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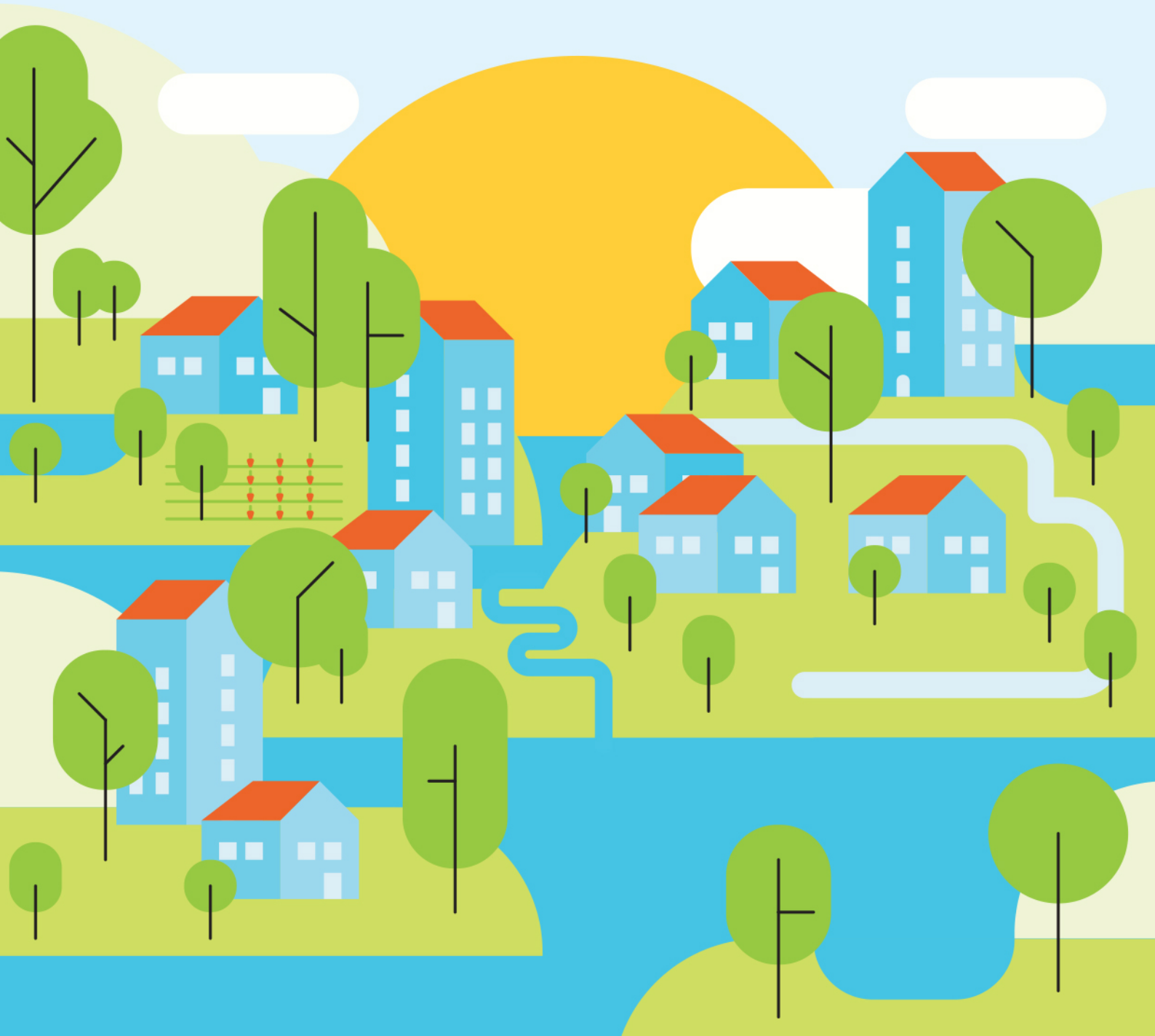
Oxford Infrastructure Analytics

UNIVERSITY OF OXFORD

NATURE-BASED INFRASTRUCTURE (Executive Summary)

How natural infrastructure solutions can address sustainable development challenges and the triple planetary crisis



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Executive Summary

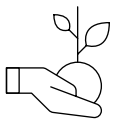
Countries are facing global challenges of development, climate change, and biodiversity loss. Decisions on infrastructure are an essential component of meeting these challenges. A disproportionate focus on built infrastructure is leading to negative outcomes, including driving climate change through greenhouse gas (GHG) emissions, and the loss and degradation of nature (Seiler 2003; Ibisch et al. 2016). Nature-based infrastructure solutions (NbI) offer decision-makers opportunities to address these challenges simultaneously and progress development agendas including the 2030 Agenda for Sustainable Development, the Paris Agreement and the Convention on Biological Diversity, through strategic integration with built infrastructure systems.

