12% of revenue from fees (Searle, 2013).	Perth and Sydney taxpayers and users of the parks

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3.3 Public financing and/or funding supplemented by philanthropy

Conservation philanthropy can be defined as voluntary contributions (e.g., cash, property, or time) to nature conservation (Ramutsindela et al., 2013). It can include foundations, environmental NGOs, private individuals, corporations, and other private sector actors, as well as crowdfunding. A recent editorial by Gruby and colleagues (Gruby et al., 2023) reported that the share of overall philanthropic donations to environmental causes remains small, estimated at around 3% of total giving in the United States and less than 2% in the European Union. At the same time, environmental philanthropy is among the fastest-growing philanthropic sectors, mainly focused on biodiversity conservation (Taylor & Blondell, 2023, as referenced by Gruby et al., 2023). Indeed, the current pace and scale of philanthrope are reportedly unprecedented (Beer, 2022). The Bezos Earth Fund committed $10 billion in 2020 to "nature" and "climate." Still, at least in the United States, small donors contribute significantly to philanthropic giving (Reich, 2020, p. 10), and crowdfunding is an increasingly important conservation finance mechanism (Takashina et al., 2023). The current increase in philanthropic support of nature "will have ripple effects throughout the funding 'ecosystem' for biodiversity conservation by supplementing, catalyzing, and influencing public sector spending" (Gruby et al., 2023, p. 1).

The different ways donors and volunteers can contribute to nature-based solutions are described in table 3(c), including cost-sharing arrangements between the public sector and non-profit organizations, as well as crowdfunding. In all the examples, the public sector plays a significant role in the financial arrangements. An example (good practice case 10) is tree planting in Sofia, Bulgaria, where over 60 thousand saplings have been planted by a coalition of volunteer organizations and private persons.

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Good practice case 10: Bottom-up urban forestation in Sofia, Bulgaria

To counteract significant air pollution in Bulgaria's capital, Sofia, the Coalition Sofia-Green Capital was initiated by a group of architects and 28 NGOs, community groups and industry associations in 2018. Since then, it has afforested over 225 acres of urban land since 2018. Forest areas are located in previously neglected urban areas bought by the Coalition and planted by volunteers. Through these areas, the project aims to create recreational space for the city's population. At the same time, it improves air and soil quality, restores habitats and biodiversity, reduces noise pollution, and sequesters carbon emissions. So far, over 60 thousand saplings have been planted (Urban Nature Atlas, 2022).

The Coalition is funded through donations and crowdfunding and executed and maintained through volunteer work and private-sector pro-bono services. The land is provided by the municipality, which also serves as a future management body for the afforested area. The NATURVATION project termed the initiative "an inspiring example of civic engagement and the variety of benefits provided by ecosystems in an urban environment" (Naturvation, 2023, p2).

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Multiple challenges should be considered regarding the funding of NbS supplemented by philanthropic contributions. Philanthropic donations are an unpredictable source of funding in the long term (Trinomics & IUCN, 2019). Furthermore, the social and spatial dimensions of philanthropic contributions may pose a limiting factor to NbS implementation. NbS projects in less affluent areas can receive fewer donations compared to NbS projects in more affluent areas, resulting in less funding by virtue of their geography (Drayson, 2014). Looking specifically at crowdfunding, financial resources are needed to develop and maintain the relevant platforms (Climate-ADAPT, 2016d).

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Table 3(c) Public NbS financing/funding supplemented by philanthropic donations (6 cases)

Financing instrument/ arrangement	Barriers & limiting factors	Case study example	Who pays for the NbS?
Public cost sharing with NGOs and donors	Most grants are awarded on a competitive basis (Trinomics & IUCN, 2019). Regional or national levels may themselves be facing diminishing resources for environmental spending (Trinomics & IUCN, 2019). Philanthropic contributions can be an unpredictable source of funding in the long term (Trinomics & IUCN, 2019). Because of their spatial character, projects in more deprived areas can receive fewer donations compared to projects which receive a greater number of potential donors (Drayson, 2014).	**WaterSMART Aquatic Ecosystem Restoration Projects (United States)** The Aquatic Ecosystem Restoration Projects is a competitive grant program that will provide funding for the study, design, and construction of aquatic ecosystem restoration and protection projects in western states. Projects must be likely to improve the health of fisheries, wildlife, or aquatic habitat, and applicants may apply for a federal cost share of up to 65% of total project costs. A sum of $250 million was provided for this program by the BIL (National Wildlife Federation, n.d.) which is a private, non-profit organization. **Baumstarke Stadt, Leipzig (Germany)** Through a cooperation between the municipality and the NGO Ökolöwe the Straβenbaumkonzept was developed. Citizens and residents can contribute to the funding of street trees with a minimum donation of €250 (Wolff et al., n.d.). However, public funding and strong involvement of the NG O are still needed to administer the program (Toxopeus, 2019). **Central Park Conservancy, New York (United States)** The Central Park Conservancy acts as the stewards of Central Park, raising funds to cover its management costs. The more than 18,000 trees in the park improve air quality, reduce the urban heat island effect and provide urban habitat for wildlife (Sain-Baird, 2017). The Conservancy is funded primary by individual donations (Central Park Conservancy, n.d.).	NYC taxpayers and supporters of non-profit organizations Leipzig taxpayers; NGO donors; individual donors NYC taxpayers; individual donors; NGO donors

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		Armenia Tree Project, Armenia In 1994 the Armenia Tree Project (ATP) was founded. Trees are planted annually by ATP, volunteers and NGOs in the cities and rural areas of Armenia. The aim of planting trees is to improve air quality and reduce the urban heat island effect. In addition to greening areas, ATP aims to create a stronger bond between inhabitants and the land they live on (Urban Nature Atlas, 2022). In 2020, donations constituted 43% of the €2.5 million revenue (Armenia Tree Project, 2020).	Armenian taxpayers; NGO donors; corporate donors; individual donors
Crowdfunding	A limiting factor of this type of instrument is financial resources needed to build and maintain crowdfunding platforms (Climate-ADAPT, 2016d). Crowdfunding can be an unpredictable source of funding for longer-term project (Trinomics & IUCN, 2019).	**City Forest initiative, Sofia (Bulgaria)** The City Forest project was initiated and implemented by the non-governmental organisation Grupa Grad in collaboration with the Sofia municipality and its active citizens. Planned as a community tree park, the project targets the sustainability challenge of air pollution in Sofia, and is expected to provide a place for recreation. The initiative relies on contributions from citizens, following crowd-funding principles (Naturvation, n.d.-a). **Crowdfunding voor Natuur (Netherlands)** In 2014 Crowdfunding voor Natuur was founded by IVN, Landschappen NL and Innovatie AGro & Natuur in collaboration with IVN. Individuals can start a campaign on the platform if the project is related to nature and biodiversity in the neighbourhood (Crowdfunding voor Natuur, n.d.-a). If the project is to be implemented in Gelderland the province will supplement the crowdfunding up to 60% of the funding goal, with a maximum of €5.000 (Crowdfunding voor Natuur, n.d.-b). If the project is to be implemented in Noord-Brabant the project has a chance to win a contribution to their crowdfunding goal up to €5.000 (Crowdfunding voor Natuur, n.d.-c).	Sofia taxpayer; individual donors Individual donors; ...

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3.4 Private financing and funding

The dearth of private investment in NbS may be changing. Interviews recently carried out by the European Investment Bank (EIB, 2023) consistently showed that interest in NbS is growing steadily among institutional investors - banks, insurance companies, asset managers (including pension funds) and multilateral development banks (e.g., the EIB and EBRD). The strategic declarations of large banks, insurers and asset owners confirm the intention of the private and public financial sectors to contribute an increasing amount of capital towards nature-based solution investments. In principle, financial institutions can support NbS projects with market-rate and concessional loans and equity. The latter are less commonly used given the risk-adjusted returns sought by most equity investors and the need for more scalability and liquidity of many investments in nature-based solutions. Although rare, public financial institutions, e.g., the EIB and EBRD, can support NbS with grants, which, of course, solves the 'bankability' issue. Grants can also be a part of ESG investing, and a case of an insurance company providing grant funding for a rainforest is documented in section 4.

To meet the $700 billion financing gap for nature over the next decade, most observers agree that public investments will need to mobilise private sector finance. According to Marsh McLennan "In 2019, private capital accounted for just 14% of total investment in nature-based solutions, but the majority (56%) of climate finance flows. A growing understanding of the interplay between business and nature will likely be accompanied by increasing interest from private investors" (Marsh McLennan, 2022, p. 14). Despite the optimism, the intention of financial institutions to provide financial and other support for NbS is challenged by the bankability of projects. The majority of EIB's interviewed project managers reported struggling to develop nature-related business models and generate revenue flows and failing to meet the requirements of financial institutions in providing loans or equity. Most nature-based projects analysed by the EIB did not incorporate bankability assessments in their project plans.

A primary reason for the non-bankability of NbS investments is that many, if not most, NbS are public goods, meaning they offer non-excludable benefits and co-benefits and thus do not generate cash flows. This means many of nature's benefits currently have no capturable financial market value. The problem for private investment thus goes beyond estimating the social, ecological and economic benefits and co-benefits of NbS. It lies more in the inability to capture a revenue stream. Despite this fundamental challenge, the EIB (2023) notes that in the policy discourse, there has been little discussion about the near-intractable difficulties of private investment in public goods, which reduces and even eliminates the incentive for the private sector to invest. At the same time, according to the EIB: "If the necessary conditions can be established, nature-based solutions could represent an opportunity for private sector investment in the pursuit of sources of revenue that would bring the benefits of increased resilience and lower costs."

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What are the necessary conditions? According to the EIB, private sector investment to generate a return will require one or more of the following:

- **"A change in market structures,** including regulatory interventions to provide direct incentives for private entities to either deploy nature-based solutions or to reduce the environmental impact of their economic activities;
- **The development of private markets for public goods,** such as extending carbon credit markets to cover biodiversity enhancement or pollution abatement, acknowledging the significant challenges in defining such certificates/credits and administering such markets;
- **Co-financing,** to blend public funds for the public benefits and private funds for the private benefits of investments in nature-based solutions." (p. 5)

In Table 3(d), we illustrate these conditions with cases of private investment in the absence of public support. We see one case of investment motivated by a revenue stream, beekeeping at the Hungarian Audi plant, and two cases spurred by public regulation that require offsets and that motivate trading credits in stormwater management. One NbS case reports on a condition set by the municipality for NbS by a commercial developer bundled with the sale of municipal property. Also included is a case illustrating an instance of private investors reaping benefits from reducing flood risks to their properties.

The extension of carbon credit markets, as well as the potential establishment of biodiversity offset regulations, deserve special attention as much-discussed measures for monetarising otherwise non-monetised NbS benefits. Good practice case 11, the Livelihood-Yagasu project, is partly financed with carbon offtakes from 12 different carbon investors to fund mangrove forests along with other livelihood-generating activities.

The World Economic Forum estimates that nature-based solutions can provide up to 30% of the mitigation needed to limit global warming to 1.5°C above pre-industrial levels by 2030; yet, in the last three years, only 1.2% of the annual cost-effective potential of NbS has been unlocked by the voluntary carbon market (Moore et al., 2023). Still, global carbon credit markets, both regulated and voluntary, are offering significant incentives to governments and the private sector to invest in nature. The market value of global regulated carbon credits traded in 2021 was approximately USD 851 billion, a 164% increase compared to 2020 due to higher carbon prices and a modest volume surge. The voluntary market size is currently estimated at USD 1 billion, with significant potential to grow over the next decades as the world transitions to a low-carbon economy (Moore et al., 2023).

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Good practice case 11: The Livelihoods-Yagasu project

Mangrove forests in the Sumatra region of Indonesia are essential for coastal protection during extreme weather events, yet they have been devastated by intensive aquaculture and palm oil production. The ongoing Livelihoods-Yagasu project aims to restore and protect mangroves and build a coastal "greenbelt corridor" that combines mangroves with forests and fruit trees along the Indonesian coastline and, at the same time, promote income-generating activities. The project works hand in hand with local communities to protect local ecosystems and develop additional livelihoods, focusing on the economic development of vulnerable groups, women and youth.

Yagasu's activities are financed through carbon finance in the form of both pre-financing (upfront investment at the start of the project - approximately USD 3,000 per ha)) and carbon offtakes (payment for carbon credits delivered throughout the project's lifetime) from 12 different carbon investors with varying investment terms. Yagasu also receives grant funding from public funders to implement adaptation activities. Upfront investments provided by carbon investors finance mangrove planting and restoration projects as well as livelihood activities, including supporting women-led enterprises and generating additional livelihoods.

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Despite good practice examples, carbon markets have been criticised for lacking transparency, accessibility, equitability and quality (Cheikosman et al., 2023). They also remain underused and fragmented. An investigation by the Guardian found that only a few rainforest carbon offsetting projects by Verra, the world's leading carbon standard, showed evidence for reforestation reduction (Greenfield, 2023). A study by West et al. (2023) found similar results for carbon offsets for REDD+ projects. Similar to other voluntary and regulated offset programmes, accurate monitoring and reporting is a prerequisite to guarantee the quality of the environmental and climate benefits being sold (Illes et al., 2017). There is some optimism that new approaches and emerging technologies, for example, blockchain carbon credits, may expand the reach, credibility and scalability of carbon markets. However, significant challenges still must be addressed (Cheikosman et al., 2023).

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The development of carbon credit markets provides new markets for carbon insurance coverage. For example, the quality of carbon credits can vary significantly, and there is the risk that some lower-quality credits may be invalidated. There is also a physical risk of loss for some types of credits, for example, through wildfires destroying trees or mangroves being destroyed by severe storms. Insurance against these events is an area of increasing interest for both existing insurers and new startups in this space. Opportunities for insurers will be discussed in more detail in section 4.

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Table 3(d) Private NbS financing/funding (10 cases)

Financing instrument/ arrangement	Barriers & limiting factors	Case study example	Who pays for the NbS?
Business financing without public support	Only limited budget may be available. Incentive to invest in NbS may be lacking	**Beekeeping at Audi plant, Győr (Hungary)** The Audi beekeeping project is a medium-scale intervention financed mainly from the local Audi budget. The project was set up within the factory grounds in 2015. It integrated biodiversity preservation efforts, environmental education and pollution biomonitoring. Furthermore, a total of 200-240 kilograms of honey are produced each year, which are either gifted to visitors or sold in the gift shop. The generated income is used for nature conservation programmes (Naturvation, n.d.-b).	Enterprise (shareholders?) and product (honey) purchasers
Credit trading schemes (public regulation)	This kind of mechanism may be slow to take off as result of uncertainty regarding the value of credits at the beginning (Spector, 2016).	**Stormwater Retention Credit Trading Program, Washington (United States)** In 2013, the District Department of Energy and Environment created retention credits to accelerate the development of green infrastructure in the city. The credits are available to homeowners, churches, business, and landowners whose land can be upgraded to retain more rainwater. Developers can purchase credits from other actors in the city who expanded their retention capacity if they meet 50% of their water retention requirements. This gives developers some flexibility to meet the regulatory requirements, and incentivises unregulated properties to install green infrastructure in order to generate and subsequently sell credits (Spector, 2016).	Developers and property owners
Carbon credit market (voluntary and regulated)		**Peatland restoration and management (United Kingdom)** In 2017, The Peatland Code was established in the United Kingdom (Tanneberger, 2020). The majority of peatlands in the United Kingdom no longer store carbon and have become a source of greenhouse gases. Restoring and preventing further damage to peatlands can play a significant role in climate mitigation. The Peatland Code aims to unlock private financing of peatland restoration through carbon finance. Funding obtained from the sale of carbon credits can be supplemented by traditional	Carbon credit buyers?

