Nature-based solutions: An innovative pathway to addressing mountain hazards at speed and scale

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The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) indicate that addressing climate concerns and biodiversity protection are mutually reinforcing goals, and must be jointly pursued. Nature-based solutions (NbS), defined as "actions to protect, sustainably use, manage, and restore natural or modified ecosystems to address societal challenges effectively and adaptively, providing human wellbeing and biodiversity benefits",[1] are gaining global attention as measures that can collectively address pressing challenges of the 21st century, including climate change, biodiversity loss, natural disasters, food security, economic development and rising inequalities among people. They include a broad range of actions such as ecosystem-based adaptation, ecosystem-based disaster risk reduction, ecosystem services management, integrated landscape management and more.[2]

In this commentary, we briefly elaborate on the art and science of NbS, relate them to the context of mountain hazards in the Hindu Kush Himalaya (HKH), and provide a conceptual design for replication and spread of NbS in wider spatial scale to address hazards and disaster risk in the mountains through quicker adoption and promotion with investments.

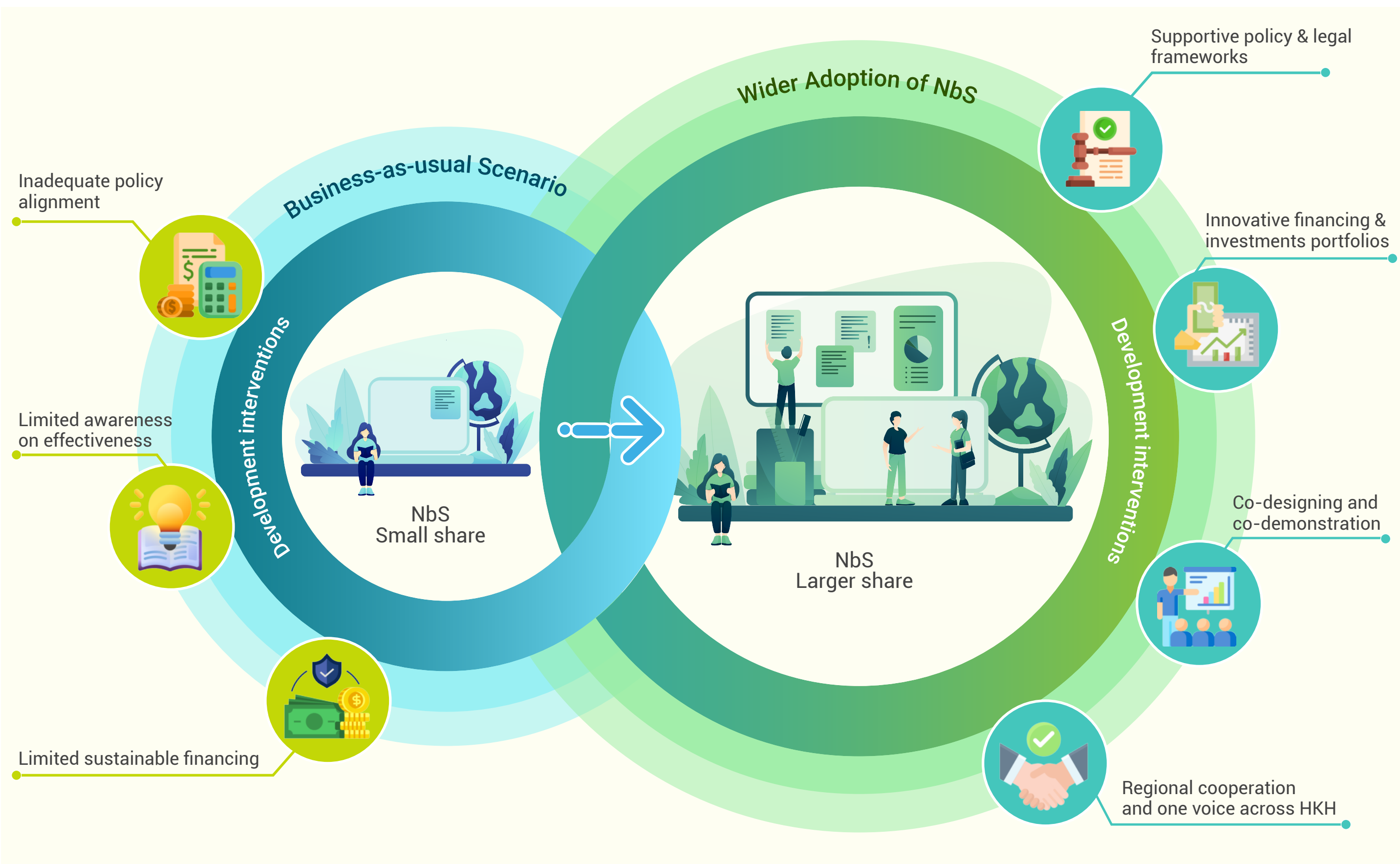

Figure 1. The design for scaling NbS. The future is making NbS a larger share of development interventions promoted at wider spatial and temporal scales.

The context of mountain hazard from the Hindu Kush Himalaya

Mountain landscapes of the HKH, similar to other mountain complexes, are characterised by high elevation topography, steep slopes, and complex geological formations. They are susceptible to risks from hazards such as earthquakes, landslides, glacial lake outburst floods, and rock avalanches, and subject to cascading and multi-hazard risks, where several hazards interact and their effects multiply, compounding the impacts on biodiversity, infrastructure, economy, and people's lives. While technological measures such as early warning systems and engineered solutions such as concrete dykes and dams have played important roles, the use of green infrastructure such as network of natural spaces and ecosystems, biological corridors, and wetlands applied in tandem with technological and engineering measures have highlighted the prospect of NbS towards effectively reducing mountain hazard and disaster risk.[3] A wider awareness and understanding of NbS and their potential to deliver as cost-effective and long-term solutions is crucial. This calls for careful understanding and integration of both the science and the art of NbS.

Understanding the science of NbS