It is estimated that almost US $100 trillion of investment in infrastructure is required globally by 2040 (Global Infrastructure Hub 2022). Investments in infrastructure lock in patterns of development for decades to come, whether that be positive or negative. Finite resources mean that countries need to invest wisely and in solutions that can maximize benefits and minimize negative trade-offs (Thacker et al. 2019). It is therefore imperative that NbI are factored into infrastructure planning from the outset, to ensure they are optimized for climate-compatible development.

The purpose of this report is to assess the contribution that NbI can make to addressing global sustainable development challenges, with a view to increasing awareness and uptake. It provides a framework for thinking about NbI and the benefits of its deployment as an alternative or complement to built infrastructure, and identifies barriers to scaling its deployment. This report provides recommendations for overcoming the barriers and for increasing implementation of NbI as a key component of sustainable infrastructure systems.

A framework for thinking about NbI

This report provides a framework for thinking about nature-based solutions (NbS) in the context of infrastructure service delivery. Following Haggis et al. (forthcoming), and building on the work of Ozment et al. (2015) and Browder et al. (2019), this report defines five functions through which NbI can provide benefits to infrastructure and beyond, with respect to the provision of services:



Deliver Function

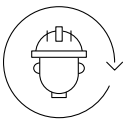
Deliver infrastructure services directly, therefore substituting for built assets.

Enhance Function

Enhance infrastructure service delivery, therefore complementing built assets.

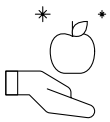
Protect Function

Protect infrastructure service delivery by protecting built assets and/or the resources upon which they depend from the impacts of climate change and natural disasters.



Workforce Function

Provide benefits to sector workforces and as such benefit the human capital that underpin the functioning of infrastructure systems.



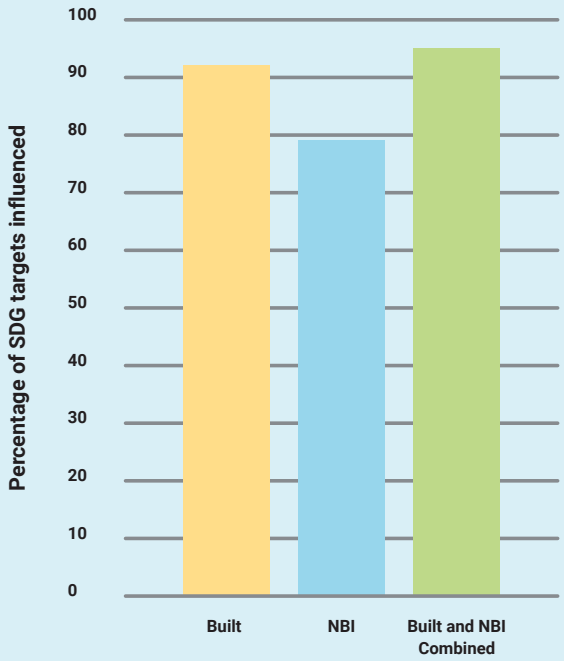
Multiple Additional Benefits Function

Provide multiple additional benefits, including social, environmental, and economic benefits, beyond the primary infrastructure service being delivered.

The role of NbI in sustainable development

The applicability of NbI to some infrastructure sectors, such as water, is well-known (e.g. UN 2018). However, by assessing the potential for nature to provide services to infrastructure across a range of sectors, this report finds that NbI has much broader applicability to infrastructure, and that all infrastructure sectors can integrate NbI via one or more of the five functions. Three sectors – culture and recreation, health, and water - can deploy NbI to deliver the service of their sector directly. Ten sectors – buildings, education, energy, finance, health, manufacturing, retail, solid waste, transport, and water – can implement NbI to enhance the quality, quantity and reliability of the service. All sectors can derive benefits from NbI through the "protect", "workforce", and "multiple additional benefits" functions. The systematic consideration of NbI across all sectors is necessary to ensure that the value of NbI is recognized and factored into infrastructure decision-making as a means of providing services and benefits.