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		public sources of funding to enhance peatland restoration and conservation over long time horizons (National Committee United Kingdom, n.d.). **Regenerating mangroves (Philippines)** The Restoration Insurance Service Company (RISCO), has initiated a pilot project to protect and restore mangrove forests in the Philippines. The pilot will target 3,400 ha of mangrove forest to be conserved and 600 ha to be restored. The pilot is estimated to avoid and sequester 600,000 tonnes of CO2 emissions over ten years. Revenue streams are created by monetizing climate mitigation value of mangroves through blue carbon credits and by incorporating mangroves risk reduction values into insurance product pricing (Conway and Mazza, 2019). See good practice case 23	Carbon credit buyers?
Sale of development rights and leases	Only applicable when the project creates opportunities to commercialise the use of government land or other assets (Infrastructure Victoria, 2016).	**ACROS Fukuoka Prefectural international Hall Step Garden, Fukuoka (Japan)** In 1990, Fukuoka City was in need of a new government building. The chosen site, owned by the city, would be leased to a commercial developer for sixty years who would construct the building. Awarded the commission, architect Emilio Ambasz designed and developed the building into which the green rooftop was integrated (Greenroofs, n.d.). The rooftop green area extends for 5,400 square meter and is open to the public (Urban Nature Atlas, 2021b). **Green-grey water infrastructure investments in Tacubaya, Mexico City (Mexico)** The Tacubaya neighbourhood in Mexico City faces the double risk of water insecurity exacerbated by urban vulnerability to flooding, with few safeguards in place to protect infrastructure. To finance infrastructure upgrades the Sistema de Acción por Cooperación (SAC) was established. NbS elements included in the water infrastructure upgrades are rain gardens, bioswales, green roofs and bioretention lagoons. The majority of the funding for infrastructure investments comes from the sale of buildings rights within its jurisdiction (Marsters, 2021).	Commercial developer with costs passed on to the government who leases the building?
Voluntary offsets	The success of projects depends on the effort of companies to commit to these schemes.	**Green Area Inner-city Agreement (GAIA), Bologna (Italy)** The GAIA project allows businesses to calculate their carbon footprint and voluntarily compensate for this footprint by making donations towards tree planting. The	Businesses and LIFE?

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		financial compensation is used to purchase the plants and maintain trees throughout the city. For the initial phase of the GAIA project approximately half of the budget was provided by LIFE (Climate-ADAPT, 2016e).	
Offsets (public regulation)	Requires accurate quantification of how much compensation of required (Illes et al., 2017). Monitoring and reporting are needed to ensure compliance with the offsetting requirements (Illes et al., 2017).	**Naturcent program, Hamburg (Germany)** The Naturcent program was set up by the municipality of Hamburg in 2017 to enhance ecological and recreational value of green areas in the city, while at the same time ambitious building plans are in place (10,000 houses a year to keep housing affordable). The program is funded by an additional land taxation income from real estate development in the areas that are designated as landscape protection areas to reinvest in the development of green spaces (Toxopeus, 2019).	Real estate developers who may pass on charges to home purchasers
Regulated development via public land ownership	Difficulties in administering and monitoring, e.g., to control for greenwashing	**Parc Marianne Ecodistrict, Montpellier (France)** The Parc Marianne Ecodistrict was built between 2010 and 2018 as part of a larger new-district development. NbS integrated in the district include community gardens and allotments, green areas for water management and grey infrastructure featuring vegetation. The project was financed though developers buying parcels of municipality-owned land (Naturvation, n.d.-c). The land was sold to developers investing in urban development. The pre-set requirements, including environmental and social sustainability criteria, had to be fulfilled by the developers. The developers' investment will presumably be paid back by private persons purchasing the apartments. (Or are the NbS funded by the revenues from the land sales? This is unclear.	Developers and purchasers of apartments?

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3.5 Hybrid-blended financing/funding

In its review of over 1300 successful NbS cases, the EIB (2023) found that many were financed with a combination of instruments. "Instead of a one-size-fits-all instrument for nature-based solutions, successful case studies show that tailored structures, combining different funding, financing and revenue streams for various operations, are the most effective strategy" (EIB, 2023, p.4).

We have identified seven cases shown in table 3(d) to illustrate those that are especially hybrid by combining private and public sources. They include business-as-usual mechanisms such as public subsidies or grants to private investors as a way of sharing costs. In fact, alongside direct public funding, the EIB identifies grants as the most common public tool to cover revenue shortfalls. As our case shows, grants can be offered with conditions to encourage revenue-generating nature-based projects. They can also be used to enable public-private partnership, as we see in the case of the Atlantis Water Fund Pilot project in Cape Town. In other words, grants (and equity) can unlock multiple revenue and benefit streams. As a good practice case, the Environmental Protection Agency capitalizes state infrastructure programs (sometimes called state infrastructure banks) that provide revolving low-interest loans to water quality activities with an emphasis on NbS (good practice case 12). This might be a replicable case for the European Union by capitalizing 'NbS' banks that could be set up by member states.

Good practice case 12: The U.S. Clean Water State Revolving Fund (CWSRF)

Under the CWSRF, the Environmental Protection Agency (EPA) provides grants to states to capitalize their CWSRF loan programs. The states contribute an additional 20 per cent to match the federal grants. The state programs function like environmental infrastructure banks by providing low-interest loans to eligible recipients for water infrastructure projects, emphasising NbS. The loans are revolving in that as they are paid back, the state makes new loans to other recipients for high-priority water quality activities.

Under the CWSRF, states may provide various types of assistance, including loans, subsidies, grants, principal forgiveness, refinancing, purchasing, or guaranteeing local debt and purchasing bond insurance. States have the flexibility to target financial resources to their specific community and environmental needs, for instance, customizing loan terms to meet the needs of small and disadvantaged communities. Through the Green Project Reserve, the CWSRFs target critical green infrastructure, water and energy efficiency improvements, and other environmentally innovative activities (CWSRF, 2015)

This case raises the question of whether a similar model for an NbS infrastructure bank could be considered for the European Union, where the EC capitalizes NbS banks in the member states.

Table 3(d) illustrates other novel public-private arrangements financed with trusts, environmental impact bonds, equity investing and insurance-based finance. Marsh McLennan (2022) reports on innovative financial instruments such as venture funds specifically focused on biodiversity and banks with funds targeted for natural capital. A global bank recently announced the launch of a blue impact bond targeting nature-based mitigation activities in coastal areas of Australia, and the Republic of Seychelles launched the world's first sovereign blue bond to support sustainable marine

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and fisheries projects in the country. The EIB (2023) views these hybrid arrangements as critically important for bringing the private sector to the table. In their recommendations, they suggest using multiple instruments and combining synergies between different providers. The EIB also suggests that together with the European Commission, they could facilitate closer collaboration with multiple entities in the Member States, private investors and NGOs to support the development of nature-based projects.

While hybrid financing aids the development of NbS by combining private and public funding streams, limiting factors must be considered. Even with public support, attracting capital from the private sector for public-private partnerships (PPP) will need to deliver an attractive return on investment (Trinomics & IUCN, 2019). Public subsidies, revolving loan funds and grants can assist in developing projects less attractive to the private sector in terms of revenues. However, only a limited amount of funds for NbS projects is often available. Both environmental impact bonds (EIBs) and insurance-based finance can be difficult to establish due to estimation uncertainties. (Gustafsson-Wright et al., 2015; Linnerooth-Bayer and Hochrainer-Stigler, 2015).

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Table 3(e) Hybrid and blended NbS financing/funding (10 cases)

Financing instrument/arrangement	Barriers & limiting factors	Case study example	Who pays for the NbS?
Public subsidies or grants to private investors	Municipalities have many competing demands and limited resources.	**Urban Forest Fund, Melbourne (Australia)** The Urban Forest Fund was launched in 2017 by the City of Melbourne to provide financial support to new greening projects on private property. Such projects include NbS such as green roofs, green walls or facades, green areas for water management and tree planting (City of Melbourne, n.d.). Private actors are offered a 50% subsidy on the greening costs, up to $500,000 (Lehner, 2020).	Municipal taxpayers and private property owners
Blended finance via a trust	Large upfront costs to set up the endowment (Mell, 2018). May cause public opposition if sale of land is required to help establish the endowment fund (Mell, 2018).	**Newcastle Park Trust, Newcastle (United Kingdom)** The Newcastle Park Trust was established by the Newcastle City Council as an independent charity trust, to care for parks and allotments in the city. The two key activities of the Trust include generating revenue by providing commercial activities and maintain and develop the Newcastle's parks (Toxopeus, 2019). The Council agreed to make a contribution to the Trust of £9.5 million to support the Trust. Some of these resources may be used to create an endowment fund (Newcastle City Council, 2017). Quito Water Fund, Quito (Ecuador) In 2000, the Fondo para la Protección del Agua (FONAG) water fund was established in Quito. The endowment fund was capitalized with an initial $20.000 investment from Quito's water utility (EPMAS) and $1000 from The Nature Conservancy (TNC). Furthermore, FONAG signed contracts requiring the watershed's diverse beneficiaries to make annual contributions. Over the course of 20 years the endowment grew from $21,000 to $21.5 million. Projects funded by the endowment include restoring 2,500 acres with native species to maintain and improve water quality (Marsters et al., 2021).	Municipal taxpayers, users of commercial park activities and contributors to endowment fund Contributors to endowment fund; watershed beneficiaries
Public Private Partnerships (PPP)	Only suitable for projects that deliver an attractive return to	**Atlantis Water Fund Pilot project, Cape Town (South-Africa)**	Private sector (mainly), public

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	a private entity (Trinomics & IUCN, 2019). Coordination of partners requires alignment of developmental and business objectives (PPPLab Food & Water, n.d.).	The Greater Cape Town Water Fund is a public-private funding mechanism, working together with authorities, the private sector, NGOs and communities. The project seeks to increase water supply to Cape Town by the removal of invasive species in the Atlantis Aquifer catchment area, which use significantly more water than indigenous species. Funding is coming primarily from the private sector (Urban Nature Atlas, 2021c) **Public-private partnership for a flood-proof district, Bilbao (Spain)** To redevelop the Zorrotzaurre district into a flood-resilient area, a public-private partnership was established between landowners and the City Council of Bilboa. To protect Zorrotzaurre from flooding, the 7.5 km long riverbank will be converted into a 20-meter-wide public green space for pedestrians and bikers. The members of the public-private partnership pay for all the expenses of the project and contribute financially relative to the share of land they own (51% public, 49% private) (Climate-ADAPT, 2016f).	sector, NGOs, communities ??? Landowners and City Council (taxpayers)
Revolving loan funds and grants	In the case of CWSRF, green infrastructure projects may compete against other water quality-related projects for a limited pot of funds (Thompson, 2023).	**Clean Water State Revolving Fund (United States)** Using a combination of federal and state funds, state CWSRF programs provide low-interest loans for projects aimed at improving water quality. The Environmental Protection Agency (EPA) provides grants to the CWSRF loan programmes, while the states contribute an additional 20 percent to match the federal grants. Repayments of loan principal and interest earnings are recycled into the programmes, making the funds 'revolve' over time (EPA, 2023). The Green Infrastructure Policy, released in December of 2015, promotes CWSRF investment in green infrastructure projects and broadly encourages investment in sustainable infrastructure (EPA, n.d.).	Federal/state taxpayers with grants; municipal taxpayers or private Businesses pay back loans
Environmental Impact Bonds (EIBs) combined with grants	EIBs can be complex to establish. Outcome metrics and the costs and benefits of interventions need to be determined, which can result	**Norfolk Rivers Trust (United Kingdom)** The Norfolk Rivers Trust was awarded a grant of £70,000 to develop an Environmental Impact Bond (EIB) to finance the creation of NbS to reduce phosphates and other pollutants from entering the River Stiffkey. An EIB signals to impact investors that the issuer has market-leading ESG transparency and accountability in their bond. The	UK taxpayers for the grant; If project is launched: Private and corporate

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	in complex budget analytics (Gustafsson-Wright et al., 2015).	project will assess the potential for revenues in the form of phosphate credits and it will explore other ecosystem services for additional revenue sources (Norfolk Rivers Trust, n.d.). The Trust is a conservation charity funded by government bodies (local and national), private corporations, and independent donors.	donors to pay back bond; polluters via payments for ecosystem services
Resilience bond		**Forest Resilience Bond, California (United States)** In 2018, the Forest Resilience Bond was codeveloped by Blue Forest Conservation (BFC), World Resources Institute (WRI), Encourage Capital and the US Forest Service (USFS) to restore forests and reduce the risk of wildfire on public land. In the North Yuba River Watershed a pilot FRB was started as 15.000 acres in the watershed were facing a high risk of catastrophic wildfires, which would impact downstream water users such as the Yuba Water Agency. A cost-benefit analyses estimated $8.8 million in avoided costs with forest restoration treatments in the watershed. The Yuba Water Agency committed to pay $1.5 million over 5 years, with the addition of $2.6 million in grant funding committed by the State of California to repay investors. With this committed cash flow, the BFC secured two concessional loans (the Rockefeller Foundation and the Gordon and the Betty Moore Foundation) which in turn attracted two market rate investors (Calvert Impact Capital and AAA Insurance) (Marsters, 2021).	Californian taxpayers; watershed beneficiaries
Equity funds		**Ecodistrict Ulaanbaatar (Mongolia)** The Ulaanbaatar Green Affordable Housing and Resilient Urban Renewal Project (UHURP) aims to transform the highly climate-vulnerable traditional Mongolian ger areas into eco-districts that are low-carbon emitting, climate resilient and affordable (Green Climate Fund, 2018). The project is largely financed by a loan from the Asisn Development Bank to the Mongolian government. In addition, the Green Climate Fund (GFC) pledged to finance 25.4% of the project, in the form of a concessional loan and a grant (Green Climate Fund, n.d.). The Fund, in turn, is funded by commercial banks, finance institutions, equity funds institutions, United Nations agencies, and civil society organizations. The grant and loan will be combined with equity investments from real estate developers to cover the funding of the project (Green Climate Fund, 2018).	

