European Environment Agency

Scaling nature-based solutions for climate resilience and nature restoration

Wider application of nature-based solutions (NBS) to climate change adaptation would deliver multiple societal benefits and contribute to biodiversity conservation. However, there is limited experience scaling solutions beyond local contexts. The lack of standardised methods for assessment and monitoring of NBS is a major challenge for replicating and applying them at a wider scale. This briefing looks into applied assessment frameworks and the scaling potential of selected NBS, and how they may contribute to ecosystem restoration outside protected areas.

Key messages

Nature-based solutions (NBS) for climate adaptation and disaster risk reduction can contribute to the EU nature restoration agenda. Applied at scale, they would enhance biodiversity in both urban and rural landscapes.

Accelerating and scaling NBS across Europe is key to achieving EU policy targets. Expanding and replicating local initiatives will be necessary to respond to the growing climate and biodiversity crises.

More insight is needed into the factors that enable local success, and the barriers to scaling. This requires systematic monitoring, reporting and evaluation schemes to inform about the effectiveness and efficiency of NBS in the long term.

The costs and benefits of NBS need to be clear to stakeholders and potential investors. While NBS serve multiple purposes, the quantification of social and economic aspects, including the distribution of costs and benefits across stakeholders, is still limited.

To realise the full potential of NBS, further targeted governance and coordination would be needed. Apart from financial incentives, NBS uptake would benefit from regional planning based on risk profiles, a catalogue of corresponding NBS, and baseline information on their current application.

Nature-based solutions can make Europe more resilient to climate change

As climate-related hazards and their associated impacts are increasingly felt in Europe and around the globe, adaptation measures become more urgent. In 2013, the European Commission (EC) adopted its first Adaptation Strategy (EC, 2013). Building on the lessons from the 2013 strategy, the EC's second Adaptation Strategy, from 2021, calls for greater efforts to strengthen our resilience and preparedness for climate change. This includes more investments in NBS to generate benefits for climate adaptation and mitigation, disaster risk reduction, biodiversity and health (EC, 2021a; EIB, 2023).

More recently, the EC launched the draft Nature Restoration Law (EC, 2022) within the framework of the EU Biodiversity Strategy (EC, 2020a). It calls for legally binding restoration targets, particularly for the habitats in Annex I of the EU Habitats Directive, as well as for ecosystems with the highest potential to capture and store carbon and reduce the impacts of extreme climate events, such as forests and peatland[1].

The briefing synthesises information from two earlier reports by the European Topic Centre on Climate Change Adaptation (ETC-CA), focusing on applied assessment frameworks (ETC/CCA, 2021) and upscaling potential (ETC-CA, 2022) for NBS.

What are nature-based solutions (NBS)?

NBS address societal challenges such as climate change, disaster risks, food and water security, and human health by protecting, sustainably managing or restoring natural ecosystems. They simultaneously provide human well-being and biodiversity benefits, enhancing ecosystem services such as erosion control, drought and flood prevention, carbon sequestration, cooling and wildfire prevention. Additional benefits in urban environments are increased air quality and reduced noise pollution (see e.g. Climate-ADAPT, 2023; World Bank, 2022; IUCN, 2020).

The potential of nature-based solutions to deliver multiple benefits to society is increasingly recognised in national, EU and global policies[2]. NBS are also relevant to all EU policies related to land use (EEA, 2020; Calliari et al., 2019). This briefing builds on a review of 97 NBS cases, implemented in urban areas, mountains, coastal areas, agriculture and forestry[3].

