Addressing scale in nature-based solutions

SEI discussion brief
October 2022

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IMAGE (ABOVE): Mangrove trees at low tide, Australia © VICKI SMITH / GETTY

Key messages

- **Despite the growing interest in the use of nature-based solutions (NbS) to adapt to climate change, little is known about how to effectively scale up such measures to achieve wider benefits for society, biodiversity and the climate.**
- **NbS planning should thus seek to explicitly model cumulative and combined effects to inform the design of projects to address issues involving scales of time, landscapes, and jurisdictions involved.**
- **NbS designs should set quantitative targets and create monitoring systems to systematically measure outcomes and report on progress.**
- **NbS designs should implement "no regrets" options – that is, they should devise strategies to maximize positive outcomes and minimize negative outcomes in the short and long terms and irrespective of climate change. This is particularly important in light of the longer time scales that NbS often entail, the time pressures to adapt fast enough to reduce risk, and the desire of politicians facing short elective cycles to respond to constituents' needs.**

Introduction

Nature-based solutions (NbS) are "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits" (United Nations, 2022). The literature on NbS often alludes to the need to implement such projects with a landscape approach (Calliari et al., 2019), but the term is ill defined. For a long time, landscape planning focused on the protection of exceptional natural areas and on overseeing the appearance of the built environment. More recently, however, the term has evolved to recognize the importance of landscapes for people's quality of life, highlighting the need to adopt a more comprehensive approach that incorporates human well-being (Selman, 2006). Landscapes have therefore come to be understood as the result of interactions between human and natural elements (Council of Europe, 2000).

This shift raises important issues for the design, monitoring and governance of NbS. Where does a landscape begin or end? What is the right scale for landscape interventions? How should one assess performance in relation to the many and sometimes contradictory goals for biodiversity, societal benefits, mitigation and adaptation today and in the future? What metrics should be measured to understand whether NbS are adequate and effective?

DEFINING NATURE-BASED SOLUTIONS (NBS)

A resolution adopted by the United Nations Environment Assembly (UNEA) at the fifth session (2021-2022) frames NbS as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits" (United Nations, 2022).

ABOUT THIS SERIES

The key levers of change for our seas and coasts revolve around the need for an integrated climate, biodiversity and development agenda. Nature-based solutions (NbS) are increasingly seen as an important piece of the puzzle for delivering multiple and sometimes contradictory goals. If these options are to succeed, assessments of these options must go beyond simplistic promises of this win-win discourse. What are the potential pitfalls of NbS? What questions must be asked and answered to overcome these issues? This brief focuses on the social equity and justice dimensions and implications of NbS-related design, governance and implementation.

Scale

These questions are essentially about scale and the governance of processes that determine scale. Scale is a complex concept with many dimensions, including temporal, spatial, jurisdictional, and analytical elements (Herod, 2010; Jonas, 2006; Leitner & Miller, 2007; cf. Marston et al., 2005).

Temporal aspects, or time frames (Cash et al., 2006), of NbS are complex, dynamic and difficult to assess within conventional planning and policy-making periods. It can take years, or even decades, to realize the effectiveness of some NbS interventions. For example, interventions in forest landscapes take many years to establish and they offer benefits that go beyond the boundaries of the forest itself (Powell et al., 2019).

The breadth of impacts, costs and benefits of interventions differ widely, depending on their scale and on their location. The impact of time on biological variables such as species composition, traits and their position in the food web to landscape modifications occurring in different spaces of differing sizes are still poorly understood (Metzger et al., 2009).

Some NbS, especially those involving the restoration of badly degraded ecosystems, can be slow to achieve adaptation benefits or to deliver potential co-benefits in full. For example, roughly 10 years passed before the full impacts could be realized from the world's largest and longest regreening effort: the Conversion of Cropland to Forest Program (also known as the "Grain for Green" programme), initiated by China in 1999 (Qiu et al., 2011; Zhang et al., 2017).