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Insurance-based finance (Swiss Re)	Establishing long-term premium financing strategies	**Quintana Roo coral reef (Mexico)** In 2018 the Quintana Roos Government, in partnership with the Nature Conservancy, Comisiót Nacional de Áreas Naturales Protegidas, and hotel owners established trust funds in order to purchase the Coral Reef Insurance offered by Swiss-Re. Hurricane Delta, which hit the coast of Mexico in 2020, resulted in the world's first ever coral reef insurance payout, totaling $800,000, which was used to offset the costs of repairing the insured reefs (INAS, n.d.). More details on this case can be found in section 4.	Contributors to Nature Conservancy, taxpayers and hotel owners

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3.6 Summary and deliberations

Taking stock of over 50 cases of financing/funding for NbS shows a diverse range of financing and funding arrangements for implementing nature-based solutions. By far, the most dominant are publicly financed projects funded or paid for by local and national taxpayers and, in some cases, supplemented by users and donors. A good practice example is the polycentric arrangements of municipalities in Portugal to fund the Parque das Serras do Porto NbS project. Only one identified project is entirely private in generating a cash flow resulting in net benefits for the company. For the most part, private funding is motivated by regulations that require NbS as an addition to already bankable ventures, e.g., the greening of housing projects in return for public land leases or investing in carbon mitigation projects to offset commercially viable investments. It is notable that from the selected projects, more than half are fully funded by present and future taxpayers, and many more partially based on public budgets, including funding from the European Union. The others are funded by donors, carbon credit investors, businesses, consumers and beneficiaries.

A central message is that neither public budgets nor private investment, acting alone or possibly even together, will be capable of urgently closing the NbS financing gap. The European Investment Bank (EIB, 2023) recommends thus exploiting multiple synergistic financing instruments, such as grants, equity arrangements, land easements and the establishment of land trusts and nature-restoration developers. Likewise, a report from The Geneva Association (Golnaraghi & Mellot, 2022) emphasizes the need for public-private partnerships and opportunities, for example, with the insurance industry for risk assessment and risk management, as well as broader engagement with the private sector for co-financing and risk sharing.

Even with hybrid funding, a fundamental issue persists. Most NbS are public goods, which means that public-sector budgets will have to provide a large share of the funding. This can be in the form of public-private partnerships, public subsidies, revolving loan funds and grants to assist in developing projects that are less interesting to the private sector. In Europe, public funding can come from municipal budgets, national budgets or from the European Union, which is increasingly difficult in light of tightening austerity requirements following the large deficits from the pandemic.

It appears prudent that innovative funding sources, for example, equitable user fees and stepped-up philanthropic donations, are exploited outside of general taxes. The Copenhagen Cloudburst Management Plan could serve as a model for Member States to finance NbS with user fees imposed by public utilities. In Copenhagen, after revising the water law, corporatized utilities can legally co-finance privately and municipally owned projects with water tariffs. The EIB (2023) has flagged utilities as well-positioned to allocate capital to NbS. Moreover, philanthropic donations, although currently small, could be encouraged. An example is voluntary tree planting in Sofia, Bulgaria good practice case 10).

As discussed earlier (section 3.4) the EIB has put forth three conditions to increase private funding: regulatory interventions, extending carbon markets and blended finance. As discussed, blended finance will not avoid the issue of scarce public funds. Regulatory interventions are clearly

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needed. It seems evident that regulatory regimes across the EU will need strengthening so that private developers will be required to refrain from nature-negative land use and product development or carry out credible offsets that can finance innovative projects such as the Livelihoods-Yagasu project for planting Mangrove forests. The EU might also consider cross-NMO subsidies from the wealthier countries to those least able to invest in NbS. The U.S. Clean Water Revolving Fund, which is administered by the national Environmental Protection Agency, could serve as a role model for the European Union.

4. Insurance to enable nature-based solutions

As shown in figure 6, the (re)insurance business encompasses two pillars: underwriting and investing. As underwriters, insurers bear risks for other individuals and entities in exchange for a premium, ensuring stability and crisis recovery through risk transfer. The collected premiums from the underwriting business fuel the investment business, which consists of a broad portfolio of financial assets that can include bonds, stocks, currencies, cash and cash equivalents, and commodities. (Re)insurance companies rank among the largest institutional investors, including asset managers, banks and risk capital investors, giving them substantial power over allocating economic resources.

The insurance sector includes large insurance companies, reinsurance companies, and smaller companies with a network of providers and claims adjusters. It also includes brokerages, which are financial intermediaries who match retail clients, corporations and insurance companies with insurance or reinsurance providers. Brokers typically oversee the whole insurance process and provide risk engineering and prevention advice to the project rather than the insurance companies themselves. The largest insurance brokers, including Marsh McLennan, Aon, WTW and Arthur J. Gallagher, produce research and advice on climate and ESG risks, including, for instance, Aon's annual report on weather, climate and catastrophes (Aon, 2023), Marsh McLennan's ESG Risk Rating assessments (The ESG Risk Rating, 2023), and WTW Research Network's Annual Review (WTW 2023).

The core expertise of insurers is in assessing, modelling, quantifying, and pricing risks. This expertise provides them with a unique perspective on the systemic aspects of nature/biodiversity loss and its potential cascading effects on both their underwriting and investment businesses. As reported by the Geneva Association, some (re)insurers have already started on their journey to assess, understand and quantify the risks and opportunities related to nature-based systems through investing in research and development (Golnaraghi & Mellot, 2022). Their expertise provides them with opportunities to support NbS in a number of different ways, from incentivizing nature-positive behaviors from customers and clients, to facilitating capital flows to nature-positive projects (CISL 2022).

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As shown in figure 6, we have identified five interrelated ways insurance underwriters can enable NbS, as well as three ways the investment business can encourage a nature-positive economy. In what follows, we discuss each in turn and provide good practice examples of these activities. Our classification builds on previous work by both the Geneva Association and Climate Wise (Golnaraghi & Mellot, 2022; CISL 2022).

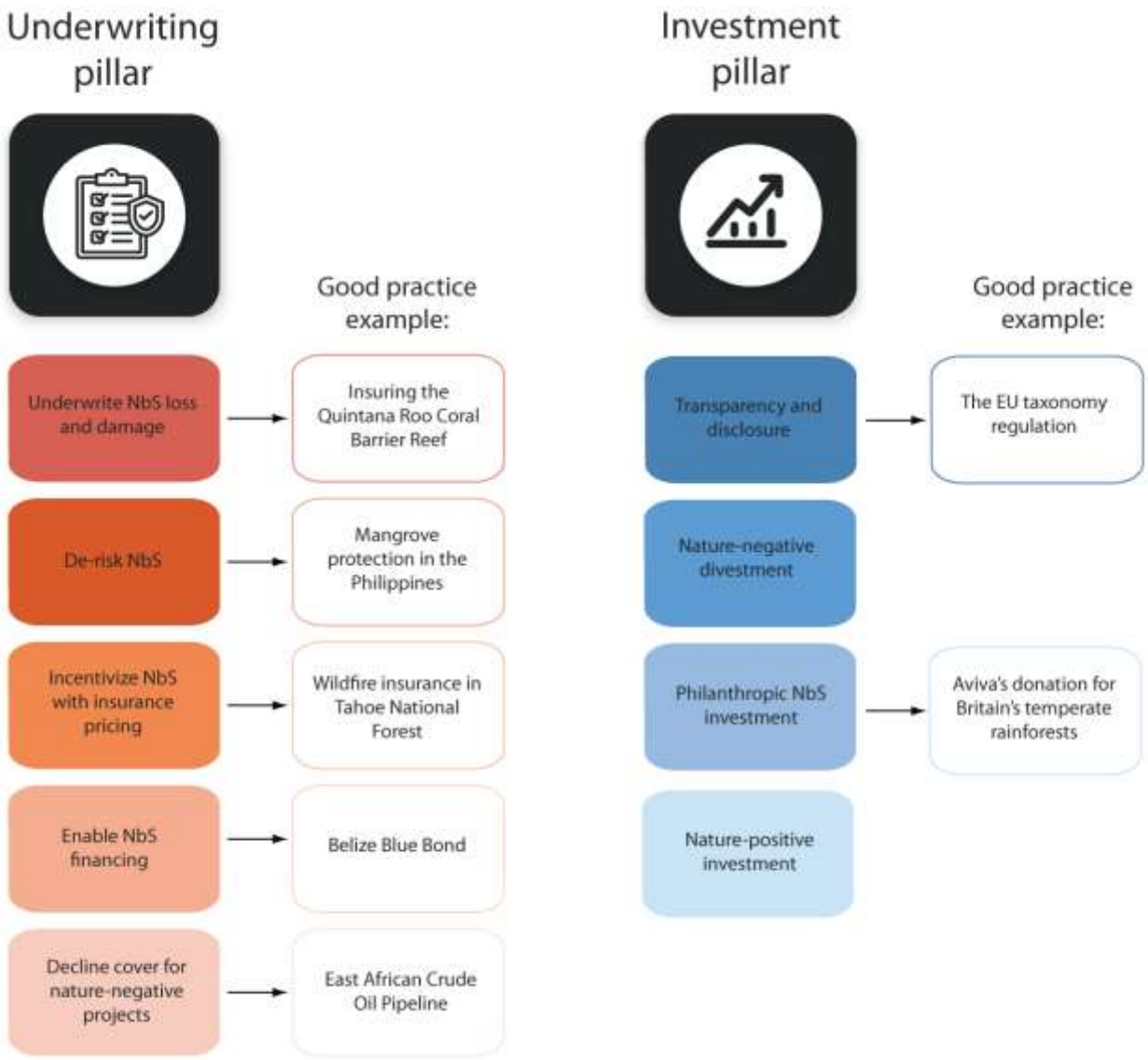

Figure 65: A classification of insurance activities that support nature-based solutions

4.1 Underwriting pillar

In the underwriting business, there are at least four types of insurance that are relevant for enabling nature-based solutions, each offered to individuals and organizations:

- *Property and casualty insurance* that covers mainly physical damages to property, operating losses, trade credit and liabilities during both the construction and operating phases,

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- *Agriculture insurance* that covers organic environments against specific weather perils, such as storms, droughts, typhoons, floods, fires, frosts and hail,
- *Environmental liability insurance* that protects against an infringement on third parties or public environments and
- *Engineering all risk insurance* that protects project construction against delays and disruptions.

In what follows, we focus mainly on property/casualty, environmental liability, and engineering all risk insurance. We describe how product lines and activities can enable the design, construction, implementation and operation of nature-based solutions. While other lines of business such as, motor, marine, aviation, and surety could potentially facilitate NbS (for details, see WWF and Deloitte, 2023), we focus on those lines that have made the most progress in this area. We then turn in section 4.2 to point out enablers and barriers of insurers' pro-NbS activities. In section 4.3, we discuss the consistencies and inconsistencies of pro-NbS activities with insurers' business models.

4.1.1 Underwrite NbS loss and damage

The core business of insurance underwriting is developing and marketing products to provide protection against the risks of external events that cause loss and damage to property and assets, including residential and commercial buildings, their contents, crops and timber, and public infrastructure. The market for insurance against all types of events causing loss and damage, especially (un)natural hazards, is vast. According to Swiss Re (2023), natural disasters resulted in global economic losses of USD 275 billion in 2022, of which USD 125 billion were covered by insurance. Losses are steadily rising due to increased exposure of assets, inflation, climate change and potentially biodiversity loss.

Insurers and brokers assess risks by estimating the probability of the event and the exposure and vulnerability of exposed assets. As loss events from natural hazards increase, insurers invest heavily in risk models that provide probabilistic estimates of losses, sometimes also taking into account climate scenarios. They protect themselves against the low-probability but extreme-loss events by diversifying their portfolios and reinsuring. Another hedging strategy for insurers and governments is to issue catastrophe bonds that transfer the risk directly to investors, that is, to broader and deeper capital markets that give investors, such as pension funds, hedge and mutual funds, an opportunity to earn a return on investment that is not correlated to stocks or bonds (Linnerooth-Bayer et al., 2019; Linnerooth-Bayer et al., 2015; Michel-Kerjan et al., 2012; Amendola et al., 2013). In 2021, catastrophe bond issuance hit a new record of US$12.8 billion, surpassing the previous annual record set in 2020 by US$1.5 billion, or 13 per cent growth (WWF & Deloitte, 2023).

In concept, the same business model can be extended to natural capital. For example, a green façade and its construction can, in principle, be insured against damage from strong winds, floods and other events if the probability of the event can be estimated and if the value and vulnerability of the green façade can be assessed. While the extension of the business model to the construction

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and operation of natural capital is in early stages, below we illustrate important pioneering products.

NbS construction insurance

Insurance is a near essential factor in enabling NbS construction and operation, although each presents different challenges. Construction insurance is a broad categorization of policies typically offered to developers, contractors, architects, engineers and handypersons. *Builders risk insurance,* also known as *course of construction* insurance or *construction all risk insurance*, is routinely required for buildings, infrastructure and other structures while under construction. The policies typically cover damage caused by fire, weather, vandalism, or theft and can be extended to cover additional risks such as flooding and winds. There are also construction liability insurance policies, which will be discussed in the next section.

Builders risk insurance is standard and routine, yet it is difficult to purchase for many types of NbS mainly because of the lack of NbS construction experience and confidence in the risk estimates. Two good-practice examples, insurance for the construction of sand dykes (Good practice case 13) and insurance for mass timber buildings (good practice case 14), illustrate novel initiatives insurers have taken in providing policies to enable the construction of NbS.

Insurers are also playing a role in enabling mass timber, sometimes referred to as engineered wood. This is a relatively new technology where wood products are glued, nailed, doweled and/or compressed together to create solid and loadbearing material. It offers an environmentally friendly NbS option for replacing carbon-intensive products such as concrete or steel and further enhances climate mitigation by storing carbon (Churkina et al., 2020).

Despite its advantages and growing experience, especially in North America, a barrier to constructing buildings with mass timber remains the affordability of insurance for both the construction phase and the life of the building. Indeed, the high insurance price has rendered it unaffordable in many instances. As one case in point, in Canada property insurance for mass timber buildings is seven to ten times higher than for concrete and masonry buildings (Came, 2022) despite growing evidence that the risks are comparable (Giddings, 2022). Insurers are concerned explicitly about fire, long-term moisture ingress or water damage, the durability of mass timber products, and the quality of design and construction. Because of the perceived risk wood products carry for fire and water damage, insurers continue to assess higher risk for underwriting purposes. Other contributing factors are the lack of performance data and certification. According to the Building Resilience Coalition, the problem is not the risk but the uncertainty or ambiguity stemming from the lack of experience (Came, 2022).