Scaling local initiatives is key

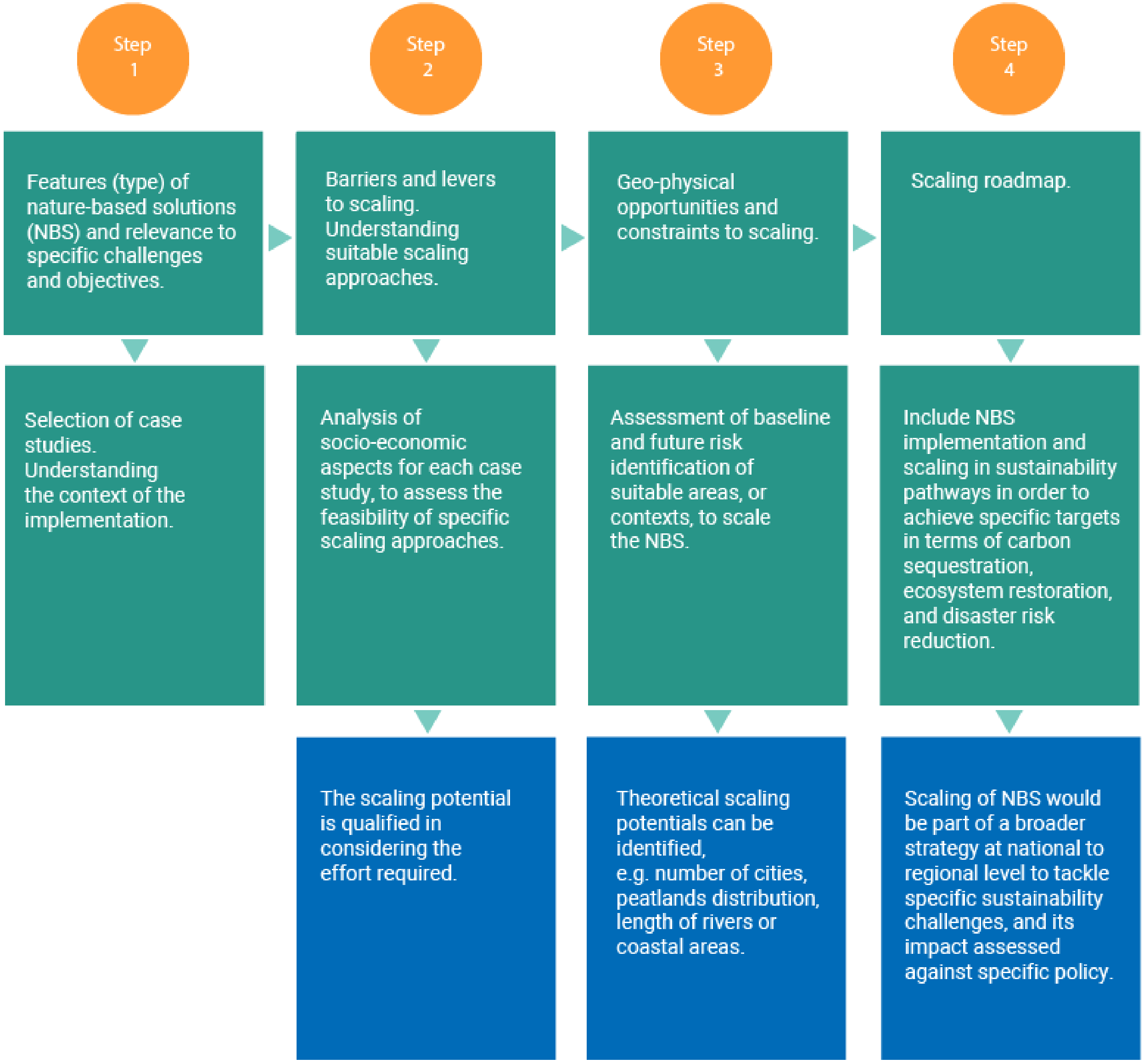
NBS are typically small, stakeholder-driven projects tailored to local biophysical, socio- economic, political and cultural conditions. In most cases, they cannot be replicated without various adjustments. Therefore, scaling requires nuanced knowledge of the original context and success factors. Three scaling approaches have been described in literature: ‘scaling out’, ‘scaling up’ and ‘scaling deep’ (Salafsky et al., 2021).

‘Scaling out’ replicates an NBS in a similar context with minor adjustments. ‘Scaling up’ applies where the approach needs to be substantially adapted, e.g. addressing regulatory barriers at the regional, national or European level. Finally, ‘scaling deep’ tackles the predominant socio-economic drivers of biodiversity loss and landscape degradation, and may include changes in values, policies and institutions. This is effectively a sustainability transition at landscape level.

Assessing scaling potential

In 2021, a four-step framework for assessing the scaling potential of NBS (Figure 1) was suggested and tested on six of the 97 available cases (see figure in ETC-CA, 2022). Cases were selected based on their relevance to ecosystem restoration and stakeholder involvement (step 1). The socioeconomic barriers and enablers of scaling these cases were then identified by considering the assessed societal, economic and environmental benefits (step 2). Steps 3 and 4 require quantitative geo-physical analysis beyond the scope of this study and, therefore, were not included.