Time frames of NbS – and more specifically the delivery of the benefits from NbS – are many times seen in relation to the benefits from more conventional interventions (i.e., grey infrastructure). On the one hand, protective grey infrastructure projects, such as flood walls, typically achieve the desired benefits almost immediately (Kabisch et al., 2016). But while grey infrastructure projects may generate immediate returns, they also depreciate more quickly. On the other hand, over a longer time frame and under climate change, some NbS might also depreciate or generate maintenance costs, as is the case with beach nourishments. However, depreciation and maintenance requirements are not easily comparable to those of grey infrastructures, where standardized costs and processes are more established (Mayor et al., 2021; Seddon et al., 2020; Smith et al., 2009; Toxopeus & Polzin, 2021; Van Oijstaeijen et al., 2020). Ultimately, due to the time-lagged responses of NbS, a challenge is that they may not yield the risk-reduction effects within the time frame needed to meet the challenges that societies face (World Bank, 2017). This is particularly true when considering time frames in relation to **jurisdictional scales**. Political cycles are far shorter than natural ones, and, as a result, short-term planning may lead decision-makers to prioritize solutions with fast results to deliver to their constituents more quickly.

Spatial scale refers to the extent of a process or issue (Lloyd, 2014). The spatial scale considered for planning NbS substantially affects their ability to deliver expected outcomes for various reasons (Calliari et al., 2019). First, ecosystems depend on landscape-level processes, and as such, their integrity and health will determine the effectiveness of NbS (OECD 2020). For example, coastal interventions largely depend on changes in upstream sediment loads that influence downstream coastline stability. Similarly, pollinators in cities depend upon the habitat and resources available and their composition within an urban matrix; resilient pollinator communities materialize once the landscape provision as a whole is enough to support them (Baldock et al., 2019).

Understanding of spatial scale has implications for how to assess the performance of NbS. Despite calls for a landscape approach, monitoring of NbS is often spatially limited. For example, research on wetlands, a well-studied type of NbS, shows that there is a mismatch between the scales at which hydrological changes take place and the scales at which observations and predictions are made (Thorslund et al., 2017). The changes in land use, water use and climate that impact wetland functions and services have impacts far beyond the scale of the individual wetland. Thus, to achieve landscape-level change, NbS cannot be managed through individual sites in isolation because the delivery of expected ecosystem services will depend on processes taking place on larger scales (OECD 2020).

Lastly, the effectiveness of measures is also connected to scale. In contrast to the standardized measures available for grey infrastructure projects, each type of NbS intervention is unique. For example, evidence suggests that natural water-retention measures such as buffer strips, reforestation, and hedgerows, can be effective in small catchments but may not have the same effectiveness when upscaled to larger areas (Collentine & Futter, 2018). For catchments, the impacts of the interventions decrease as watershed sizes increase; this is due to offset effects such as storage capacity of the river bed and the self-cleaning capacity of the river (Kiersch, 2000). At the same time, some impacts such as salinity can become more important with increasing scale because of accumulation effects. Green solutions such as buffer strips and wetlands have long been used as multifunctional measures in agriculture (Andersson, 2012; Graversgaard et al., 2021; Thorslund et al., 2017). However, in more urban or industrial sites, the space dedicated to NbS often implies that the land cannot be used for another productive use. Thus, in places where the space requirements for NbS are particularly difficult to meet, interventions then tend to be smaller and disconnected from ecosystem flows (van Wesenbeeck et al., 2017).

Emergent issues of scale: implications for governance

While much of the effort to address scaling of NbS has focused on spatial and temporal issues, more work is needed to tackle the combined implementation challenges of time *and* space (Barquet et al., 2021). The governance of NbS is aligned to the bounded and organized political units in which they are located (e.g., cities, towns, counties, states, provinces and nations), which in turn are governed by constitutional and statutory regulations (Cash et al., 2006). There are usually jurisdictional implications when proposing NbS, especially at large spatial scales; this is because interventions often require involvement, negotiations and collaboration with multiple stakeholders including diverse landowners (Albert et al., 2019). The need to address these matters adds to the time and costs of engagement across the regulatory jurisdictions and may lead to confusion over responsibility. Moreover, even the responsible authorities (such as flood-management authorities) that provide adaptation services for water-related risks may not have the capacity or legal legitimacy to engage with landowners and users (OECD, 2020).