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Good practice case 13: Swiss Re insures construction of the Prince Hendrik Sand Dyke reinforcement

The Dutch Island of Texel is a World Heritage site renowned for its (most extensive worldwide) tidal flat system. It is currently protected by the Prince Hendrik Sand Dyke. Due to sea-level rise and erosion, the preexisting 17km dyke could no longer meet safety standards (Witteveen & Bos, 2023). To mitigate risks stemming from rising sea levels and to restore the natural dunes, five million cubic meters of sand from the North Sea were placed and planted with two million marram grasses that protect the dyke from erosion and create a natural habitat (Bechauf et al, 2021). This NbS, referred to as "duning", includes the restoration or construction of dunes instead of traditional 'grey' dyke construction (Frodeyn et al., 2019).

The project delivered an estimated one million EUR in benefits to fish production as well as benefits to climate regulation and water quality regulation (Swiss Re, 2020). In addition, the sand dunes will protect a flower bulb yield of (maximum) €21,447/ (ha/y) (Fordyen et al., 2019). The final cost of construction amounted to €23.9 million, with yearly maintenance costs of € 0.12 million and an estimated ecosystem service benefits per year of €0.84–1.67 million (Terra et Aqua, 2019).

This project is part of the Netherlands Coastline Care Programme. The tender was awarded and implemented by the Jan DeNul construction firm. Swiss Re Corporate Solutions supported the construction with a traditional Construction All Risk policy (Jan DeNul, 2023; Swiss Re, 2020). While insurance for constructing grey infrastructure is not new, Swiss Re has addressed complex challenges for grey-green infrastructures, which mostly revolve around the uncertainty of long-term performance. It is therefore necessary to adopt an adaptive management approach which includes the cycle of monitoring and evaluation of the installations and the modification of the project according to new insights (Green-Gray Community of Practice, 2020).

The concept of insurance is not new, nor is the need to protect our environment – the paradigm shift lies in our ability to merge the two concepts, and take action. (Swiss Re, 2020 p.2)

(c) B10m

However, in recent years, this issue has been addressed on multiple fronts, and a few insurers, like Zurich North America (good practice case 14), are offering products for their construction. In the United Kingdom, the Alliance for Sustainable Building Products (AFBP), partnering with multiple stakeholders, has published a "Playbook" for insuring mass timber. The solutions offered revolve around the early engagement and communication with insurance companies and brokers to co-design and include necessary changes to reduce real and perceived risk, the inclusion of second fire consultants, the encapsulation or filling of combustible voids, as well as fire suppression technologies such as glue-laminated or cross-laminated timber (AFBP, 2023)—the AFBP further calls

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for government-backed insurance like flood and terrorism policies in the UK. Significantly, the International Building Code 2021 (IBC) has been updated to include encapsulation and external charring for fire risk reduction. Still, as mass timber projects have proliferated, many developers, building owners, and contractors have found that insurance companies unfamiliar with these buildings are reluctant to provide insurance (Woodworks, 2023).

Good practice case 14: Zurich North America insures mass timber

Based on the International Building Code, and in response to the rapidly growing market, Zurich North America recently launched the Massive Timber Builders Risk proposition, deploying up to 50 million USD for "highly qualified risks" while continuing research into mass timber (Zurich North America, 2021). This insurance product offers coverage for commercial construction projects using mass timber products to "qualified customers" (Cision PR Newswire, 2021). The insurance product is tailored to cover a single construction project typically including property damage, theft, construction materials, delays in completion, natural hazards, among other risks. (Zurich North America, 2023).

(c) Province of British Columbia; 12-story mass timber building in the City of New Westminster (left); (c) David Baillot/Jacobs School of Engineering/University of California San Diego (right)

Property/casualty insurance

Investors will be reluctant to construct and maintain NbS without insuring the natural capital assets against loss and damage caused by storms and other extreme events as well as other causes of damage. It is becoming more apparent that natural disasters and pest infestations can damage or destroy forests, wetlands, coral reefs and mangroves. Coverage for project developers can include

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ecosystem restoration costs and carbon revenue loss protection for specified events. This can be especially important for enabling nature and climate offsets/credits to assure compensation and reconstruction if damage occurs. As mentioned above, a core business pillar of insurers is underwriting the risks of external events that cause loss and damage to property and assets.

A pioneering product developed by Swiss Re (good practice case 15) insures coral reefs against storm damage to provide post-disaster financing for their restoration. Coral reefs are essential marine ecosystems for maintaining biodiversity and providing ecosystem services for fisheries, tourism, and protecting shorelines from erosion and flooding (Reguero et al., 2018). A healthy reef can reduce up to 97% of wave energy (Ferrario et al., 2014). Indeed, reef protection and conservation can be a significantly lower cost option for protecting against storms and coastal erosion than building grey infrastructures such as sea walls, and one key component is restoration of coral reefs following damage from storms or other hazards (Ferrario et al., 2014).

4.1.2 De-risk NbS with liability insurance

Implementing NbS projects may result in adverse environmental or other impacts, including property damage and bodily harm. Planting non-native tree species may negatively impact freshwater availability, and, as another example, carrying out prescribed burns to mitigate wildfire risk may endanger assets and people. The risk of liability from mal- or under-performance of NbS during their construction and operation can be a serious inhibitor to their implementation. Indeed, municipalities and other NbS owners have expressed strong reservations about the safety and performance of NbS, mainly if they are meant to protect communities against landslides, floods and other disaster risks (Linnerooth-Bayer et al., 2023).

General liability insurance, sometimes called commercial general liability (CGL) or contractor general liability, is a class of insurance (usually required by law) that provides liability protection to businesses in the case of bodily harm or property damage during the course of business. Errors and omissions (E&O) insurance, also known as professional liability insurance, protects mainly against negligence in the construction and operation of projects by providing coverage for businesses against claims arising from errors or mistakes in their work, i.e., negligence. For example, suppose an engineer makes an error when calculating the structural requirements for a building, which later causes the owner to have to make costly repairs. The owner might sue the engineer to recover the costs in which case the engineer's E&O policy would, in most circumstances, cover the claim.

Environmental liability products can protect owners against financial consequences from environmental loss and damage by compensating third parties for property damage, clean-up costs, and natural resource damages. This protection can greatly facilitate investments in NbS, for example, by de-risking carbon offsets and wildfire mitigation. We discuss each below.

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Good practice case 15: Swiss Re insures the Quintana Roo coral reefs in Mexico

In 2018, Swiss Re offered an innovative insurance product to insure the Quintana Roo coral barrier reefs in Mexico against storm damage - the first natural ecosystem to be insured. The reefs span over 100 miles and are part of the Mesoamerican Barrier Reef. The Nature Conservancy (TNC) first conducted an economic risk analysis on storm damage in case of reef degradation. Swiss Re and stakeholders from the Cancun and Puerto Morelos Hotels' Association, and government actors were brought together to co-design the products. (Green Finance Institute, 2023).

The product is parametric, meaning claim payments are not based on assessed losses but are triggered when hurricane or storm wind speeds reach a certain level. Because coral reefs must be repaired quickly to mitigate damage, a parametric product was preffered, as the payments ideally allow the policyholder to repair the area's coral reef quickly (Martin, 2018). In a recent example, Hurricane Delta in 2020, a payment of 800,000 USD was released, and a team of approximately 80 persons was able to stabilize 1200 displaced coral colonies and transplant 9000 broken coral fragments within a week (Einhorn & Flavelle, 2020). However, the payment still faced delays, both at the insurance company and government levels.

The policyholder is the Coastal Zone Management Trust (CZMT), which is funded by the public hand, hotels and others in the tourism industry, as well as donations via TNC. It is thus a hybrid finance approach combining contributions from taxpayers, tourism businesses and philanthropic sources.

The MAR Fund, together with WTW, have since created a regional reef insurance product, covering sites in the four Mesoamerican Reef (MAR) countries of Mexico, Belize, Guatemala and Honduras. The scheme was set up with funding from the InsuResilience Solutions Fund, with the earlier support of the Government of Canada via ORRAA and is currently underwritten by AXA Climate. (MAR Fund, 2023; World Bank, 2022).

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<u>De-risking carbon offsets</u>

Regulated and voluntary carbon markets offer significant incentives to governments and the private sector to invest in nature. The market value of global regulated carbon credits traded in 2021 was

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approximately USD 851 billion, a 164% increase compared to 2020 due to higher carbon prices and a modest surge in volumes (Golnaraghi & Mellot, 2022). The voluntary market size is currently estimated at USD 1 billion, with significant potential to grow as the world transitions to a low-carbon economy (Blaufelder et al., 2021). However, as discussed in section 3.4, carbon trading is controversial. Despite good practice examples, carbon markets have come under heavy criticism for their lack of transparency, accessibility, equitability and quality (Cheikosman et al., 2023).

A significant impediment to carbon markets is the risk that they do not provide the claimed benefits of carbon sequestration. The quality of carbon credits can vary with the risk that some lower-quality credits may become invalid. There is also physical risk of loss for some types of credits, for example, through wildfires destroying trees or mangroves being destroyed by severe storms (good practice case 16). Insurance against these events is an area of increasing interest.

Good practice case 16: Insuring mangrove forests to increase resilience and generate carbon credit revenue streams

Mangroves are considered among the most important ecosystems for biodiversity and climate resilience of coastal communities, among the most carbon-dense ecosystems, and they are also considered to be one of the most threatened ecosystems (TNC, 2021; SwissRe, 2021). A feasibility study conducted by Beck et al. (2020b) finds mangrove insurance for public customers as the most feasible action, whereas insurance products for private customers, while possible, face challenges given the public-good nature of the mangrove forest benefits. Swiss Re, in partnership with Conservation International, is developing an insurance product much like the coral reef parametric insurance discussed above (good practice case 15) to strengthen mangrove conservation and restoration (The Nature Conservancy, 2020; Swiss Re, 2020a). The project is run as a social enterprise, the Restoration Insurance Service Company (RISCO), which will manage both the insurance-related payments and the blue carbon payments (SwissRe, 2023b). The product would cover the loss and damage to mangroves from unexpected natural and weather-related events that result in reduced carbon benefits, which may negate the need to set aside a portion of the buffer credits related to those specific risks (Golnaraghi & Mellot, 2022). Premiums would be partly paid with carbon credits and geared mainly towards public clients (Swiss Re, 2020).

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De-risking NbS for wildfire risk mitigation

Comprehensive liability insurance for NbS operations and performance can be challenging due to the lack of operating experience and data on NbS operational safety. This is especially the case for prescribed burns. Although the use of prescribed or controlled burns to mitigate wildfire risk is controversial, many experts agree that in certain conditions, they are effective for reducing fuel and thus reducing wildfire risk. Prescribed burns are the intentional application of fire to live or dead vegetation for wildfire risk management purposes. By mimicking natural fires, they can be very effective at reducing hazardous fuels and restoring ecological conditions. In other words, prescribed fire, many practitioners maintain, can be an effective NbS for mitigating wildfire risk although the practice in some contexts may have costs in terms of biodiversity.

There are also risks associated with their implementation. As extensively discussed by a recent report from the U.S. Wildland Fire Mitigation and Management Commission (WFMMC, 2023), practitioners of prescribed and cultural burns perceive and potentially face significant legal risk due to current U.S. liability laws, limited legal protections, and limited access to insurance (Clark et al., 2022; Huber-Stearns et al., 2023; Shively, 2022). Indeed, recent assessments indicate that fear of legal liability is a widely held concern among practitioners because of the potential for damages from an escaped burn or smoke (WFMMC, 2023, p 56). The report points out that practitioners consider the potential financial implications associated with prescribed fire liability and risk as a primary hurdle in the ability to scale up prescribed and cultural burns and that practitioners would increase their prescribed fire implementation if costs for insurance premiums and deductibles were reduced (Huber-Stearns et al., 2023). Although some pioneering products are entering the market (good practice case 17), the WFMMC recommends a national fund to supplement insurance.

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Good practice case 17: Insurance to cover liability for prescribed burns

In 2012, the Lower North Fork prescribed fire escaped southwest of Denver, Colorado, and destroyed 22 homes, burned 4,140 acres, and killed three local residents. Colorado's Department of Natural Resources conducted the prescribed fire. After it was revealed that the Department violated its policies while conducting the burn, that is, after establishing negligence, state lawmakers changed the immunity law, which had capped their liability at $600,000. The total compensation for the people affected by the fire was $18.1 million (Gabbert, 2014).

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While insurance to cover public liability may not be advisable if the risks can be spread across a large pool of taxpayers (Linnerooth-Bayer et al., 2019), land managers, contractors, landowners and prescribed burning service companies, among other private agents, are seriously constrained in carrying out prescribed burns in the absence of liability insurance. In the U.S., liability insurance has, for the most part, been unavailable or unaffordable (Godwin, 2022) despite exceedingly low risk estimates (WFMMC, 2023).

Recently, however, a new insurance carrier has entered the market, offering coverage to qualified practitioners across much of the United States. Forest Specialty Underwriters, Ltd., along with Lloyds of London, are offering liability insurance coverage for those who plan or conduct prescribed burns. According to Conservation Digest, the insurance limits include $10,000 up to $100,000 per day for fire suppression costs and $1,000,000 for overall liability. Note that this will not be sufficient for very extreme wildfires where suppression can cost up to $3 million per day (Conservation Digest, 2023).

4.1.3 Incentivize NbS with insurance pricing

Many experts from the disaster risk management community claim that Insurance, beyond enabling post-disaster relief, reconstruction and recovery, is a powerful pre-disaster tool for promoting risk reduction (Kunreuther, 1996; Kunreuther & Michel-Kerjan, 2009; Crichton, 2008; Botzen, 2013). Botzen (2013) associates these risk-reduction incentives with risk-based pricing and insurance warranties: "Risk-based insurance premiums could act as a price signal for settlement in an area and thus stimulate development in less risky areas and restrain development in hazard-prone areas since premiums would be higher in the latter. […] Insurance can require the undertaking of

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mitigation as part of the policy conditions or reward the insured who invest in mitigation measures with premium discounts or increased levels of coverage" (Botzen, 2013, p. 30).

Insurers appear confident that their role is not only to pool premiums to compensate for loss and damage but also to prevent them. The European Insurance Federation (CEA) vigorously promotes the idea that insurance, essentially by pricing risk, plays a strong role in facilitating disaster risk reduction and climate change adaptation (CEA, 2009). Others more explicitly spell out the link between insurance and risk reduction: "Insurers can give incentives to induce behaviour changes in consumption and living habits that impact both the causes and the consequences of climate change. Indeed, risk-based insurance premiums and adapted claims management are strong incentives for society to address risks and improve resilience" (AXA 2015).