Figure 1. Proposed scaling approach



Three of the cases are presented below to illustrate various scaling aspects of NBS in urban and rural settings. The cases cover: green roofs in Hamburg (Germany), agriculture and river catchment restoration in Tullstorpsån (Sweden), and paludiculture in Mecklenburg-West Pomerania (Germany).

Green roof implementation is comparably straightforward where basic conditions are met. River catchment management is more complex in terms of stakeholder buy-in, governance and coordination, and spatial planning. Paludiculture is arguably the most demanding, requiring a fundamental sectoral reorientation supported by spatial planning and infrastructure. As such, the cases represent different scaling challenges, but they all combine aspects of scaling up, scaling out and scaling deep. The Mecklenburg-West Pomerania case is at the pilot stage, while the Tullstorpsån case and the Hamburg case have started to scale out.

The most common challenges for scaling are economic drivers (e.g. agricultural and forestry interests, investors and industrial development); and funding continuity, since all initiatives predominantly rely on public financial support. Furthermore, the inclusive governance and engagement of stakeholders with varying and sometimes opposing views is yet another challenge.

Case 1. Green roofs

- **Thematic area:** City greening
- **Location:** Hamburg, Germany

Context and objectives

Urbanisation exerts a variety of pressures on biodiversity (e.g. habitat fragmentation, destruction and disturbance) and may facilitate the spread of invasive species (Kronenberg et al., 2013). Green roofs can enhance urban ecosystems and thus mitigate biodiversity loss to some extent. They are also frequently implemented as part of climate adaptation plans due to their demonstrated capacity to reduce storm water run-off and mitigate heat island effects. Generally, green roofs provide benefits both to the public (e.g. rainwater storage) and to private users (e.g. thermal insulation and reduction of local stormwater fees). Hamburg is a pioneer in the development of a comprehensive Green Roof Strategy with the overall goal of developing 100 hectares (ha) of green roof surface in the metropolitan area. This will be implemented on existing and new buildings.

Scaling insights

The scaling potential of green roofs depends on awareness about this solution’s economic advantages; willingness to invest and accept the corresponding legal requirements; and the availability of suitable roof surfaces. While the benefits of green roofs are well-known in the scientific community, the real estate market does not reflect or promote the long-term economic advantages of green roofs. These advantages include lower cooling and heating costs for upper floors, and lower roof maintenance costs that can compensate for the up-front cost of green roof installation (Clar and Steurer, 2021). This lack of awareness contributes to a low level of demand for such features in the real estate market, despite the incentives offered by the city. Hamburg municipality provides financial support, which partly compensates for the higher installation costs. It also offers reduced stormwater fees, recognising the public benefits of rainwater retention provided by green roofs (Clar and Steurer, 2021). However, these barriers have been addressed in new urbanisation areas, where planning regulations make green roofs obligatory for all buildings with flat roofs; but in these cases, only reduced stormwater fees are offered as incentives for their realisation (Clar and Steurer, 2021). Scaling green roof implementation is physically limited by the availability of adequate surfaces with the correct inclination and suitable construction. This restrains the widespread implementation of green roofs in existing urban areas, even in the case of planning regulations or bylaws. In fact, such obligations would become effective only in the case of re-building, restructuring or other building works requiring building licences.

Case 2. River catchment restoration

- **Thematic area:** Agriculture and river catchment restoration
- **Location:** Tullstorpsån, southern plains of Sweden (Skåne County)

Context and objectives

The Tullstorp Stream Project is a stream catchment restoration project. Uniquely, it is operated by an association of all landowners along the stream, i.e. the Tullstorp Stream Economic Association (TSEA) (Tullstorpså Projektet, 2023). Located in the southern plains of Sweden, a region known for its agricultural potential, the Tullstorp Stream (or Tullstorpså) is 30km long. The project takes a holistic approach to the entire 6,300ha catchment area. Since its inception in 2009, 39 wetlands and 10km of the stream have been restored by re-meandering, riverbed restoration, levelling riverbanks, creating buffer strips, flooding areas and planting trees. The project also led to the construction of multifunctional water reservoirs, recirculating irrigation and customising drainage. The goal of the Tullstorp restoration project is to achieve ecological benefits (consistent with the Water Framework Directive objectives) and economic benefits for landowners by making the territory more resilient to climate change. For this, several NBS have been implemented to reduce nutrient leaching into the Baltic Sea, protect the area from flooding and drought, improve ecological conditions in the catchment area, and make river management easier for landowners. While inundated floodplain areas can cause local crop losses, increased water retention can benefit agricultural production during long periods without rainfall (Wamsler et al., 2016).