The science of NbS implies to the maintenance of biodiversity structure, processes and functions, the flow of ecosystem services, and their use for human well-being. NbS is underpinned by various types of ecosystem services and benefits that flow from healthy ecosystems – such as soil stabilization, climate and air regulation, water regulation, carbon sequestration, waste decomposition, nutrient recycling, and biodiversity and habitat supporting, while also generating co-benefits through provisioning and cultural services that are part and parcel of human society and wellbeing. The net biodiversity gain through management of green infrastructure such as forests, wetlands, peatlands, agroforestry landscapes, and riverine vegetations thus means increased environmental, biodiversity, climate and economic co-benefits. Use of vegetation management along mountain terraces and slopes can significantly reduce the risk of landslides and mud flows while also providing additional benefits such as improved water management and enhanced biodiversity. Similarly, community-led projects around the construction of terraced fields, rain gardens and vegetated embankments can successfully reduce the risk of flash flooding and landslides while also improving water and food security.[4]

Being aware of the art of NbS

The art of NbS reflects upon the principle of diversity, inclusion and symbiosis and highlights the importance of collective social learning and blend of diversity of knowledge. For example, designing an effective drainage system that mimics water absorption by wetlands and their filtration capacity to reduce the risk of urban flooding and restore vegetation on degraded hill slopes requires blend of both engineering and ecological knowledge as well as traditional ecological knowledge of local communities. The NbS, to be effective and sustainable, requires strong ownership of both state and non-state actors, with special consideration of gender equality and social inclusion. This is to better address the needs, preferences and vulnerabilities of diverse stakeholders – especially those of women, youth, differently abled, and the most marginalized. Records of natural disasters indicate that women are at greater risk than men, and vulnerability is greater when poverty and discrimination intersects. Collaborative governance to promote wider social learning, awareness and ownership is key to successful adoption and implementation of NbS.

Getting the NbS design right for scaling

To embrace and apply NbS across wider spatial scale, it would be necessary to make a shift from sectoral approach to cross-sectoral innovation, leveraging investments and promoting cooperation beyond boundaries. In terms of hazard mitigation, bioengineering presents a good example of cross-sectoral innovation. Currently, such innovations are applied in small geographical areas and they receive a smaller share of development investment (Figure 1), mainly because government policies and programmes emphasize sector specific mandates and objectives - such as for water, irrigation, disaster, forests, infrastructure and agriculture and intersectoral planning do not come organically. With such sectoral mandates, there is also limited societal awareness on NbS and their effectiveness in generating cross-sectoral innovation and co-benefits.