Figure 1. The influence of built infrastructure versus NbI on the SDG targets



NbI and the SDGs

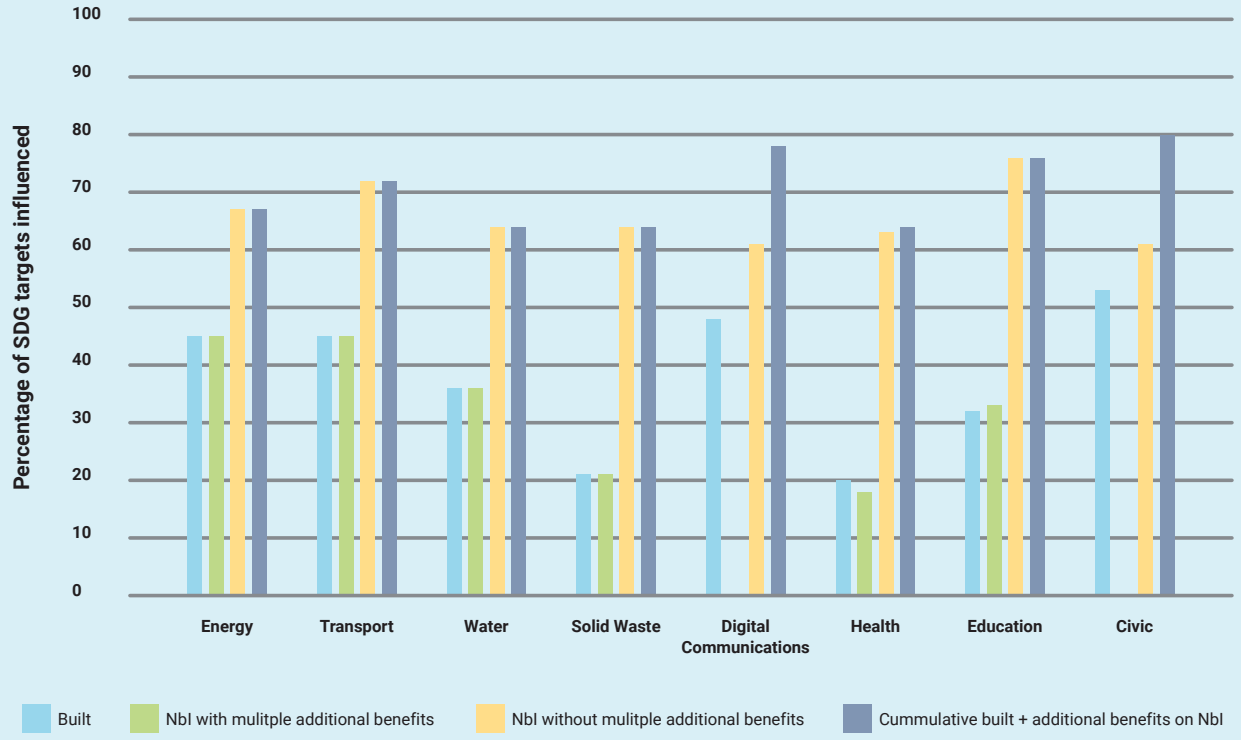
This report assessed the 8 infrastructure sectors that Thacker et al. (2019) report could influence up to 92% of SDG targets (civic, digital communications, education, energy, health, solid waste, transport, and water), and found that NbI can influence up to 79% of SDG targets across all 17 SDG Goals *(see figure 1),* including four targets that were not considered to be influenced by built infrastructure *(see table 1).*

Table 1. Targets that can be influenced only by NbI and not by built infrastructure across the eight infrastructure sectors considered by Thacker et al. (2019). Based on evidence from Blicharska et al. (2016); Fuldauer et al. (2022) and Thacker et al. (2019).

Target	Description	Justification
15.9	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.	Influenced via services including environmental education and value for scientific research.
15a	Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.	Environmental education: better understanding of ecosystems helps makes the case for increasing financial resources to conserve them.
15b	Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.	
17.3	Mobilize additional financial resources for developing countries from multiple sources.	

