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Editorial: Introduction to the *Nature-Based Solutions* journal

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The journal *Nature-Based Solutions* provides a scholarship space for the research of nature-based solutions, to both broaden and deepen scientific knowledge on nature-based solutions and advance the adoption, synthesis and application of this knowledge to address critical societal challenges at multiple scales.

Nature-based solutions (NBS) represent a holistic approach to adaptation and resilience building of social-ecological-technological systems with equal reliance upon social, environmental and economic pillars. The harnessing of nature and natural processes via NBS implementation can strengthen a system's capacity to deal with multiple and interconnected challenges. Nature-based solutions can provide integrated, multifunctional solutions to critical societal challenges by delivering multiple primary benefits and co-benefits through the provision of ecosystem services [1,2]. Nature-based solutions inherently enhance ecosystem quality and biological diversity, and planning of NBS needs to involve stakeholders in collaborative NBS design, implementation and evaluation processes. At present, identified key societal challenges addressed by NBS include climate resilience (both adaptation and mitigation), water management, climate and natural hazards, ecological restoration and green space management, biodiversity enhancement, air quality, and urban regeneration. In addition, NBS can also contribute to improved land use strategies, participatory planning and governance, social equity, social justice, and social cohesion and inclusion, knowledge and social capacity building for resilience transformations, health and well-being, and economic opportunities, socio-ecological innovations and green jobs [3].

Nature-based solutions range from protection and conservation via, e.g., land use programs for landscape-scale interventions, to urban planning strategies and sustainable resource management protocols, and the restoration or creation of entirely new ecosystems. Newly implemented NBS that are designed and constructed to yield specific ecosystem services are increasingly more 'visible' and include both hybrid and ecosystem-based solutions. Hybrid NBS, such as green roofs, green walls, bioswales and similar installations, tend to be smaller in size, focus on relatively fewer co-benefits and have more clear business cases than the more complex ecosystem-based NBS that are highly connected with local

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Fig. 1. Nature-based solutions address critical societal issues by delivering social, economic and environmental benefits via the generation of ecosystem services. Image © Monika Żybura (University of Life Sciences in Lublin)

and regional site conditions [4]. As the research and practice of nature-based solutions proliferates and matures, we expect to see new types of NBS, new forms of their applications for environmental and social challenges as well as further evolution of hybrid solutions, modification of existing NBS types and improvements to NBS and hybrid designs.

The concept of NBS embodies the synthesis of several well-established ideas related to the global pursuit of sustainability, such as ecological engineering [5,6] natural capital, green and blue infrastructure, and ecosystem services (Fig. 1) and as such is an umbrella model that aims to connect and bring the knowledge and evidence of 'building with nature and for nature' under one common narrative and body of knowledge [3,7,8]. Additional concepts and practices that can be broadly placed under the umbrella of NBS include ecosystem-based adaptation, ecosystem-based disaster risk reduction, natural asset management, low-impact development, sustainable urban drainage systems, water-sensitive urban design, greening measures, and environmental engineering solutions such as constructed wetlands. Nature-based solutions advance the principles of these preceding concepts and practices by explicitly engaging all stakeholders within collaborative design, implementation and management processes and by simultaneously considering the multiple benefits and trade-offs of NBS across ecological, social, technological, and economic domains.

The implementation of NBS through the deliberate inclusion of ecological processes within human-influenced environments to deliver relevant outcomes in the form of ecosystem services can support high-level objectives related to sustainable development, climate change adaptation and mitigation, urban resilience, and ecosystem restoration. At both global and local levels, nature-based solutions can play an important role in achieving the Sustainable Development Goals (SDGs) and enable greater synergies between individual goals through the simultaneous delivery of co-benefits. In addition, NBS support charting of a post-pandemic recovery that equally benefits people and planet. In particular, NBS can play a key role in climate change adaptation and disaster risk reduction and, as such, can form a core element of local, regional, and national policy initiatives. There is an urgent need to develop a widespread understanding of not only the potential benefits of NBS but also any associated trade-offs.