Institutional arrangements also have specific jurisdictional characteristics that fall into a hierarchy of rules, ranging from basic operating rules and norms to systems for making rules or constitutions (Ostrom et al., 1999). The involvement of large numbers of stakeholders increases the difficulty of organizing, agreeing on rules, and enforcing rules. Additionally, the implementation of NbS also faces various regulatory barriers (Powell et al., 2019; Whelchel et al., 2018). Though these exact barriers differ by location, regulations are generally designed for more traditional, grey infrastructure.

Finally, there are benefits to including different sources of knowledge in the context of scale to bridge the gaps between different kinds of information. For example, sources of information comes from both the highly generalized knowledge and understanding from formal science, and from the practical understanding from local or traditional knowledge sources; incorporating both sources can provide needed cross-level interaction of different knowledge systems (Cash et al., 2006; Palomo et al., 2021).

The very nature of NbS translates into **implementation** challenges that raise issues of scale (Cousins, 2021). The promises of multiple benefits may be attractive for tapping into different global discourses concerning sustainability, adaptation, and green recovery; but from a planning approach, NbS demands shared responsibilities and a requirement for the coordination and cooperation across administrative levels, governmental structures, and jurisdictional boundaries. Understanding their governance and how benefits accrue at different spatial scales is fundamental (Demuzere et al., 2014; Pataki et al., 2011). Several knowledge gaps remain that pertain to processes that define how to provide, govern and distribute ecosystem services across the urban landscape (Brink et al., 2016; Haase et al., 2014).

From an institutional perspective, governing NbS is complex because of the regional reach that changes may have upon landscapes, with costs borne by one area and benefits accruing to another. For example, after Hurricane Sandy hit the United States in 2012 many of the areas located upstream of wetlands benefited from reductions in damages that stemmed from flood-reduction mechanisms employed in downstream wetlands (Narayan et al., 2017). This is a challenging issue. Those who receive the upstream benefits are often in different communities than those impacted by the land allocation or the payment required to fund the interventions, meaning that the benefits and the costs of establishing NbS may not be spatially equitable. Thus, there is a need to find appropriate mechanisms to improve cross-level and cross-jurisdictional coordination (Nelson et al., 2020).

Additionally, no stand-alone method currently exists to monitor the performance of NbS to encompass dynamics of scale. For example, connecting freshwater management with coastal and marine planning is well recognized as key for attaining good ecological status in the European Union Water Framework Directive (EU Water Framework Directive, 2000); yet, monitoring of water-based interventions or species remains fragmented. Furthermore, few studies have monitored NbS throughout the lifespan of projects (before and after project execution) or analysed whether the multiple benefits that NbS were expected to deliver (for example, for both upstream and downstream communities) were, in fact, achieved (Kumar et al., 2021).

Conclusions

Efforts to scale up NbS as a strategy to help reduce risk and adapt to climate change are the subject of growing debate. Despite increasing interest in mainstreaming NbS from both public and private actors, little is known about the mechanisms and conditions for scaling up NbS in practice or how upscaling can be brought about. There is a risk that large-scale implementation of NbS will also lead to large-scale maladaptation and adverse effects (Barquet et al., 2021). Therefore, NbS need to be explicitly designed to deliver measurable benefits for nature and society. Such efforts require baseline assessments to establish monitoring systems to achieve multiple benefits and to systematically report progress towards quantitative targets. Such steps will help shed light on the spatial scales and timeframes over which NbS can deliver benefits to society, biodiversity and climate.

The different dimensions of scale could be better incorporated in the future design of NbS as follows:

- **Spatial scale** – Create connections between monitoring tools. For example, assessments of freshwater interventions should link with downstream impacts on rivers, coasts and marine areas.
- **Analytical scale** – Model cumulative and potentially combined effects to inform NbS design.
- **Jurisdictional scale** – Design for quality rather than quantity. Scenario approaches could be useful to identify areas where action is most needed and is likely to be most effective.
- **Temporal scale** – Implement "no regrets" options. That is, devise strategies to maximize positive outcomes and minimize negative outcomes in the short and long terms.

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SEI Stockholm Environment Institute

Published by
Stockholm Environment Institute
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104 51 Stockholm, Sweden
Tel: +46 8 30 80 44

DOI:
https://doi.org/10.51414/sei2022.043

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