The question is how Insurance as an incentive for DRR can apply to NbS? The Nature Conservancy and WTW (2021) provide some insights on the potential role of NbS in reducing wildfire risk and thus reducing insurance premiums in California (good practice case 18). With more than 2.7 million Californians living in very high wildfire hazard severity zones and the increasing number and severity of wildfires causing billions of dollars in damage, practices to reduce wildfire hazard are paramount. As discussed above, one increasingly popular option is ecological forest management (thinning and prescribed burns) for fire-adapted forests. For the urban-wildland interface, it is becoming clear that wildfire risk mitigation requires structural and landscape modifications at the scale of entire neighbourhoods or communities, not only individual parcels. For this reason, a recent US Commission (WFMM, 2023) recommends community-scale actions such as hazard disclosures and support for local land use planning and building codes. These actions have the potential to impact insurance affordability and availability positively.

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Good practice case 18: Insurers model NbS for preventing wildfire in Tahoe National Forest

Wildfire insurance companies can incentivize NbS by offering reduced premiums to properties if the surrounding forests are fire-adapted, for instance, with ecological forestry as an NbS. This was the idea behind the Wildfire Resilience Insurance project, which focused on an ongoing forest management project (French Meadows) in California's Tahoe National Forest. The project was conceived and carried out by The Nature Conservancy (TNC) and WTW (2021). The objectives were to determine whether the wildfire risk reduction associated with ecological forestry could be accounted for in insurance models and to quantify the reduction in expected losses and the consequent technical and actual premium savings. Another idea behind the project was using insurance premium savings to fund or finance additional investments in ecological forestry. Ecological forestry uses prescribed fire and strategic thinning to reduce forest fuel load. Hence, they are healthier and more resilient to drought, fire and a warming climate, and there is a reduced risk of high-severity wildfires (Kelsey, 2019). Ecological forestry can also include grazing in forests by domestic or wild animals.

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Assuming the application of ecological forestry at landscape scale, the model results showed the potential for substantial savings in aggregate annual home insurance premiums of 41% or approximately $21.1 million. Premium savings results of 52% for home insurance accounting for ecological forestry were also obtained when analyzing a single community of 533 homes in the watershed. However, the costs can be significant. Kelsey (2019) found that a minimum investment of approximately $5-6 billion per year over the next ten years is needed for the highest priority work to reduce wildfire risks across federal, tribal, state and private lands and for community and infrastructure investments.

A significant recommendation for Europe is that insurers and risk modellers consider incorporating the findings and methodology presented in this study in their wildfire risk score models so that homes and businesses for whom ecological forestry reduces wildfire risk see the benefit of that risk reduction in their premiums. This raises the question of whether insurers are willing to adopt pricing mechanisms that allow for the reduction of premiums based on risk reduction measures (Surminski & Oramas-Dorta, 2013). While cost-effective risk reduction measures mean benefits to be captured, who can capture this is an open question. If premiums decline in proportion to the reduced risk, private insurers may not have an interest in funding or otherwise promoting these activities.

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Not only can premium reductions benefit insurance clients, but they can also be redirected into nature-positive investments. As one example, Canada experiences significant losses from flooding, which can be reduced by restoring wetlands. The Insurance Bureau of Canada (IBC) has proposed a blended-finance scheme, modelled after the Quintana Roo Coral Reef insurance, where cities take out parametric or indemnity insurance to protect and insure against damages to public infrastructure. A dedicated trust would undertake conservation and restoration activities, including wetland restoration on private property. Similarly to a resilience bond, this would result in lower flood losses and (in theory) reduced insurance premiums, which would be re-invested in restoration and flood resilience activities (Bechauf, 2020).

4.1.4 Facilitate NbS financing

Insurance is vital in facilitating financial transactions including offering protection against loan defaults, political instability and regulatory changes. According to the CEO of AXA (quoted in WWF and Deloitte, 2023, p. 30):

"Without insurance, there is no financing […] If you get the majority of the market together to align on principles of insuring in a climate-friendly way, it will have an even bigger effect on financing."

The insurance and the financing business are strongly interlinked. The more comprehensive and sound insurance coverage is, the less risky it is for a bank or other financial institution to provide a loan or otherwise support the activity. Insurance thus acts as a risk mitigant and strengthens the resilience of financial institutions. In what follows, we show how insurance has facilitated and enabled the financing of a marine protection program in Belize by protecting investors against both natural hazards and political risk (good practice case 19) and, in another case, enabling the African Development Bank to increase its loans for climate adaptation and consequently for investments in nature-based solutions (good practice case 20). While the Belize case is complex, involving multiple financial institutions and donors, insurance can be an essential vehicle for enabling single-transaction investments typical of domestic and development banks in their lending portfolios.

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Good practice case 19: Belize blue bonds made possible with insurance for credit, political and catastrophe risk

Debt levels in Belize rose above 120 per cent of GDP as of 2020, and investors realized that the government would be unable to pay the entirety of the balance. Indeed, Belize bonds were trading at 40 cents per dollar of face value, meaning that investors expected only to be paid back 40% of what they had lent. In this scenario, it is common for debt restructuring to occur, where bondholders agree to write down, or effectively forgive, some of the debt in return for guarantees that the country will stabilize its finances moving forward.

In the case of Belize, such a restructuring was facilitated by The Nature Conservancy (TNC), which set up an investment vehicle that would buy $553 million of Belize debt and convert it to a loan of $364 million. In exchange, Belize agreed not only to enact policies that would ensure that its debt stayed at sustainable levels but also pledged to protect 30% of its ocean and allocate $4 million per year for marine protection programs.

To secure private investment for the debt conversion, three layers of insurance were lined up. The most significant part of the insurance is for political risk, provided by the United States International Development Finance Cooperation (DFC). This covers risk to the investment from political instability factors such as government interference and political violence, including terrorism, for the entire amount of debt plus interest payments. While the United States government backs the insurance provided by the DFC, it secured reinsurance on the private market for 50% of the coverage. In addition to the political risk insurance, WTW structured, with Munich Re selected as capacity provider, a parametric catastrophe insurance that provides coverage for up to one year of payments in the event of a hurricane passing close to Belize with associated wind speeds or rainfall above pre-defined intensity. So far, the deal has resulted in Belize reducing its total debt relative to GDP and making significant investments in marine protection.

As part of the deal, the Belize Fund for a Sustainable Future was established, which has subsequently allocated funding for protecting eight designated areas across Belize to non-governmental organization partners. One organization to receive funds is the Turneffe Atoll Sustainability Association, which manages the protection of the Turneffe Atoll Marine Reserve. This area includes 28,300 hectares of coral reef and 41,000 hectares of mangrove forests and supports a significant fishing and tourism industry. It has been estimated that the reserve prevents $287 million in expected annual property damages from storms (Felder 2011).

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Good practice case 20: African Development Bank Room2Run

The African Development Bank (AfDB) loans money to member governments to finance projects focused on economic development and climate change objectives. Because it bears the risk of these loans not being repaid, it must hold substantial amounts of reserve capital. One way it has been able to reduce the amount of its reserve capital and, therefore, free more capital for lending is through credit insurance.

In the Room2Run operation in October 2022, the AfDB worked with the UK Foreign, Commonwealth and Development Office (FCDO) to transfer the repayment risk away from the balance sheet of the AfDB and onto external insurance providers. Three private insurers are covering $400 million in "first loss" insurance, meaning the first $400 million to go unpaid will result in losses to the insurers, and the FCDO is covering $1.6 billion in "second loss" insurance, meaning any losses over the $400 million will be covered by their funds. The additional lending made possible by the insurance will be directed toward climate mitigation and adaptation projects. Future use could also be explicitly focused on implementing nature-based solutions.

The Room2Run project illustrates the important role of insurers in enabling development banks to finance NbS. The World Resources Institute has created a database of projects, including NbS, funded by the AfDB and other development banks. One recent road construction project in Tanzania, for example, will include tree planting and grassing along the side of the road in order to reduce soil erosion and siltation. This type of portfolio risk transfer has been encouraged by the G20 Independent Review of Multilateral Development Banks' Capital Adequacy Frameworks (Boosting MDBs' investing capacity 2022).

4.1.5 Decline cover for nature-negative activities

A final way insurers can support nature-positive activities and NbS is by declining insurance policies for nature-negative activities and investments. Withdrawing support for fossil-fuel projects is trending in the insurance industry, with 41 insurance companies placing restrictions on underwriting coal projects, 22 companies on tar sands, and 13 companies on oil and gas (Reuter et al., 2022). These withdrawals potentially open up funding for additional support to NbS as insurance companies seek out new areas to replace this business. Aviva, for example, has underwriting exclusions for arctic drilling due to the high potential of oil spills in the region that could negatively affect biodiversity, as well as oil sands, which can also affect biodiversity and water quality. Another way that insurers are encouraging reductions in risky behavior is by declining cover in very high-risk areas. For example, major U.S. insurers withdrew from providing new wildfire cover in California (Good practice case 21). However, in a recent deal with the State Insurance Commission, insurers can now factor climate change into their premiums but must also cover homes in high-risk areas although with high premiums. This is part of California's Sustainable Insurance Strategy.

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Good practice case 21: Sustainable Insurance Strategy in California

After multiple years of large wildfires and increasing damages, Farmers Insurance and State Farm decided to stop issuing new homeowners insurance policies in California. This pushed many homeowners onto the state-run FAIR plan, the California insurer of last resort. However, the plan is not designed to bear a significant fraction of the insurance market and, in the case of large disasters, could become insolvent.

One concern of the insurers was that their rate-setting was allowed only to consider historical damage in setting premiums for their policies. This did not allow insurance companies to consider the future implications of climate change. The State Insurance Commission argued that complex forward-looking models could be used to raise premiums unfairly, and regulators could not adequately assess these models for fairness. As of September 2023, the commission has announced an agreement to relax this restriction as part of the Sustainable Insurance Strategy in exchange for transparency requirements and coverage increases in high-risk areas that will reduce pressure on the FAIR plan. There are also requirements for insurance companies to reduce premiums for households that have taken risk reduction measures such as upgrading roofs and windows, as well as community risk reduction efforts. (California Department of Insurance 2023).

The problem of insurability extends beyond wildfire in California, and in many cases, the only option left for insurance to cover weather damages is a state-run insurance agency, such as Texas Windstorm Insurance Agency, Florida's Citizens Property Insurance Corp., and the California FAIR plan.

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4.2 Investment pillar

Insurance companies are estimated to hold around $1.5 trillion in assets, putting them in a position to have a significant influence on how companies in which they invest do business. In comparison, the "Big 3" asset managers (BlackRock et al. Street) manage approximately $4 trillion in assets, and

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they have had a measurable influence, for instance, on the carbon emissions of the companies in which they hold equity (Azar et al., 2021).

Failure to account for and mitigate the impacts of the loss of nature presents economic risks, potentially jeopardizing economic and financial stability. As noted earlier, it is estimated that over half of global GDP depends on nature and the services it provides and that biodiversity loss could lead to between €1.7 trillion and €3.9 trillion losses each year (quoted in EIOPA, 2023). It is, therefore, vital that institutional investors, including asset managers, banks, risk capital investors and insurers, consider their role in contributing to the restoration and conservation of nature through their investment and divestment strategies.

The insurers' role manifests in two directions, what is referred to as *double materiality* (Baumuller & Sopp, 2021), a concept introduced recently by European regulators in assessing disclosure information on environmental, social and governance issues. The first direction, *financial materiality*, is 'from the outside in' since the degradation of nature can seriously impact insurers' underwriting and investment pillars. Financial materiality is core to business accounting. It is defined by the US SEC as any information such that "a reasonable person would consider it important" to the functioning of a business (SEC, 1999). As one example, the deterioration of coral reefs is predicted to raise storm and flood risks, increasing losses to insurers and making some areas uninsurable. Not only can physical risks affect insurers' balance sheets, but also transition risks from policy changes, litigation risks and reputation risks.

The second direction, *environmental materiality,* is 'from the inside out' since insurers impact nature through their investments. For example, by investing in nature-negative projects such as unsustainable agriculture, insurers directly contribute to the deterioration of nature, which impacts their business operations and profits. International standard-setters around climate and biodiversity impacts have emphasized that it is not only a firm's exposure to environmental risk that matters for investors but also their contribution to the problem (Adams et al., 2021)

4.2.1 Transparency and disclosure

To date, attention has focused on the disclosure of environmental materiality of financial institutions, including insurers. The European Union (EU) requires certain large companies, including listed companies, banks, and insurers, to disclose data on their management of social or environmental issues (EC, 2019). In April 2021, the European Commission adopted a Corporate Sustainability Reporting Directive (CSRD) that includes additional companies and requires audit or assurance of the reporting. Corporate disclosures by individual companies would feed into reporting by investors such as asset managers, insurance companies, and pension funds. Other important initiatives include the UK's plan to introduce legislation mandating climate-related disclosure for large companies and financial institutions conforming to the International Sustainability Standards Board (ISSB) reporting standards, which are expected to be adopted worldwide. International companies listed on the stock exchanges in the UK, EU, or US will have to report on a consolidated global basis.

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Many insurers and brokers have signed on to the UNEP Financial Initiative Principles for Sustainable Insurance (PSI), a global framework for insurers to address environmental, social and governance risks and opportunities (https://www.unepfi.org/insurance/insurance/the-principles/). The PSI initiative includes the Net-Zero Insurance Alliance, the Sustainable Insurance Facility of the Vulnerable Twenty Group of Finance Ministers (V20), research on nature-positive insurance, development of Environmental, Social and Governance (ESG) guides for insurers as well as work supporting the implementation of the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) and relevant to emerging frameworks such as the Task Force on Nature-related Financial Disclosures. While the largest insurance brokers have joined the PSI, they typically focus little on the external environmental impacts of the underlying insured activities they facilitate (WWF & Deloitte, 2023).

Of particular importance is the European Union Taxonomy (ET) for Sustainable Activities as part of the European Green Deal, a standardized classification system for economic activities aimed at stimulating private investments toward sustainable activities (Schütze & Stede, 2021; TEG, 2020). The ET is also aimed at increasing transparency and reducing information asymmetry by disclosing the sustainability characteristics of investments (Bertomeu & Magee, 2015; Chiyachantana et al., 2013) and decreasing greenwashing via identifying and codifying 'green' investable activity. The taxonomy and associated regulations will require European-listed and large public-interest companies to submit detailed annual reports attesting to their green credentials. Complementary to the Taxonomy is the EU Biodiversity Policy, which promotes four pillars: protecting nature, restoring nature, enabling transformative change, and supporting EU action promoting biodiversity globally. The Taxonomy stresses NbS for climate mitigation and adaptation and has begun to encourage the development of NbS (Papari et al., 2024).