There is an urgent need for an improved understanding of the contribution of NBS to ecosystem protection, restoration and management, and how NBS support the delivery of vital ecosystem services. At present, the widespread adoption of NBS and their incorporation within multi-level policy instruments is hindered by the fragmented and largely discipline-specific nature of existing evidence regarding NBS performance and impact. At the same time, the diversity of scholarships and disciplines that advance the research and knowledge of NBS generates a plethora of results and evidence but requires a careful synthesis and bridging. Additionally, the geography of NBS research creates additional barriers to the collective advancement of the knowledge frontier, gaining new insights on designs that function well in different socio-ecological, climatic and socio-economic contexts as well as across local, regional and national scales. At present, there is also a shortage of longer-term studies, comparative cases, or higher-level (meta-) analyses of NBS.

Bringing the science and knowledge of nature-based solutions to a progressive pathway will require not only dedication, imagination and research support but also a place to celebrate and deepen the dialogue and knowledge. We are committed to the new journal *Nature-Based Solutions* acting as such a place. **The journal *Nature-Based Solutions* aims to support NBS mainstreaming through the generation of an increasingly detailed knowledge base on NBS, including emerging theories, concepts and frameworks to support NBS practice, and NBS (co-) design, implementation, monitoring and maintenance, performance, impact and cost-effectiveness. New knowledge about** NBS **supports the further development of policy instruments related to climate change mitigation and adaptation, physical and mental health promotion, social wellbeing, biodiversity enhancement, disaster risk reduction, natural resource management, sustainable agricultural practices and industrial processes, and landscape and urban planning and development.** We are particularly interested in enhancing the global knowledge base concerning the holistic impacts of NBS across multiple challenge areas, and supporting scientific discourse on NBS with a view to advancing scientific knowledge whilst contextualizing NBS within multi-level, evidence-based policy. *Nature-Based Solutions* seeks to contribute to a comprehensive, cross-disciplinary, international knowledge base on NBS, initially focusing on:

- **Nature-based solutions' performance and management/maintenance needs, particularly in the longer term**. This knowledge is needed to inform regulatory instruments and management plans applicable to NBS as well as technical (engineering) specifications. Longer-term case studies at field scale level are particularly well suited for illustrating NBS performance and impact.
- **The near- and longer-term impacts of NBS across a range of socio-ecological and economic challenge areas**. We have at present relatively limited evidence of NBS impact that has been compiled and assessed in a systematic and integrative way. The existing knowledge base is patchy, largely anecdotal in nature, limited to short-term studies, and/or lacking the requisite experimental controls to definitively attribute effect. Longitudinal studies and focused meta-analyses across multiple NBS types, scales of implementation, climate zones, and socio-economic contexts are urgently needed to provide the robust scientific evidence required for the incorporation of NBS within science-based public policy.
- **NBS in and for cities.** Nature-based solutions are explicitly named in numerous policy instruments and identified as a means of attaining high-level policy objectives, including those outlined in the UN SDGs. Decision-makers at multiple levels are increasingly looking to NBS to adapt to and mitigate the impacts of climate change whilst simultaneously providing health and well-being and economic benefits. It is essential that we continue to build the evidence base regarding the social, environmental and economic impacts of NBS with respect to those NBS implemented to reconnect urban areas with the surrounding environment.
- **Additional evidence on NBS multi-functionality, including full consideration of synergies and trade-offs.** Social inequalities can

result from poor planning of urban regeneration efforts, potentially leading to "green gentrification" where NBS underpin regeneration efforts. Additional trade-offs may be associated with, e.g., food security/dedication of productive land to non-food production uses, opportunity costs with regard to land development, potential inducement of urban sprawl (less dense, more green urban centers) and concomitant increase in transport-associated greenhouse gas emissions. It is critical to recognize the full scope of potential trade-offs and devise effective strategies to reduce or eliminate potential negative consequences.