Scaling insights

The scalability potential for this type of project is high, both in Sweden and across parts of northern Europe subject to similar climate challenges (EEA, 2021). The TSEA is already assisting landowners in another catchment area (the Ståstorp Stream) to scale out the approach. However, in different conditions, e.g. in drier areas or areas subjected to more extreme events, this approach may not be appropriate, or may come at a higher cost with lower benefits. To promote this type of NBS project, a multi-actor approach is needed to develop integrated catchment programmes and agree with landowners on compensations for potential yield loss. In the Tullstorpsån case, bottom-up processes driven by landowners from the start guaranteed a strong sense of ownership and buy-in, which enabled large-scale restoration measures to be implemented. The main barrier to scaling the project was the lack of funding: the measures taken are costly, and irrigation and drainage projects are not always considered in national funding programs (TSEA, 2020). With sufficient external funding, scaling out and scaling up is feasible. Large, publicly funded wetland restoration programs exist in the Netherlands, the UK and Germany, for example. Scaling deep, i.e. the structural integration of the measures in mainstream agricultural practice, would require fundamentally different economic incentives and consumption patterns, as well as corresponding regulations. This would contribute to climate-proofing agriculture on a larger scale and to food security.

Case 3. Peatland restoration

- **Thematic area:** Paludiculture
- **Location:** Mecklenburg-West Pomerania, Germany

Context and objectives

As defined by the Greifswald Mire Center, 'paludiculture' is the productive land use of wet and rewetted peatlands that preserves peat soil and thereby minimises CO_2 emissions and subsidence (EU Peatlands & CAP Network, 2021). Paludiculture provides multiple benefits related to soil restoration, water retention and water quality by cultivating plants suited to very wet conditions. These include reeds, sedges, willows and peatland species. The produced biomass can be used for food, construction materials, biofuels and pharmaceuticals. Paludiculture has the potential to generate important climate mitigation and adaptation effects, as the restoration of water storage functions helps prevent inundations and droughts.

In the federal state of Mecklenburg-West Pomerania, 291,361 ha are peatlands. Currently, 57% of the state's peatland area is used for agriculture and therefore drained, causing greenhouse gas emissions of 4.5MtCO_2 per year. Moreover, lowering the groundwater table leads to a large loss of water, exacerbating climate change impacts e.g. droughts. To address this situation, a technical strategy for implementing paludiculture was developed by the Mecklenburg-West Pomerania Ministry of Agriculture and the Environment in 2016/2017 (Greifswald Mire Centre, 2017). An interdisciplinary working group from nature conservation and agriculture, among others, discussed and accompanied the development process (Greifswald Mire Centre, 2017).

Scalability insights

Paludiculture could, in theory, be implemented in many degraded peatlands. However, reversing agricultural land use is not easy, and some agricultural transformations may be irreversible. This calls for a clear assessment framework to evaluate the feasibility of paludiculture. Paludiculture remains a very recent NBS which has mostly been implemented in Germany and the Nordic countries. The scaling out of paludiculture is currently restrained by the limited demand for this new system and its products. Scaling up is limited by a few constraints, too. Specifically, rewetting peatland requires coordinated water management rules across all land users. Scaling up depends on market valorisation and value chains for the produced commodities (food, feed, fuel and fibre), and it requires specialised farming practices and technology. For scaling deep, paludiculture deployment would require support from a variety of actors. New policies could and should support transformation into paludiculture through a mix of regulations, subsidies and market instruments. Holistic approaches to value chain development, including financial incentives, would need to be designed and implemented. The public sector could also play a role in supporting private investment and risk-taking by developing guarantee mechanisms. Carbon markets can be a significant economic lever based on the mitigation benefits of peatland rewetting. Guidance on how to transfer criteria and quantification methods to other regions, in order to use extended carbon credits as a new instrument for financing peatland protection, is described in MoorFutures (Joosten et al., 2016).