In an analysis of the ET for encouraging the upscaling of urban NbS, Papari et al. (2024) note some deficiencies, including its disregard of innovative urban NbS types and its failure to provide incentives for investments that can deliver multiple sustainable objectives. The authors recommend that "public actors leverage the ET to obtain private funding for UNbS via (green) bond issuance and public-private co-finance instruments" (p. 1). Other elements of the Green New Deal will also support nature-positive investments, such as the requirement that certain products do not contribute to deforestation or forest degradation.

While the taxonomy has, to date, focused on climate-related disclosures, the Taskforce on Nature-related Financial Disclosures (TNFD) has published its recommendations on how to address nature-related risks and opportunities (figure 7) by identifying, assessing, managing and where appropriate, disclosing nature-related issues. The recommendations provide companies and financial institutions of all sizes with a risk management and disclosure framework. Following the example of the TCFD, the TNFD will track voluntary market adoption annually through an annual status update report beginning in 2024. This is a landmark in addressing the climate and biodiversity nexus and moving towards commitments to nature-impact targets and making decarbonization pledges.

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Figure 7: Recommendations of the Taskforce on Nature-related Financial Disclosures (TNFD)

Governance	Strategy	Risk & impact management	Metrics & targets
Disclose the organisation's governance of nature-related dependencies, impacts, risks and opportunities.	Disclose the effects of nature-related dependencies, impacts, risks and opportunities on the organisation's business model, strategy and financial planning where such information is material.	Describe the processes used by the organisation to identify, assess, prioritise and monitor nature-related dependencies, impacts, risks and opportunities.	Disclose the metrics and targets used to assess and manage material nature-related dependencies, impacts, risks and opportunities.
Recommended disclosures	**Recommended disclosures**	**Recommended disclosures**	**Recommended disclosures**
A. Describe the board's oversight of nature-related dependencies, impacts, risks and opportunities. **B.** Describe management's role in assessing and managing nature-related dependencies, impacts, risks and opportunities. **C.** Describe the organisation's human rights policies and engagement activities, and oversight by the board and management, with respect to Indigenous Peoples, Local Communities, affected and other stakeholders, in the organisation's assessment of, and response to, nature-related dependencies, impacts, risks and opportunities.	**A.** Describe the nature-related dependencies, impacts, risks and opportunities the organisation has identified over the short, medium and long term. **B.** Describe the effect nature-related dependencies, impacts, risks and opportunities have had on the organisation's business model, value chain, strategy and financial planning, as well as any transition plans or analysis in place. **C.** Describe the resilience of the organisation's strategy to nature-related risks and opportunities, taking into consideration different scenarios. **D.** Disclose the locations of assets and/or activities in the organisation's direct operations and, where possible, upstream and downstream value chain(s) that meet the criteria for priority locations.	**A**(i) Describe the organisation's processes for identifying, assessing and prioritising nature-related dependencies, impacts, risks and opportunities in its direct operations. **A**(ii) Describe the organisation's processes for identifying, assessing and prioritising nature-related dependencies, impacts, risks and opportunities in its upstream and downstream value chain(s). **B.** Describe the organisation's processes for managing nature-related dependencies, impacts, risks and opportunities. **C.** Describe how processes for identifying, assessing, prioritising and monitoring nature-related risks are integrated into and inform the organisation's overall risk management processes.	**A.** Disclose the metrics used by the organisation to assess and manage material nature-related risks and opportunities in line with its strategy and risk management process. **B.** Disclose the metrics used by the organisation to assess and manage dependencies and impacts on nature. **C.** Describe the targets and goals used by the organisation to manage nature-related dependencies, impacts, risks and opportunities and its performance against these.

Elizabeth Mrema, Co-chair of the TNFD, commented the following on the TNFD:

> "Nature degradation is increasing, and with six of the nine planetary boundaries already breached, nature risk is financial risk. Yet to date, businesses have mostly considered nature to be an unlimited and free provider of critical inputs into their operations and value chains. "Scaling up action to restore the resilience of nature is now a global policy and regulatory priority, and it is business-critical, posing significant long-term financial impact if not acted upon. Increasingly extreme weather events, the collapse of ecosystems and the extinction of species presents physical risks to business. Policy making and regulatory attention stemming from growing community concern about nature loss also creates elevated transition risks. Business as usual is no longer an option and business and finance can no longer consider nature and biodiversity as just a Corporate Social Responsibility (CSR) issue. It is now squarely a central and strategic risk management issue." (TNFD, 2023, p 2)

The effectiveness of the TNFD will largely depend on the work of organisations and financial institutions in identifying, assessing and prioritising nature-related dependencies, impacts, risks and opportunities, including in their upstream and downstream value chains. This difficult task has already begun, for example, by AXA in its Climate and Biodiversity Report (Good practice case 22).

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Good practice case 22: AXA Biodiversity Investing

Few asset managers currently disclose the impacts of their investments on biodiversity and nature. AXA, in its Climate and Biodiversity Report (AXA 2022), has implemented the Corporate Biodiversity Footprint (CBF) methodology developed by Iceberg Data Lab (IDL) and iCare&Consult, which assesses the supply chain of companies to determine their impact on biodiversity. The goal of the CBF is to measure the impact of an investment portfolio on biodiversity. This is achieved by assessing the products in a company's value chain based on data from IDL and allocating inputs/outputs to NACE sectors. Then, the company's environmental pressures are identified using life-cycle analysis. These pressures are then inputs to the Global Biodiversity model for policy support (GLOBIO), which converts these pressures to biodiversity impact units. The different impacts are then aggregated back to the company level. The CBF provides coverage for 27 industries with high to medium biodiversity impacts. The company-level impacts can then be combined up to a portfolio level.The CBF relies on the biodiversity measure of mean species abundance, which captures species abundance relative to what would occur in an undisturbed state. Impacts are divided into four broad categories: climate change, land use change, air pollution, and water pollution.

Finally, the effectiveness of the TNFD will depend on formal and informal enforcement methods. Large insurers and brokers can have a great deal of influence, in a way similar to how large asset managers have begun to prioritize nature. For example, BlackRock, the world's largest asset manager, claimed that it would not support the re-election of board directors if companies had not "effectively managed, overseen or disclosed" risks associated with nature loss (quoted in Dixon et al., 2022).

4.2.2 Nature-positive investing and nature-negative divesting

The terms *nature positive* and *nature negative* have been interpreted in many ways, including conceptual, process-oriented, or objective-oriented (Ermgassen et al., 2022). While many organizations have adopted the concept of nature-positive, it is not easy to settle on a practical definition for implementation. Even the objective-oriented definitions have remained relatively abstract, focusing on targets related to increasing biodiversity, ecosystem services, or natural capital. These differ from previous targets around "no net loss" in that they recognize the need for improvement upon the status quo rather than simply maintaining it. While not all nature-positive investments will necessarily fit the definition of NbS, nature-positive assets can be an essential part of investment portfolios. They can also incentivize companies to avoid participating in nature-negative projects and instead direct their business to green or green-grey infrastructure.

Despite vagueness in the terms, long-term investors and insurance companies are uniquely positioned to support nature-based solutions, especially since they have a responsibility to maintain capital to cover exposure to future risks and to maintain their investments for the long term (Duijm & Steins Bisschop, 2018). The investments, in turn, rest upon preserving nature and biodiversity. Although direct investment opportunities for insurers into biodiversity and nature are limited

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(World Bank, 2022), insurers are increasingly motivated to invest in nature-positive assets and divest from nature-negative assets in order to ensure their long-term profitability. This motivation manifests in avoiding four types of risks: reputation (*ESG investing),* physical, transition, and liability.

Reputational risk - ESG investing

The most actionable motivation for insurance firms to invest in nature-positive assets is to promote their environmental, social, and governance (ESG) activities. Evidence shows that firms that engage in these activities perform better financially (Flammer, 2015). For insurers, the main appeal of ESG investing, also called sustainable insurance by the Sustainable Insurance Forum, is to convince clients of their responsible role in society and thus avoid reputational risk. For this, they must demonstrate that firm management is credible and can engage in critical societal issues. Outside of the insurance sector, nature has drawn increasing attention from impact investors who are actively looking to demonstrate the positive social, economic, and environmental impact of their investments. A recent survey found that more than half of investors plan to have a core focus on biodiversity in their strategy in the next two years (Marsh McLennan, 2022).

Despite noteworthy progress in ESG investing, the OECD (2021) notes considerable challenges hindering its value in reaching climate- and nature-related objectives. These include promulgating different approaches, data inconsistencies, rating methodologies, and inadequate clarity over how ESG integration affects asset allocation. Ultimately, these challenges could constrain the pace and scale of the capital allocation needed to achieve tangible progress to support long-term value and a transition to nature-positive economies.

Physical risk

Physical risks refer to physical changes from the loss of nature, such as from species currently at risk of extinction. For example, if honeybee populations are reduced in the U.S., it is estimated that more than $50 billion a year in crops that depend on their pollination will be at risk (quoted in McCraine et al., 2019). Physical risks also manifest in losses from climate-related hazards. With increasing hazard intensity and exposure, insurance premiums in some risk areas, notably flood, wildfire and hurricane, are becoming ill-affordable. The resulting loss of markets directly impacts insurers' p*roperty and business interruption* lines. The most salient motivation for insurers to protect nature is thus to protect their markets, which will depend on choices around biodiversity and climate change today and over the coming years. This has been demonstrated recently as more risks have become uninsurable in some instances where investments in nature could promote a more insurable environment, for example, wildfire risk in California (Good practice case 21) (Boomhower et al., 2023).

Investments in nature such as mangroves to reduce storm intensity at the coast, can ultimately reduce insurance losses. This has been frequently cited as a motivation for insurers to invest in NbS. Indeed, insurance companies are among the few institutional investors who, it is claimed, can benefit directly from solutions that reduce physical risks and, thus, lower payouts for claims over

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time. However, as we will discuss in section 5, there is little incentive for investors to invest in public goods for disaster risk reduction (DRR) since competitors can 'free ride' on their investments and capture the market. Good practice case 23 engages insurers and other actors in the Philippines for supporting the planting of mangroves, but it is not clear if insurers invest directly in this project beyond purchasing the risk estimates. There is little precedent for insurers investing in DRR in order to reduce claims and premiums and more research will be needed to explore practice.

Good practice case 23: Protecting mangrove forests in the Philippines

Mangroves protect coastal assets and reduce flood and storm damage to the shoreline, including to coral reefs. Importantly, they also mitigate climate change by acting as carbon sinks (Beck et al., 2020). The benefit of restoring and protecting mangrove forests is well acknowledged. For example, in the Philippines, communities and infrastructures surrounded by mangroves have sustained fewer losses after typhoons than areas where mangrove forests had been cleared (Earth Security, 2020). Like coral reefs, mangroves can be more cost-effective than grey infrastructures such as concrete seawalls (TNC, 2020; Earth Security, 2022). In addition to the protection mangroves offer, they create attractive new revenue streams for fisheries by selling carbon credits (Earth Security, 2020).

The Restoration Insurance Service Company (RISCO) is a social enterprise seeking to finance mangrove conservation and restoration by capturing two key revenue streams. These are the DRR value of mangroves, in the form of reduce insurance premiums, and the carbon sequestration value of mangroves in the form of carbon credits. A pilot phase of this initiative is currently being implemented in the Philippines, where 3400 ha of mangrove forests will be conserved and an additional 600 ha restored (Conway and Mazza, 2019). The scheme engages insurance, government and market actors while working with local communities (IISD,2020). It is estimated that mangrove forests will generate an estimated 10 million USD in savings to the insurance sector (Swiss Re Foundation, 2021).

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While the most direct effects of nature degradation will manifest in property losses, other impacts can affect the insurance industry, especially since large (re)insurers typically take on risk across multiple domains to ensure a diversified portfolio. For instance, erosion and droughts are causing more interruptions in waterway navigability*, affecting marine, aviation, and transport insurance;* soil productivity and crop yields may decline due to poor nature practices, including the destruction of pollinators, impacting c*rop insurance;* disease transmission can increase due to habitat destruction, and respiratory diseases and temperature-related deaths can increase because of changes in the natural environment, including the creation of unmitigated urban heat islands, all affecting *life and health insurance.*

Transition Risk

A second salient motivation for insurers to invest in nature is to avoid transition risk, driven by shifts in policy, regulations, markets, and technology changes (Marsh McLennan, 2022). Transition risks are amplified by the pace of policy changes at the global, national and local scales, including sustainable finance frameworks, environmental and sectoral public policy and regulatory landscapes, litigation cases, and the incorporation of nature-related factors in credit ratings. Policy changes, for example regarding the use of land and water, can have cascading effects on multiple assets in which insurers may be invested. Technological factors represent another transition risk. With the rapid growth of technological solutions to mitigate nature risk, for example, digital data platforms and earth observation, failure to effectively implement technological solutions can result in not meeting ESG goals or effectively reporting and complying with environmental requirements. Insurers will also need to consider how the lines of business they are covering will change as business shifts out of traditional areas including oil fields and into new growth areas such as metal mines serving battery manufacturing plants.

Transition risk is further complicated by the fact that many policies related to climate and biodiversity are still in process, and most are not yet formalized in national legislation. These include, for example, the EU Biodiversity Strategy aiming for legal protection of a minimum of 30% of the EU's land area and 30% of the EU's sea area and ensuring that habitats and species do not show deterioration in conservation trends and status. The European Commission's Proposal for a Regulation on nature restoration, as well as the EU Taxonomy that is needed to set criteria for meeting 'nature-related' objectives, will present numerous challenges, adding to transition risk (European Commission 2023). The speed of implementation of measures and the effectiveness of enforcement does and will vary across countries and sectors, which will make for considerable policy and regulatory unpredictability, with organizations often facing challenges related to a lack of clear and quantifiable targets (Surminski et al., 2023).

Although, to date, most financial frameworks are voluntary, the prospect of mandatory commitment is looming. Insurance companies that are unprepared to adapt to changing regulations often leave themselves open to legal liability and reputational consequences.

Liability Risk

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Another risk to insurers' investment portfolios is their exposure to liability due to nature-negative activities. This is closely linked with transition risk but stems from court action rather than new legislation. There are several ways that litigation can be brought, as has been seen in the context of climate change (Setzer & Higham, 2023). Litigation can be directed at individual companies that negatively impact nature, either under environmental protection laws or under general constitutional claims of individual rights. Governments can also bring enforcement actions under their provisions. New rules can raise the probability that companies face enforcement under current laws, such as the writing of new Securities and Exchange Commission rules regarding ESG investments.