When NbI solutions are combined with built infrastructure assets, infrastructure systems can have greater cumulative impact on the SDG targets than either built infrastructure or NbI can alone, influencing up to 95% of SDG targets. For any individual sector, integrating NbI with built infrastructure can influence 24%-47% more SDG targets compared to the use of built infrastructure alone in that sector *(see Figure 2).* This is owing to the ability of NbI to provide multiple additional social, environmental and economic benefits in addition to the primary intended infrastructure service (Thorn et al. 2021; UNEP 2014).

Figure 2: Percentage of SDG targets influenced by infrastructure with and without built infrastructure with and without the mulitple additional benefits of nature



NbI and the Paris Agreement

In addition to the SDGs, NbI can also contribute to climate mitigation and adaptation objectives. On the adaptation side, NbI can protect infrastructure in all sectors from the impacts of climate change, as well as support national adaptation outcomes more broadly. Some NbI are also more flexible and adaptable to climate change, and therefore themselves more resilient to climate impacts than built infrastructure options (Ozment et al. 2015; Kapos et al. 2019). Through the provision of additional benefits, such as diversification of income streams, improved livelihoods, provision of food and other natural resources, provision of habitat and species diversity, NbI can support the wider resilience of economies, natural ecosystems, and societies, including indigenous communities and women.

The benefits of NbI for meeting mitigation targets associated with the Paris Agreement are well-known - the deployment of NbI can provide carbon sequestration services and avoid land use change. However, this report finds that NbI could have a potentially larger role in contributing to mitigation strategies across all infrastructure sectors. By substituting built infrastructure assets, NbI can remove or reduce GHG emissions embedded within the built infrastructure lifecycle, including within materials, transport, operation, maintenance and decommissioning of built infrastructure components. By complementing built infrastructure assets, NbI can help to reduce emissions embedded within the maintenance of built infrastructure, including through reduced requirements for dredging and mowing, and embedded within inputs such as flocculants. By protecting built infrastructure assets, NbI can extend the lifespan of built infrastructure components (Ozment et al. 2015), and the frequency at which they are maintained and repaired, leading to reductions in associated GHG emissions.

NbI and Investment

NbI options can also be more cost-effective than built infrastructure options (Browder et al. 2019). They can reduce the need for investment in built infrastructure assets, provide lower cost solutions compared to built infrastructure, reduce costs associated with built infrastructure maintenance, and generate multiple additional economic benefits, such as tourism, increased property prices and marketable products. They can also increase in value over time, as ecosystems mature (Ozment et al. 2015; Kapos et al. 2019; UNEP 2014).

There is an investment gap of US $15 trillion that will be needed by 2040 in order to meet the US $94 trillion required for infrastructure investment. At the same time, there is an annual average shortfall of approximately US $330 billion per year in funding for nature by 2030 (UNEP 2022). NbI can help countries to maximize the use of finite resources and close both the infrastructure and nature financing gaps. Through the deployment of NbI, infrastructure funds can help to bridge the nature financing gap, while nature funds can help to fill the infrastructure financing gap.

The barriers to NbI

The deployment of NbI has the potential to provide many benefits. However, NbI solutions are complex, and there are multiple uncertainties, challenges and constraints that mean that the deployment of NbI is not yet being planned, financed, and implemented consistently as part of mainstream practice. Key challenges include:

- **Time delays to benefit provision:** NbI options have different timeframes over which they develop, function and have capacity for service provision. Many take time to implement and achieve full potential for service delivery (Kapos et al. 2019; UNEP 2014), longer than built infrastructure options, and others have seasonal functionality, which can be a factor in suitability for implementation. Delays in benefit provision mean that cost-benefit ratios which underpin infrastructure decisions can change over time. However, not all infrastructure projects will require solutions to reach 100% potential for service provision immediately.

Figure 3: NbI is the only type of infrastructure that can contribute to mutual, synergistic progress on sustainable development, climate change, and biodiversity

- **Resilience of NbI:** the ability of NbI to persist, function and provide services is impacted by local and broader-scale socio-political and environmental conditions, including infrastructure development, agricultural intensification, climate change, invasive species, pests and disease. These factors are not all fully understood but need to be accounted for in decisions on NbI to ensure the solution will be viable long-term.

- **Data and information availability:** there are gaps in data and on the applicability of NbI to different infrastructure sectors, and the costs, benefits and potential effectiveness at service provision that impede the scaling of NbI. This includes data on implementation cost breakdown, maintenance costs, the outcomes of NbI, and their capacity for providing multiple additional benefits.