Costs and benefits need to be clear to stakeholders

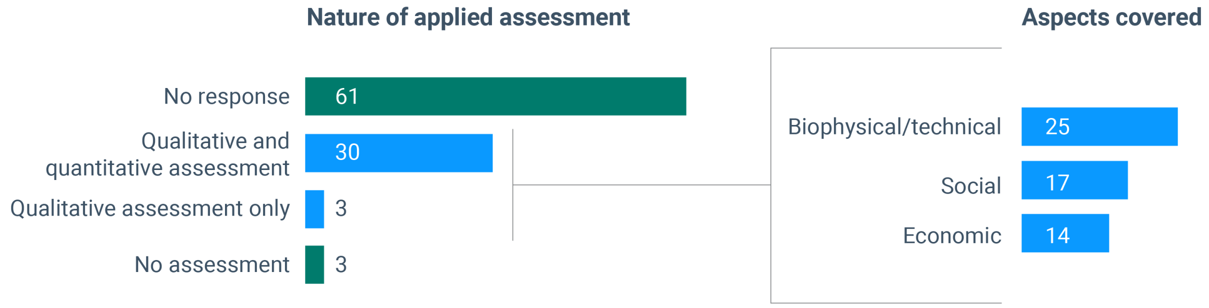
Scientific evidence of the multiple benefits of NBS is rapidly expanding, but the approach is still new. Unfamiliarity with measures, and uncertainty about the results, may hamper uptake at a wider scale. Socio-economic aspects and cost considerations are crucial due to their key roles in securing stakeholder buy-in and attracting private investments.

Capturing social and economic aspects

If costs and benefits to different stakeholders and societal groups can be monetised, the financial return on investment, or cost efficiency, can be determined. Quantification in non-economic terms, though, may still provide insight into the cost effectiveness of solutions where monetisation is difficult, e.g. for recreational opportunities, air and water quality, and human health and well-being. Assessments can be done ex-ante to support initial decision-making or ex-post, assessing the results that were actually achieved. Monitoring during the operational stage can inform about the implementation of measures and their preliminary results.

Although a key argument for NBS is cost-effectiveness, the majority of the NBS cases reviewed did not capture their results in these terms (Figure 2). Out of 29 cases, for which sufficiently detailed quantitative information is available, about half have assessed social and economic parameters. In the ex-ante phase, three projects have specifically assessed cost-effectiveness, net present value and cost-benefit ratios to underpin the decision-making process. In the operational and ex-post phases, the assessments mainly focus on outputs in biophysical and technical terms rather than capturing the full range of benefits. Return on investment does not appear to be assessed in any of the cases.

Figure 2. Assessment approaches in selected NBS cases



Source: ETC/CCA, 2021.

Going beyond public funding

The case studies largely relied on public financing and reported a diversified portfolio of funding sources, e.g. local, national, EU funding and private sources. Applying dedicated assessment frameworks (Calliari et al., 2019) may help make the business case for NBS and tap into private funding sources. Regulation can also be instrumental in transitioning NBS business models from public to private funding, as illustrated in the Hamburg Green Roof case where implementation has become mandatory. Such governance practices can increase the overall NBS uptake, but distributional effects need careful consideration, as the solution may only become available to those who can afford it (see also the section "Avoiding inequity" for more detail on 'just resilience').

Implementation relies on data and knowledge sharing

The literature on NBS points to a variety of limiting and success factors (Table 1). Prominent among these factors are available knowledge and data, particularly on feasibility and cost effectiveness in comparison to alternatives; the level of stakeholder involvement; and access to financial resources. Knowledge sharing among all parties involved is key and requires adequate monitoring mechanisms, as well as common indicators and reporting standards.

Assessments that demonstrate NBS effectiveness to decision-makers, at the relevant scale, can also facilitate cross-departmental collaboration and knowledge sharing. They can create new evidence of social, environmental, and economic costs and benefits, while facilitating access to funding and financing. EU-funded analyses of NBS effectiveness at different scales (e.g. Operandum, 2022) can facilitate cross-departmental collaboration and knowledge sharing. Levers and barriers for NBS can also be assessed at national level, providing insight in the national policy context for NBS and coherence with climate change adaptation objectives (Best and Hochstrasser, 2022).