Illustrative case 24: Ligue de Protection des Oiseaux v. Bayer

While judicial systems and laws around the world vary to a large degree, courts are often an essential forum in which to make sure that existing laws and constitutional guarantees about the protection of nature can be enforced. One recent instance is the Ligue de Protection des Oiseaux (League for the Protection of Birds) suing the producers of the pesticide imidacloprid, including Bayer and Nufarm, alleging that the pesticides have contributed to declines in bird populations across France. While the case is still pending and its outcome is uncertain, it represents an attempt to use a new law passed in 2020 that aims to hold to account those who harm biodiversity.

The law expanded the definition of many environmental offences and created distinct jurisdictions for environment-related crimes. Other laws have provided for increased penalties for environmental violations and expanded the definitions so that dangerous activities that could have led to significant pollution but, in fact, did not can also be punishable. These laws will make it more costly for firms which do not comply with environmental regulations and harm biodiversity, whether intentionally or not.

Brokers are also not exempt from liability risks. In February 2023, a US NGO and ten Ugandan and Tanzanian organizations filed a complaint with the OECD against insurance broker Marsh McLennan for insuring the East African Crude Oil Pipeline (EACOP). Under Ugandan law, large-scale construction projects such as the EACOP must have insurance. Thus, Marsh McLennan, it is claimed, is enabling the pipeline's construction and, therefore, contributing to any adverse impacts of the project on human rights and the environment. (Backtrack, 2023; Gangcuango, 2023)

4.2.3 Philanthropic investments

Philanthropic foundations are independent legal entities for charitable or public benefit purposes funded by private actors. While governments are the primary funding source for spending on biodiversity initiatives, philanthropy can play a significant role. For a discussion of individual philanthropy, see section 3.3. As far as foundations are concerned, it is estimated that private financing through philanthropic organizations and NGOs is responsible for over EUR 200 million in biodiversity and nature financing in the EU (Nesbit & Whiteoak et al., 2022). In 2020, philanthropic

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organizations contributed about EUR 87 million to biodiversity-related projects, compared to only about EUR 1 million from NGOs and over EUR 280 million from green bonds.

This can also be compared to the $340 million commitment by major philanthropic organizations, including Bezos Earth Fund, Bloomberg Philanthropies, Climate Arc, ClimateWorks Foundation, Hewlett Foundation, and Sequoia Climate Foundation, to help financial institutions develop and execute voluntary net-zero commitments (U.S. Treasury, 2023). Insurers can support philanthropic organizations in their NbS projects. One example is Aviva, which supported The Wildlife Trusts in their project to restore rainforest in the U.K. (Good practice case 25).

Good practice case 25: Aviva supports biodiversity and nature-based solutions

The UK's largest insurer, Aviva, has published a Biodiversity Policy as of 2021 that sets out guidelines for promoting biodiversity in five areas: engagement and support with companies, deforestation prevention, restoration of ecosystems, influencing policy, and developing metrics. The company has also committed to achieving net zero emissions by 2040, focusing on nature-based carbon removal to pursue this target. It has committed to provide £100 million in funding for this purpose by 2030.

A donation of £38 million to help restore Britain's lost temperate rainforests is also a crucial part of Aviva's commitment to restoring nature. Britain's temperate rainforests are hotspots for biodiversity within the British Isles. The goal of the project is to restore habitats in these areas, as well as create new rainforests in areas where they have been historically destroyed. The goal is to restore 1,175 hectares, sequestering 222,000 tonnes of carbon by 2050. The planned areas will include several tree species and foster the development of mosses, sichens, and fungi. This will allow it to provide habitat to migratory bird species, as well as include some areas for low-impact grazing.

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The prospect of insurers voluntarily donating to NbS as part of their ESG activities is promising, yet there are challenges. Aviva highlights the lack of agreed-upon metrics for guiding biodiversity-

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promoting investments. Another issue is that the achievements are primarily self-reported, with little external oversight to verify the claims made or make a holistic assessment of the company's progress toward the restoration of biodiversity. Even with good intentions, it will take extended effort to ensure donations achieve their purpose. Another issue is that companies do not have unlimited budgets for donations, which if carried out at scale would inevitably come from shareholder value, employee salaries or raising insurance premiums. A competitive environment would constrain these activities.

4.2.4 The NbS investment pillar: enablers and barriers

Despite strong motivations for insurers to invest in or donate to NbS or to divest from nature-negative activities, with a few notable exceptions like the activities of Aviva and AXA, many if not most insurance companies have not scaled up/down their nature-positive investments/divestments (Hudson et al., 2023). Without being comprehensive, in this section, we take stock of some of the reported enablers and barriers.

Enablers of nature-positive investing/divesting

A prerequisite for insurers to contribute to NbS through their investment and divestment activities is knowledge of the impacts of the firms in which they are investing, also appreciating that impacts can propagate through value chains and geographies and are often significantly shaped by an organization's stakeholders (Marsh McLennan, 2022). This is the challenge facing the Taskforce for Nature-related Financial Disclosures (TNFD), which has set out to provide a framework for disclosing firms' impacts on nature. The TNFD has recently released its final recommendations on how businesses should report on their nature-related activities, which will help to enable insurers to focus their investments activities that have the most significant impact on nature-positive outcomes, and in particular ensuring affordability of their products in high-risk areas.

Forming industry alliances can be an essential enabler for NbS investment or nature-negative divestment. Here, the industry can learn from climate alliances. Several of the largest insurance companies and reinsurers have joined the Net Zero Asset Owner Alliance (NZAOA), established under the auspices of the Glasgow Financial Alliance for Net Zero (GFANZ). There is a separate organization within GFANZ specifically targeting insurers and their underwriting activities with respect to the net-zero transition, the Net Zero Insurance Alliance (NZIA). The members of this body have committed to standards regarding monitoring, reporting, and verification of carbon emissions, financing the net-zero transition, and engaging with companies they invest in to facilitate changes in company behaviour. For example, GFANZ has set a target for its members to "eliminate commodity-driven deforestation from their investment and lending portfolios," however, there are no general targets regarding biodiversity restoration or the use of nature-based solutions.

Similarly, the Act4Nature coalition has brought together a wide range of businesses to understand better how biodiversity impacts the economy. One member, AXA, has contributed to the founding of the TNFD through the "Informal Working Group," which helped to develop the guidelines. The

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company has also traced its impact on nature, using a scheme similar to the carbon emissions accounting framework, which measures their impact on biodiversity through three scopes: direct impacts from on-site operations, indirect impacts from purchased energy, and indirect impacts from other inputs to their business (AXA 2023). They have also begun to measure the impacts of their investment portfolio, using tools developed by the Iceberg Data Lab (IDL) and iCare&Consult called the "corporate biodiversity footprint." While these types of tools are still in a developmental phase, it is useful to begin to understand the impacts of a portfolio and work to improve these tools moving forward.

Barriers to nature-positive investing

A main underlying factor constraining insurers from taking steps towards nature-positive investing is the worry that they will lose market share and return. Commercial insurers operate within competitive (if regulated) markets and have a fiduciary duty to their shareholders to act in their interests, generally interpreted as maximizing shareholder value. Insurers cannot take undue risks or solely promote social or environmental goals with their investment activities.

This point deserves emphasis. According to Golnaraghi and Mellot (2022), corporations, investors, and (re)insurers may consider addressing nature-related risks and opportunities as a scientific, environmental and, at most, philanthropic or corporate social responsibility issue. Yet, since nature-positive activities and investments are not correctly priced or offer returns, they currently carry extra costs, which few shareholders, investors and other stakeholders may be willing to pay.

Still, if equity holders push them toward nature-positive investments, this can nudge their investment strategies without violating their fiduciary duty. Moreover, insurers will have more appetite to take aggressive action with their investments if there is solid evidence that it will be financially beneficial. A main barrier here is uncertainty around the effects of nature on their underwriting risks. Further scientific work assessing the risk reduction impacts of nature-based solutions, as well as better valuations of ecosystem services, will be necessary to enable investment decisions (Golnaraghi & Mellot, 2022).

Another barrier to action is pressure from governments, as recently demonstrated by U.S. state governments threatening to take anti-trust action specifically against insurers that have joined organizations focused on climate and nature goals. As a case in point, while many large insurers and reinsurers joined the Net Zero Insurance Alliance at its launch, several have subsequently left the alliance (but kept their commitments) after threats of anti-trust-related legal action. (Reuters May 2023)

The Solvency II regulations, which set capital requirements to ensure insurer solvency after significant loss events, have been cited as another barrier to green investing since they limit available capital (EIB, 2023). According to the EIB (2022), clarifying the rules and setting preferential treatment for green assets in the regulatory framework could enable a change in insurers' investment behaviour.

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Finally, in the case of large projects seeking insurance, the role of brokers can limit the ability or willingness of insurance companies to place conditions on their underwriting service. For large projects, negotiating insurance contracts is generally one of the last steps in the financing process. If insurance companies are competing for the business defined by the broker, they may be faced with either accepting or declining the risks. According to WWF and Deloitte (2023), concerns about being excluded from future deals and losing business are typical motivations for insurance companies to agree to participate without asking too many questions or collecting more environmental data beforehand.

4.3 Reflections on the insurance business model

Upscaling NbS will require upscaling the financial activities that enable them, including insurance products and services. The insurance activities and good-practice examples reported in this section can provide realistic pathways by simply doing more of what works. Yet, in many cases, insurers will be constrained by their fiduciary responsibility to their shareholders and the competitive environment in which they operate. In what follows, we distinguish between underwriting and investment strategies consistent with the core insurance business model, which emphasizes short-term profitability and shareholder value, and those that deviate from the model. This distinction is vital since insurers can significantly upscale pro-NbS financial activities if consistent with their business model. However, inconsistent activities will require new business models that face difficult, in some cases, near-insurmountable challenges in competitive markets.

4.3.1 Core business model

Underwriting pillar

The core business of underwriters is insuring the risks of external events that cause physical loss and damage to property and assets. Insurers have written pioneering products that provide post-hurricane capital to restore coral reefs and cover the construction of sand dikes and mass timber buildings. Underwriting natural capital – construction and operation – can provide profitable markets, increasing shareholder value. It can thus be expected that (re)insurers and brokers will move aggressively into this business niche by promoting nature-based solutions and the restoration of natural assets with novel underwriting products, research, multi-stakeholder collaboration and through grants and investments ((WWF & Deloitte, 2023).

Well within the core business model, insurers also provide a valuable and profitable service contributing to the upscaling of NbS by de-risking them, for example, providing cover for mangrove forests to facilitate investments in carbon credits and protecting practitioners of prescribed burns to reduce their liability and enable wildfire NbS. Recognizing difficulties in data and risk assessments, providing novel insurance instruments for de-risking NbS offers new profitable markets.

Insurance underwriters offer another important and profitable service for scaling NbS by facilitating financial transactions, including protection against loan defaults, political instability and regulatory

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changes. As good practice examples, a major coastal restoration project was made possible in Belize by insurers absorbing the credit, political and catastrophe risk of the issued blue bonds. Insurance for a project by the African Development Bank has freed capital to expand its portfolio of NbS projects. Again, these activities provide profitable markets for traditional insurance products. Their scaleup is both in the interests of insurers and a nature-positive economy. They are all well within the core business model of insurers.

Investment pillar

The insurance underwriting pillar fuels the investment pillar, which has huge potential for contributing to the scaleup of nature-based solutions. The four main ways insurance companies can accomplish this end include i) disclosing information on the impacts of their investments, ii) increasing investment in nature-positive assets and reducing investments in nature-negative assets, and iv) contributing to philanthropic organizations that fund NbS. While the industry is far from its potential given the significant capital resources it manages, there is evidence of essential steps in this direction – many of which comply with the insurance core business.

Disclosure

The work of the EU Task Force on Nature-related Financial Disclosures (TFND) will provide needed transparency for ESG and 'green' investing and encourage divestment from nature- and climate-negative assets. As important as this first step is, it could become more effective if accompanied by an enforcement mechanism building on the Corporate Sustainability Reporting Directive (CSRD) and appropriate monitoring for banks, insurers and other financial agents to set clear restrictions on nature-negative investments. Transparency and disclosure, if required across the industry, are consistent with insurers' core business model, which has long experience in accommodating regulations on industry solvency, responsible management and restrictions on product design and pricing.

Investment and divestment

Beyond disclosure, the ultimate and urgent goal is for insurers to invest in nature-positive assets and divest from those activities that damage the environment. Insurance companies are increasingly motivated to this end mainly due to their interest in reducing climate- and biodiversity-related insured losses (especially for avoiding uninsurable losses), avoiding liability and regulatory risks associated with the transition to sustainable business practices and, importantly, enhancing their reputation.

Despite the strong motivations, investment and divestment are still in their infancy. Indeed, outside of insurers investing in the Restoration Insurance Service Company (RISCO) pilot mangrove project in the Philippines, we have found little concrete evidence or good-practice examples. One main reason reported in an industry survey by the UNDP Sustainable Insurance Forum is the lack of data and information for assessing nature-related investments, a problem being addressed by the TNFD. Indeed, the precedent for insurers withdrawing from socially undesirable investments is not

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encouraging. More than a decade after researchers revealed that life and health insurance companies were significant investors in tobacco stocks, the insurance industry had not divested (Almberg, 2009) despite strong incentives for them to do so.

Another main reason is the concern of losing investment return. So long as insurers can re-allocate their equity investment portfolio away from nature-negative to nature-positive companies, this is consistent with their business model. However, if this reallocation means divesting from high-return companies and investing in lower-return companies, this will reduce profits and shareholder value. This may be acceptable to impact investors, so the critical issue is the market power and influence of 'green' investors.

A similar narrative surrounds insurers donating to philanthropic organizations to support their NbS projects. As a good practice case, Aviva has donated £38 million to protect a U.K. rain forest (see Good practice case 25). Of course, large enterprises can afford these expenditures as part of their ESG strategies and to enhance their reputations. On a small scale, donating fits comfortably in the core business model.

4.3.2 Deviations from core business model

It is more problematic, in some cases even unfeasible, for insurers to embrace pro-NbS strategies if they result in lower short-term returns to the business and, therefore, deviate from their core business model, even in cases where it may be in their long-term interest. Still, financial materiality is looming large in boardrooms as it becomes evident that the degradation of nature and loss of biodiversity can seriously impact their underwriting and investment pillars. As one example, the deterioration of coral reefs is predicted to raise storm and flood risks, increasing losses to insurers and making some areas uninsurable. They can also be justified by catering to clients who accept higher premiums and/or have lower expectations of their investment return. In what follows, we highlight underwriting and investment activities that can result in higher premiums and/or lower returns, possibly requiring 'new' business models.