Looking ahead on the design of NbS, the wider adoption of NbS will have to be backed up by strong policy and vision that provides an overarching guideline for cross-sectoral integration and adoption of systems approach. For example, the "*ecological civilisation*" of China –promoted as national vision for a more environmentally sound development and just society- provides a legal basis for the shift in values and behaviours towards greater respect for the environment for sustainable development. Intersectoral cooperation also implies dedicated partnerships among all actors- government, academia, development partners, private sectors, and civil societies. Co-designing and co-demonstration of NbS is one way to engage stakeholders from all sectors and trigger collective actions, including leveraging of finances. Academia and knowledge institutions have a crucial role to play in building awareness and understanding the prospect of NbS. In this regard, an effective monitoring, evaluation, and learning tool for NbS is necessary.

In the HKH, despite the popularity of NbS and their increased recognition in global research and policy discourses, their application as a set of integrated collective actions is still in its infancy among most HKH countries – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan, especially when it comes to implementing the solution at scale and speed. Developing a shared understanding on the framing of what NbS is and establishing a common protocol to assess the effectiveness of NbS would allow more comprehensive conservation and restoration of ecosystems, amplification of many ecosystem services and wider sectoral co-benefits.

The regional cooperation dimension becomes crucial here to ensure that the benefits and services from NbS are available to wider sectors of societies and that a wider range of actors can become part of the solution. For most HKH countries, one of the key challenges in advancing NbS at scale is limited coordination among institutions – for both joint investments and collaborative actions. The dearth of an economic evaluation of the effectiveness of NbS over alternative solutions is another hindrance to wider adoption of NbS in the HKH region. Generating evidence around how NbS deliver on multiple objectives – related to climate, biodiversity, disasters, food , energy and water security, gender equality, social inclusion and human economic development – and feeding this evidence into policy and investment decisions would be key to ensuring greater uptake and wider acceptance of NbS.

Applying the NbS design to addressing mountain hazard

Addressing mountain hazards and disasters in the HKH through wider adoption of NbS implies taking stock of all sectoral solutions – engineered, bio-engineered and purely biological solutions - and their trade-off assessment. The solutions need to consider a wider array of hazards across wider spatial scale- for example glacial hazards, landslides, rockfalls floods, mudflows, and storm surge. This sets a strong context for co-designing NbS as collaborative and larger scale programmes, probably across two or more countries. National policies need to provide the enabling legal frameworks and incentives for mainstreaming NbS into wider sectoral mandates that can facilitate combinations of physical and vegetative measures. In terms of addressing hazards and disasters, while engineered and technological solutions provide the necessary rapid response measures, natural solutions can provide preventive and mitigative opportunities. Local communities – often at the frontline of disasters – must be engaged in the co-designing process, where traditional ecological knowledge can be consulted. Several bio-engineering measures such as the use of bamboo to prevent soil erosion, the use of deep-rooted species to prepare check dams have been inspired from traditional knowledge. Private-sector bodies need to be sensitized and brought in for financing NbS, leveraging the effort by the government. Importantly, regional cooperation among all mountain countries of the HKH is going to be key if we are to stimulate NbS actions at scale and address the hazards and disasters across all mountain countries. The role of academia in providing the scientific basis for NbS - that by preserving and restoring natural ecosystems, increase the stability of mountain landscapes and their ability to withstand and recover from natural disasters, that require comparatively less investment and maintenance costs, and that with time, generate better disaster risk reduction outcomes and more co-benefits –becomes crucial.

While there is no "one-size-fits-all NbS model" for addressing hazards as measures are context specific and defined by the geo-physical, ecological and climatic context of a place, and the type of hazards to be addressed (Ramya et al., 2023);[5] getting the design right for scaling is key – that is developing solutions that are led by the government, owned by citizens, supported by wider agencies and substantiated by science. In the case of addressing mountain hazards, key is co-designing solutions blending ecological, hydrological and engineering functions of ecosystems and promoting the regional scale partnership across all countries sharing the risk of hazards and disaster.

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DECLARATION OF INTERESTS

The authors declare no competing interests.