Table 1. The success and limiting factors of nature-based solutions in adaptation and disaster risk management

Limiting factors of NBS	Success factors for NBS
Lack of political support	Supporting plans, acts and legislation. Policy mechanisms are available to address gaps and encourage uptake
Poor stakeholder engagement and attitudes	Positive stakeholder engagement and attitudes
Social and cultural constraints due to e.g., cultural preferences for certain aesthetics (what a landscape should look like), risk perceptions relating to different management practices and sense of ownership and place	Participatory approaches engaging a range of stakeholders, which may include awareness building, giving a voice and co-creation and/or co-management
Physical and biological constraints due to e.g., degraded ecosystems as a starting point for NBS intervention	Availability of existing healthy ecosystems or ability to improve degraded ones
Lack of land or space constraints for implementation	Adequate scale of implementation and cooperation across landowners. Incentives to encourage cooperation
Lack of cooperation and consent across landowners and agencies	Alignment of activities across agencies including shared institutional structures. The use of trusted agents and stakeholder engagement throughout planning and implementation
Incomplete demonstration of own or comparative benefits (e.g., knowledge gaps on limits and thresholds under which NBS approaches might not deliver adaptation benefits) and unclear cost effectiveness	Demonstration of multiple co-benefits including multiple ecosystem services. Demonstration of cost effectiveness in comparison to alternatives, including for successful integration with grey infrastructure with demonstratable benefits and leading to optimal planning and design
Demonstration of effectiveness not tailored to purposes or not at an appropriate scale (e.g., water runoff reduction only demonstrated at plot level but not at catchment scale) and imbalance of knowledge sources underpinning assessments	Demonstration of effectiveness for the purpose at adequate scale, including adequate monitoring mechanisms
Gap of knowledge between private benefits to individual entities and broader social costs and benefits for communities. Time lags in achieving and observing benefits	Demonstration of both private and social costs and benefits over the short- and long-term
Evidence is context specific and often not transferable and is not shared	Existing knowledge and/or ongoing research and monitoring with common indicators, and innovation and demonstration projects (incl. Reporting standards). Established knowledge sharing mechanisms, education and training

Lack of finance for implementation of NBS (e.g., for land acquisition/compensation) and maintenance	Availability of finance. Multiple sources of finance linked to multiple benefits and multiple ecosystem services. Early budgeting and assignment of funds and responsibilities to meet maintenance needs
Difficulties in NBS tendering process (e.g. lack of knowledge on how to present a convincing business case for NBS, lack of track record, lack of (experienced) suppliers, path dependency favouring engineered solutions)	Engagement with NBS technical and NBS economics experts to gather supporting evidence for robust business case development. Early cross-departmental collaboration including engaging with procurement and finance units. Consideration of alternative procurement and delivery mechanisms outside own procurement