<u>Underwriting pillar</u>

Actively engage in supporting clients to take nature-positive actions

Insurers and brokers can go beyond writing conventional products and include strict environmental standards in their terms and conditions, as well as require (and verify) ambitious climate- and biodiversity-related practices (WWW & Deloitte, 2023; The Geneva Association, 2022). However, if carried out on a scale, this service can deviate from insurers' core business model. Imitating nature-positive conditions, for example, by monitoring clients, using remote sensing and on-site inspections, can be a considerable expense. While terms and conditions accompany insurance policies, they are rather general. Moreover, insurers have been reluctant to inspect properties for fire or flood risk reduction, relying instead on public authorities to enforce building and safety codes (Lorant et al., in preparation). Nor do insurers typically have the resources to engage extensively with clients or perform their environmental due diligence except possibly for the high-impact deals led by brokers. Adding this expense to underwriting formulas, if done on a large scale, will affect the

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insurers' bottom line and potentially raise premiums. This may be prohibitive in a competitive market.

Withdraw from underwriting nature-negative investments or grey infrastructure

Another opportunity for insurers to aid the upscaling of NbS is to exclude cover for investments and activities contributing to biodiversity loss and climate change. WWF and Deloitte (2023) recommend excluding insurance underwriting services for severely damaging activities, such as those that may negatively impact World Heritage Sites or other areas of high biodiversity importance. As a case in point, insurers could refuse to offer liability protection, e.g., insurance directors' and officers' liability coverage, from construction and other activities that are viewed as nature-negative (WWF & Deloitte, 2023), which would be a significant deviation from the core business model since insurers generally provide unconditional liability coverage. As another case in point, major insurers have threatened to withdraw homeowner policies from high-risk wildfire areas in California, which greatly influence home building but also open the market for competitors and potentially deviate from insurers' fiduciary duty.

Incentivize NbS with premium pricing

Many observers point to the power of underwriters to provide incentives to clients or communities to reduce risks to property and assets with the prospect that premiums will then be reduced. In the case of wildfire, a recent insurance model has estimated that premiums in California could be significantly reduced by implementing an NbS. New regulatory changes mean that insurers will be allowed to incorporate the effects of ecological forestry on wildfire insurance, reducing premiums where this is practiced. Yet, there is sparse evidence of insurers reducing premiums after risk-reduction measures or encouraging risk reduction, except, as mentioned above, when premiums become unaffordable. This reluctance to reduce premiums would counter a competitive environment where competitors enter the market with lower-cost policies. However, especially in the catastrophe reinsurance market, there does not appear to be fierce price-cutting competition (Froot, 1999; Froot & O'Connel, 1999).

The motivation insurers have to reduce risks should be examined closely since, in fact, insurers depend on risk for their core business – as long as clients can pay the premiums. According to Ranger and Surminski (2013), theory and evidence suggest that a "riskier and more uncertain world would be associated with an increase in insurance demand, and thus is favourable for an insurance market, up until the threshold where the affordability of insurance or the insurability of risk were threatened" (p 19). The appetite for reducing risks, however, may increase as risks become increasingly uninsurable and insurance markets are threatened. Moreover, as shown by the EIB (2023) survey, insurance contracts are typically taken out on a short-term (yearly) basis, which creates a principal-agent issue as premium prices are only reduced when observed losses materialize. *Expected* loss reductions are not generally factored into premiums.

Investment pillar

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Insurers are, in theory, motivated to invest in nature-positive assets and divest from nature-negative assets in order to ensure their long-term profitability. This motivation manifests in avoiding risks from loss of reputation (*ESG investing),* physical damage to assets, transitions in response to changed regulations, and liability for irresponsible investing.

Invest in NbS

Investors increasingly recognize that they contribute to adverse sustainability outcomes, including the degradation of nature through their investment activities, and these outcomes will feed into the financial risks they face. Financial materiality is a strong motivator for redirecting investment choices to support companies that contribute to implementing nature-based solutions, or directly investing in NbS. Indeed, given the size of insurers' investment portfolios and the capital they control, this could be a powerful force in scaling NbS.

While investing in nature-positive companies, specifically in NbS, appears entirely consistent with the core insurance business model, nature-positive investing and its outcomes are seriously constrained by the fiduciary responsibility to their shareholders and the competitive market in which insurers operate. The first limiting factor is the public-good nature of NbS and the difficulty of finding lucrative companies implementing NbS in which to invest (World Bank, 2022; EIB, 2023), although opportunities may improve in light of the growth potential of carbon markets. Given the lack of high-return NbS investment activities, a pro-nature investment strategy will risk reducing return and potentially adding uncertainty and volatility to the portfolio. Since nature-positive activities and investments are not correctly priced or offer returns, they currently carry extra costs, which few shareholders, investors and other stakeholders may be willing to pay. It will only be possible if equity holders as impact investors accept lower returns – a new business model.

Insurance companies can invest directly in NbS, and, indeed, there is optimism that insurers can be a leading force in confronting climate change and biodiversity loss by supporting and funding NbS, especially those that reduce disaster losses. The reasoning is that insurers and insureds stand to gain if property and asset losses, and consequently premiums, are reduced. As noted above, this motivation should be examined closely since, in fact, insurers depend on risk for their core business. Except to assure insurability and their market in high-risk areas, insurers do not have a record of incentivizing or, much less, investing in DRR. If, for example, insurers fund the planting of mangrove trees to reduce storm losses, recovering their investment costs will be difficult with lowered premiums. Moreover, non-investing competitors can capitalize on the resulting market opportunities – the 'free rider' problem. It appears thus that unless insurers are concerned about maintaining insurability in high-risk markets, investing in NbS for DRR is mainly inconsistent with their core business model.

Divest from nature-negative activities

Finally, the withdrawal of insurers from investments in nature-negative investments, e.g., grey infrastructure, is potentially a significant force in scaling NbS. Marsh McLennan (2022) recognizes the potential of financial institutions steering their balance sheets away from companies harming

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the environment, which brings opportunities from new products and services but also comes with significant uncertainties and short-term implementation pains. Unless driven by regulations, such as the European Union's Corporate Due Diligence Law (Marsh McLennan, 2022), the withdrawal of one insurer will likely open a vacuum for competitors to fill the space, as has been the case with divesting from fossil-fuel assets (WWF & Deloitte, 2023).

To the extent that environmentally harmful investments put insurers at risk for litigation or seriously tarnish their reputations, divestment would appear entirely consistent with their business model. Yet, insurers are constrained in their divestment activities to the extent that it means pulling out of high-return investments only to see competitors or short-term investors acquire them. There is also debate on the benefits of divestment since it can reduce investors' ability to influence the sustainability performance of investees directly, and evidence suggests that divestment is unlikely to alter corporate behaviour (Kahn et al 2023). Moreover, the growth in passive investing and improvements in investor stewardship may further weaken the case for divestment. Still, if large market actors divest from nature-negative companies and assets, this can have a potent signaling effect across the industry.

5. Taking stock and moving forward

5.1 Enablers and barriers

This deliverable has taken stock of extensive literature and practice documenting the barriers to and enablers of NbS implementation. From this documentation, the lack of robust evidence on NbS performance and co-benefits surfaced as one of the most formidable challenges for public authorities and private businesses when it comes to justifying NbS over their grey counterparts. The challenge is compounded by poorly-staffed and siloed administrations with little NbS experience or expertise. Perceived inequities both in stakeholder engagement and NbS benefit distribution are another highly-ranked hurdle to overcome for NbS implementation. In contrast to grey infrastructure, path dependency emerged prominently as a major limiting factor, i.e., the difficulty in changing the current legal and social norms that favor grey infrastructure. Turning to NbS enablers, stakeholder engagement and polycentric governance arrangements for overcoming siloed administrations have proven to be especially valuable.

Moving forward, NbS proposers can build on grey project experience to address those hurdles that NbS have in common, such as the need for polycentric and inclusive stakeholder processes. The thorniest hurdles are those that differentiate NbS from grey solutions, especially the long time frame needed for proof of concept. One promising idea, among many, is to shift the burden of proof from NbS to grey infrastructure projects by requiring proposers to prove 'no negative environmental impacts' in addition to requiring NbS proposers to prove NbS effectiveness. This could be accomplished by extending the scope of the EU Environmental Impact Assessment (EIA) Directive to include a broader range of projects, and exempting low-risk NbS in the same way that many renewable energy technologies have been exempted from the EIA Directive. Another idea is to require all infrastructure planning processes to include consideration of nature-based alternatives.

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5.2 Financial instruments

A prerequisite for any NbS project is the availability of private or public funds and financial arrangements for its implementation. A stocktake across over 50 cases of NbS implementation shows diverse financing/funding arrangements in place. By far the most dominant are publicly financed projects paid for by local and national taxpayers and in some cases supplemented by users and donors. Indeed, it proved challenging to find privately funded NbS that are motivated only by revenues and profits. A main reason is that NbS are for the most part public goods, meaning their value is difficult to capture in a revenue stream. In our selected cases, private funding was motivated mainly by regulations that require NbS as an addition to already bankable ventures, e.g., the greening of housing projects in return for public land leases or investing in carbon mitigation projects for the voluntary or mandatory offsetting of commercially viable investments.

An important message is that neither public budgets nor private investment, acting alone, will be capable of closing the NbS investment gap. Many organizations, for example the European Investment Bank (EIB, 2023) and The Geneva Association (Golnaraghi and Mellot, 2022) recommend thus exploiting multiple synergistic financing instruments, such as grants, equity arrangements, land easements and public-private partnerships among many others. Yet, the question remains whether hybrid and mixed funding are the magic bullet for filling the financing gap given that most require substantial public contribution, which in Europe comes from already strapped municipal and national budgets. This is increasingly difficult in light of the EU austerity requirements.

Moving forward, it is critical to recognize the limits on both public budgets and private funding for scaling NbS. It appears prudent that innovative public and private funding sources are exploited, for example, taxes on nature-negative activities, targeted but equitable user fees and stepped-up philanthropic donations. The Copenhagen Cloudburst Management Plan might serve as a model for EU members states to finance NbS with user fees imposed by public utilities. The EIB (2023) has flagged utilities as being well positioned to allocate capital to NbS.

It also seems evident that regulatory regimes across the EU will need strengthening so that private developers are required to refrain from nature-negative land use and product development, or alternatively, they are required to carry out credible carbon offsets – hopefully extended to biodiversity offsets - that can finance innovative projects such as the Livelihoods-Yagasu project for planting Mangrove forests. There are, however, formidable challenges in setting metrics for biodiversity, and for this reason there may be potential in qualifying carbon offsets to exploit their biodiversity co-benefits. The European Union could also play a more prominent role in directing capital towards NbS. The U.S. Clean Water Revolving Fund, where the EPA capitalizes state banks for investing in NbS, might serve as a model for capitalizing NbS infrastructure banks set up by member states.

5.3 Insurance instruments

As part of their larger financial portfolio, insurers' activities – both underwriting and investment - can play an important, but limited, role in scaling NbS. For the underwriting pillar, we identified five interrelated categories illustrated with good-practice cases including insurers' recent role in insuring natural capital with parametric products (e.g., coral reefs), facilitating NbS financing (e.g., Belize

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blue bonds) and refusing cover for nature-negative projects (e.g., the East African crude oil pipeline). Insurance coverage for innovative technologies has also played a role in de-risking NbS as seen in the case of mass timber or the Prins Hendrik Sand Dyke.

Turning to the investment pillar, insurers are motivated to factor nature into their operations for several reasons: to mitigate physical risks from rising insured losses, transition and liability risks from rapid changes in regulations and policies, and reputational risks from shifting societal expectations. While in principle there are reasons for insurance companies to be motivated, the path forward remains unclear. The first step will be a better understanding of the role of investment in nature outcomes, exemplified by the good-practice case of the Task Force on Nature-related Financial Disclosures (TNFD), which will encourage transparency and disclosure. Parallel to this track is insurers' philanthropic donations such as Aviva's support of rain forests in Britain. Both of these tracks will require continued pressure from customers of and investors in insurance companies. To date, however, investment and divestment activities are yet to be scaled to the level we have seen by other asset managers.

It is important to recognize that insurers have lucrative opportunities to enhance their business model by contributing to NbS scaling; however, many pro-NbS activities will require deviations from the current business model to take account of long-term developments - and some may be prohibitive in a competitive environment. Insuring natural capital, like coral reefs, is a comfortable extension of business-as-usual underwriting and contributes both to insurers' bottom line and to closing the nature gap, although it should be recognized that these services can come at high cost. In contrast, investing in public goods that reduce losses from extreme weather, like mangrove forests or wetlands, with subsequent pressure from competitors or regulators to reduce premiums, can result in company losses and, indeed, this strategy (although often cited) has little evidence of success so far. Divestment from high-value nature negative assets is equally constrained by market forces since it can open a window for competitors to buy the lower priced assets resulting in no net gain for the environment, although divestment by large corporations can send an important signal.

Moving forward, while it is unlikely that insurers will invest directly in loss-reduction NbS given the public-good nature of these assets, they can contribute importantly to NbS scaling with products and activities that fit well into their business model, like insuring natural capital, facilitating NbS financing and (small scale) ESG and philanthropic investing. Insurers may also nudge their balance sheets to account for financial materiality by taking a longer perspective on their operations even if this strategy results in some reduction in short-term returns. This will mean adopting a new business model that focuses on long-term benefits of a nature-positive economy and takes account of the emerging generation of impact investors.

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Annex A: Non-exhaustive list of key EU policies, directives, initiatives and funding instruments relevant to NbS

Type of instrument	**Name**
Strategies and policy initiatives	European Green Deal (EGD) (2019)
	Biodiversity Strategy to 2030 (2020), as part of this: • Proposal for a Nature Restoration Law (2022) • New EU Forest strategy for 2030 (2021)
	Strategy for a Sustainable Blue Economy (SBE) (2021)
	Green Infrastructure Strategy (2013)
	European Climate Law (2021)
	Farm to Fork Strategy (2021)
	New Adaptation Strategy to Climate Change (2021)
Directives and regulations	Birds Directive (1979/2009)
	Habitats Directive (1992)
	Water Framework Directive (WFD) (2000)
	Floods Directive (2006)
	Marine Strategy Framework Directive (MSFD) (2008)
	Environmental Impact Assessment Directive (EIA) (1985)
	Strategic Environmental Assessment Directive (SEA) (2001)
	EU taxonomy for sustainable activities (2020)
	Corporate Sustainability Reporting Directive (2023)
	Non-Financial Reporting Directive (2014)
	Critical Entities Resilience Directive (2022)
Financial instruments and funding programmes	European Regional Development Fund (ERDF)
	European Social Fund Plus (ESF+) (2021)
	Cohesion Fund (CF) (2021)
	Just Transition Fund (JTF) (2021)
	Social Climate Fund (SCF) (2022)
	European Agricultural Fund for Rural Development (EAFRD)
	European Maritime, Fisheries and Aquaculture Fund (EMFAF) (2021)
	Horizon Europe Framework for Research and Innovation
	Reform on the Common Agricultural Policy (CAP) (2021)
	InvestEU programme (2021)

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