- **Management and maintenance:** the management and maintenance of NbI will impact the effectiveness of a solution. This can be challenging under social, economic and political contexts that change over time, and where funding or technical skills and institutional capacities for such activities are limited.

- **Trade-offs:** there are many potential trade-offs related to NbI that need to be balanced in the decision-making process to ensure that potential negative outcomes do not undermine progress on development, climate change, and biodiversity. For example, many NbI options require more space than built infrastructure options, which must be balanced against other needs, such as space to provide food.

- **Alignment and collaboration of multiple different stakeholders:** the deployment of NbI is complex and will involve a diverse range of stakeholders who have different beliefs, values, and potentially competing interests. Coordination and alignment of stakeholders—including across national and other administrative boundaries—will be a challenging but necessary part of scaling NbI.

- **Costs and who pays:** although some NbI can be more cost-effective than built options, there are various costs associated with implementation, management, and maintenance. Given that NbI can provide benefits to multiple stakeholders simultaneously, there are questions as to who should pay for the costs of NbI.

- **Transboundary decision-making:** both built infrastructure and NbI networks can extend across country borders - considering NbI within the context of transboundary infrastructure decisions will add another layer of complexity through the addition of more stakeholders who may have different interests, and costs and benefits which are distributed across borders. This will require coordination and cooperation of stakeholders on potentially regional scales, to implement, monitor and maintain the NbI long-term.

Recommendations

Overcoming the challenges and barriers to scaling will be complex and require:

- **NbI to be embedded into infrastructure and development planning:** Thinking on NbI needs to begin from the start of the infrastructure lifecycle, during the planning and design of infrastructure systems. This should include systematic consideration of NbI in infrastructure decisions, and the embedding of NbI into National Adaptation Plans, National Development Commitments, Nationally Determined Contributions and National Infrastructure Plans.

- **Valuation of the services and multiple additional benefits of NbI:** the potential for NbI to provide infrastructure-relevant services and multiple additional benefits simultaneously can make a strong case for investment. The full range of costs and benefits and how they change over time needs to be factored into decision-making. Multi-criteria decision-making can be a useful tool in the assessment of NbI options and their range of benefits, including their effectiveness at infrastructure service provision, benefits for adaptation, mitigation, societies, economies and the environment, and consideration of time and space requirements.

- **Consideration of time:** NbI should be developed and implemented in a manner that is consistent with the time that NbI take to develop and the complexity of the ecosystem. Approaches with

long timeframes, of approximately 20-50 years, have the best chance of success. There may be a need to integrate NbI with built infrastructure or other natural solutions until the chosen NbI option reaches the planned potential for service provision.

- **Long-term monitoring, management and data collection:** NbI options should be monitored and managed long-term to build an evidence base of the costs and benefits of different NbI options in different contexts, identify opportunities to improve performance, and to implement actions that can improve the functioning of an NbI solution (World Bank, 2017; Browder et al, 2019). This should include monitoring of performance, documentation of costs, adaptive management, and collection of gender disaggregated data to help ensure that service provision is meeting the needs of both women and men.

- **Development of sector-specific guidance and awareness raising:** development of sector-specific guidance on NbI can support the systematic scale-up of NbI across infrastructure sectors. This should include details on the applicability of different NbI options to meet the needs of each infrastructure sector, good practice guidelines, and performance benchmarks.

- **Funding:** investors and other funders can support the scaling of NbI, including through funding NbI across the lifeycle, embedding flexibility into funding, funding training and capacity building, and mandating / prioritizing the inclusion of NbI as an eligibility criterion for funding.

- **Human, institutional, and technical capacity building:** this should include institutional training and awareness raising, capacity building of infrastructure practitioners, and skills development for monitoring and management. Efforts to build capacity of women and increase their participation in infrastucture planning and delivery across the lifecycle should be made.

- **Stakeholder alignment and collaboration:** practitioners should aim to co-design NbI solutions with local and indigenous communities, create specific working groups to bring together different stakeholders, and facilitate community management of projects. Civil society organisations may be appointed to support local stakeholder engagement.

- **New and continued research:** informed decision-making that considers the limits of NbI and variations in performance, potential trade-offs and variations in costs and benefits over time will require further research and broad-scale analysis. This should include research into the ability of NbI to function in different contexts, the importance of condition, connectivity and intactness, the extent to which NbI can be generalized from one site to another, the impact of time on costs and benefits, the resilience of NbI in different contexts, and trade-offs over space and time.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