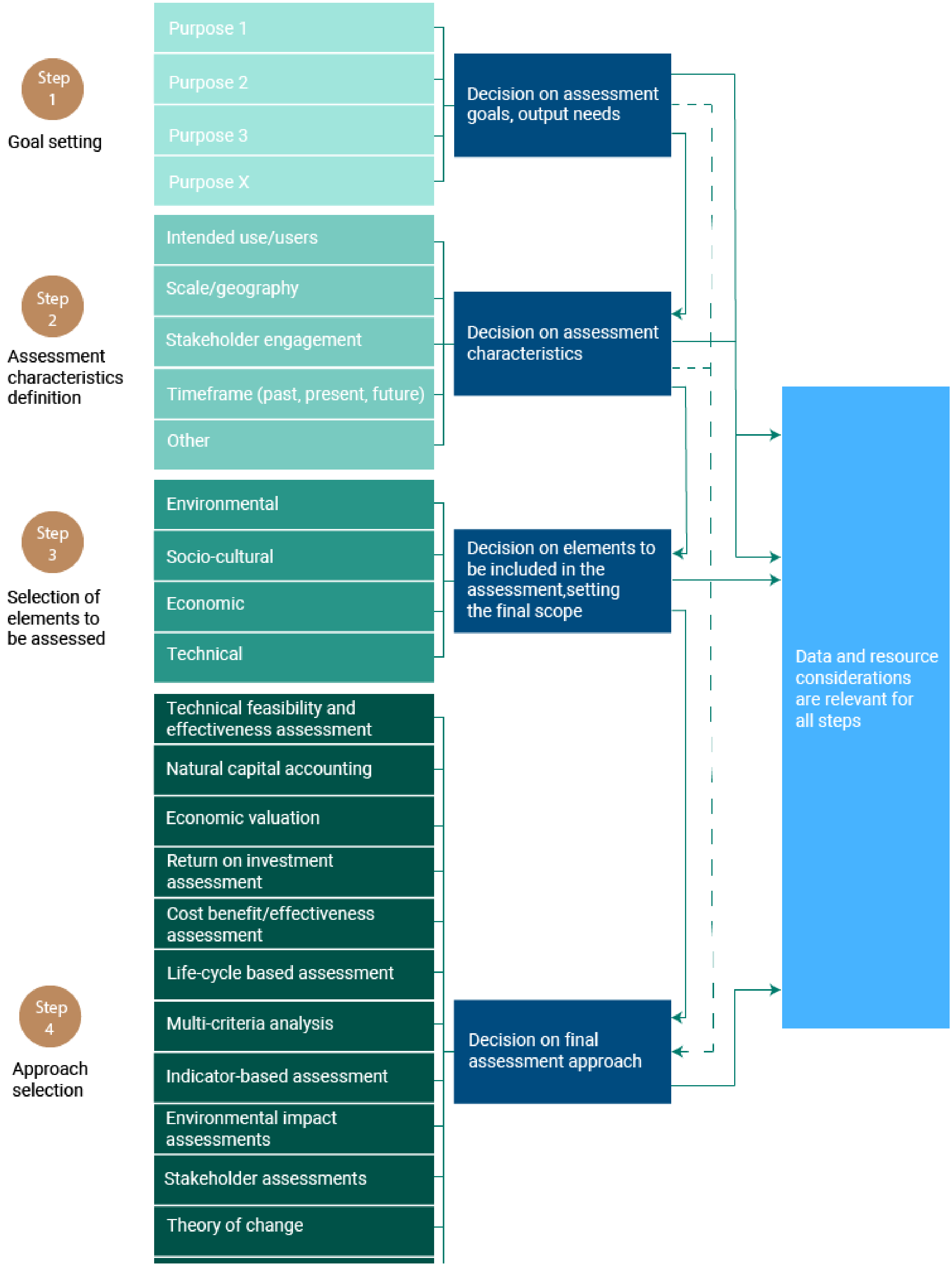
Sources: based on EC, 2020b; McVittie et al., 2018; Nalau et al., 2018; Sarabi et al., 2019; NAIAD, 2021.

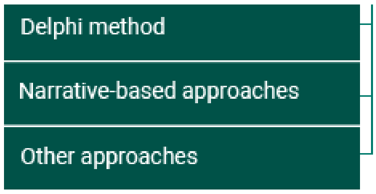
Assessing what matters

Assessing NBS performance (e.g. quantifying the multiple benefits and trade-offs of NBS) while following common standards, and using agreed-upon targets and indicators, is crucial for mainstreaming NBS into regulations, norms and plans (ETC/CCA, 2021). The resulting monitoring, evaluation and learning data can inform the development of policies aiming to mainstream NBS in land management and urban development. A lack of detailed and standardised assessment methods, reporting protocols and technical guidance is a major obstacle to scaling and replicating NBS.

NBS assessment frameworks are available (EC, 2021b) but navigating the complexity of design options and evaluation methods remains a challenge. The ETC/CCA report (2021) proposes a practical step-by-step framework for designing NBS assessments, building on key success factors and limitations identified in the literature (Figure 3).

Figure 3. Framework for NBS assessment design process





Sources: Own elaboration partially inspired by EC, 2021a and EC, 2021b (Chapter 6).

Data and resource considerations will inform the decisions to be made at all stages, especially for the purposes, goals and corresponding outputs. Each NBS assessment will thus be tailored to its context and purpose.

Inclusive governance

Increasing stakeholder engagement

Where NBS impact landowners or the general public, stakeholder involvement and co-design are key to furthering buy-in and ownership. Stakeholder involvement can also improve the design of the NBS project and the assessment approach itself. A high degree of stakeholder involvement was found in the Tullstorpsån case where local landowners were instrumental in developing the assessment approach. Stakeholder engagement requires time and dedicated processes for co-creation. Taking into account the local knowledge and expertise of multiple stakeholders is key for successful NBS implementation, and for strengthening synergies between climate change adaptation and biodiversity (Kozban et al., 2023).