- **The role of NBS in physical and mental health, quality of life, and social cohesion.** There is increasing recognition of the critical role of NBS in alleviating the burden of many common types of disease through the reduction of exposure to sources of cumulative environmental and social stress. Moreover, NBS are increasingly being used for tailored interventions to increase exposure, contact and interaction with natural processes, elements and ecosystems, and act as targeted therapies for physical and mental health issues. They also create opportunities for re-engaging with a lost sense of community and increase trust, tolerance, and solidarity, characteristics of social cohesion. Better conceptualizations and evidence of the mechanisms through which NBS deliver such social benefits are essential to the more purposeful use of NBS to enhance health and wellbeing.
- **The role of NBS in enhancing biodiversity at multiple scales.** Many newly-created NBS employ non-native vegetation and/or vegetation monocultures and lack a specific focus on biodiversity enhancement through ecosystem restoration or creation. This requires systematic analysis and the derivation of improved NBS design and implementation guidelines to optimize on-site biodiversity as well as the structural and functional connectivity of natural/green-blue spaces.
- **Economic data from cost-benefit assessments of NBS.** We need to fully understand the costs of NBS in the short and longer term, including maintenance and stewardship costs, to promote effective locally/regionally contextualized co-financing instruments and reduce barriers related to financing uncertainty throughout the NBS lifespan. In addition, focused economic comparisons among different types of NBS employed to mitigate a given challenge and economic cost-benefit analyses of NBS, integrated green-grey infrastructure and conventional engineered infrastructure are necessary.
- **The resilience of NBS to climate change.** Although NBS are widely advocated as a means to address climate change, both through adaptation and mitigation measures, the impacts of climate change on the functioning of NBS over time have not been thoroughly researched to date. In particular, we need to better understand the interdependencies between climate change, ecosystems and the services they deliver. Additional research to better understand species, community, and ecosystem level resilience to a broad range of potential climate-related disturbances that may impact NBS is needed.
- **The role of NBS in the global water cycle, and in biogeochemical cycling of nutrients and carbon.** In particular, the role of NBS in mitigating the temporal misalignment between water supply and water demand is poorly understood. The contribution of NBS and hybrid solutions to water security at local/regional scale has not been fully explored to date. Likewise, the role of NBS in water quality improvement is not consistently documented, especially in regard to emerging pollutants. Further investigation is also needed regarding the respective mechanisms of action and extent of impacts of different types of NBS on the biogeochemical cycling of nutrients and carbon.
- **Scaling effect of NBS implementation.** Evidence is needed regarding the necessary spatial scale of individual NBS or degree of connectivity among NBS/natural areas to optimize the delivery of multiple environmental, social and economic benefits.
- **The institutionalization of NBS.** Although attention to NBS is increasing, little is known regarding the integration of NBS and associated practices within routine planning and decision-making processes. The processes of institutionalization are not clear and the institutional arrangements adopted to implement this concept have yet to be widely explored. This highlights the need to further assess the embeddedness of NBS in policy, regulatory and planning schemes, as well as in practitioners' codes and guidelines, and in the curricula of universities and professional training programs, such as those targeting urban planners, architects, and environmental engineers, among others.
- **The integration of different forms of knowledge including First Nations knowledge in NBS from co-design, co-creation, co-management and co-implementation.** Current expertise and knowledge co-production processes are following conventional paradigms in knowledge generation that will put NBS implementation at risk for reinforcing inequalities and historically path-dependent injustices especially in cities. To seize and research the transformative potential of NBS through their incorporation of a plurality of knowledge, the journal invites novel conceptualizations, as well as new frameworks to illustrate a progressive integration and bringing of knowledge from different actors, origins and forms to NBS advancement in place, through culture, tacit expertise as well as experiential learning experiences.
- **The dual challenge of deepening existing frameworks for the design, planning and evaluation of NBS as well as the proposing of new integrative frameworks to complement existing knowledge, especially across diverse geographic areas.**

We welcome full-length research papers, reviews, policy analyses, perspective articles, short communications and case studies. Contributors are encouraged to explicitly address at least two, and preferably more, key societal challenges including: climate resilience, water management, climate and natural hazards, green space management, biodiversity enhancement, air quality, urban regeneration, participatory planning and governance, social equity and social justice, knowledge and social capacity building for resilience transformations, health and well-being, and/or economic opportunities and green jobs.

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