Improving measure cohesion and planning

Diffuse uptake of NBS has the advantage of the enabling approaches being tailored to local needs. At the same time, this may lead to suboptimal and inconsistent approaches at the landscape scale. Furthermore, tapping into regional funding may be hampered by the lack of an overarching implementation strategy. To develop solutions on a regional scale, it is therefore essential to have a public or private coordinating body that facilitates integral planning at the regional scale, and cooperation with sectors and public authorities.

Avoiding inequity

The European Commission and international conservation organisations, e.g. the International Union for Conservation of Nature (IUCN), World Wildlife Fund (WWF), BirdLife International and

Conservation International, have advocated for and supported community-led, ecosystem-based approaches for climate adaptation and/or ecosystem-based disaster risk reduction projects across the globe. The local implementation of these projects has shown that NBS require a broad range of stakeholders with different types of experience and expertise to work together. Even in the case of green roof regulations that seemingly bypass stakeholder engagement, there will typically be a pilot stage where buy-in, feasibility and effectiveness are tested.

Stakeholders may perceive problems and solutions differently from each other. Implementation can bring co-benefits but also disservices and disbenefits to specific people, such as restricted access, productivity loss or the spread of unwanted species. Thus, NBS need to be well-planned and preferably co-designed with local actors, and enhance a collaborative learning process, including adequate documentation of successes and failures in the process (Budding-Polo Ballinas, et al., 2022).

In the cases reviewed (ETC/CCA, 2021), none of the NBS assessments looked specifically at ‘just resilience’ and how climate change and disasters may, or may not, impact different groups differently. Some stakeholders may face constraints related to access to natural resources, credit, markets or even infrastructure. In addition, there are knowledge gaps regarding NBS effectiveness and implications for different stakeholders, resulting in potential pushback from mainstream economic actors in the wider rural and urban context (Budding-Polo Ballinas, et al., 2022). Understanding the socio-economic benefits of NBS projects can help overcome certain barriers and obtain support from the right stakeholders and investors.

Conclusion

The case studies show that NBS are adopted across a wide range of issues and regions. Their strength lies in a stakeholder-driven multidimensional approach aimed at increasing biodiversity and, at the same time, delivering multiple socio-economic benefits. The urgent need to adapt to climate change may be a powerful driver for enhancing biodiversity in urban and rural settings, and outside protected areas. The extent to which NBS can deliver on this promise will depend on systemic application beyond the local scale.

The scaling potential of NBS depends, to a large extent, on their socio-economic context, as well as on biophysical, cultural and governance factors. While conceptual frameworks for the assessment of NBS are available, socio-economic parameters are not yet routinely monitored in the majority of the NBS cases studied. Closing this information gap will help make the case for fairly implementing NBS at a wider scale, and for attracting private funding. Most of the case studies are still pilot projects relying predominantly on public funding.

To mainstream the NBS concept and the diversity of the solutions it encompasses, regulatory measures and institutional arrangements would be needed to create the boundary conditions and financial incentives for wider uptake and private investment (EIB, 2023). Implementation would also benefit from more targeted and coordinated governance. To realise the full potential of NBS, a scaling plan would be needed (ETC-CA, 2022). A taxonomy of NBS could be established with baseline data, including regional risk profiles, the scale of existing initiatives and potential areas for wider application. Further quantification of potential costs and benefits is also needed to channel funding, both public and private, into implementation at scale.

Notes

[1] The EC proposal was passed in the European Parliament (July 2023), with amendments. The final adoption by the European Council is pending.

[2] For example, the United Nation Sendai Framework on disaster risk reduction, the United Nations Framework Convention on Climate Change, the United Nations Convention on Biological Diversity, the United Nations Convention to Combat Desertification, the EU Green Deal, the EU Adaptation Strategy, the EU Green Infrastructure Strategy and the EU Biodiversity Strategy.

[3] Extracted from the following NBS-platforms: Climate-ADAPT; Natural hazards-nature-based solutions; Naturvation; NWRM; OPPLA; PANORAMA; weADAPT.

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