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Editorial

Nature-Based Solutions—Concept, Evaluation, and Governance

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1. Introduction to the Special Issue

Climate change results in an increase of the frequency and intensity of extreme hydro-meteorological risks such as floods, mudflows, landslides, avalanches and rockfalls jeopardizing a great number of people, settlements and critical infrastructures every year. For many decades, technical engineering solutions such as dams, reservoirs and avalanche barriers or galleries have been the prime choice of planners and engineers to reduce these threats. In the light of climate change and biodiversity loss, novel approaches are needed to face the predicted changes in weather patterns, to increase territory and societal resilience to risks and to recover environmental quality.

In recent years, many countries, institutions and engineers have taken a radical turn in the ways of designing solutions to reduce exposure and vulnerability to risks. Nature increasingly has become a source of inspiration for implementing new and affordable strategies to address these climatic, societal and ecological challenges. Nature-based solutions (NBS) are understood as a broad spectrum of sustainable measures that partially or fully replace conventional technical approaches, such as static flood protection infrastructures, or at least support or increase their effectiveness [1]. While traditional engineering solutions often are monofunctional, aiming to reduce or eliminate the natural hazard, NBS often address various environmental challenges in a resource-efficient and adaptable manner. They also aim to provide economic, societal, and environmental co-benefits by enhancing biodiversity and providing multiple ecosystem services.

NBS provide many opportunities for the active involvement of stakeholders and civil society, e.g., in co-creation and co-design of possible solutions. According to the NBS definition formulated by the European Commission, they are adaptations and risk mitigation measures provided or inspired by nature and continuously supported by natural processes. NBS are often part of the traditional knowledge in many regions of the world, but in recent years, NBS have risen on the political and research agendas across the world through funding for applied research and implementation. A prime example is the European Union with its research and innovation program Horizon 2020 that funds numerous transdisciplinary and interdisciplinary projects to develop, stimulate and implement NBS and to identify the barriers to design, implementation, and maintenance in order to address these barriers [2,3].

2. An Outline of the Contributions

In this Special Issue, most publications originate from work conducted under EU funding schemes for NBS and currently ongoing projects. Scientists and practitioners present their first results from the ongoing projects and portray different facets of NBS. With the strong inter- and transdisciplinary nature of NBS, papers provide on-the-ground insights into lessons learned on barriers and enablers for implementing NBS and present successful ways to design, implement and monitor NBS and to generate innovation.

2.1. NBS, Effects on Natural Capital and Evaluation

In the work by Turconi et al., the authors give an overview of natural hazards, NBS and the challenges of natural hazards, illustrating their ideas with the case of the Portofino Natural Regional Park in Liguria, Italy. The area is known for its natural beauty, for its high natural and cultural value and for attracting a large number of tourists throughout the year. The park is increasingly affected by geo-hydrological events leading to floods, debris flows, landslides and sea storms with the associated damage to natural capital, cultural values and historic buildings. The work demonstrates how NBS can be integrated into such sensitive areas to reduce the hydro-meteorological risk under climate change scenarios. The paper describes the planned design and implementation of NBS, which are, among others, supporting the natural regeneration of holms (*Quercus ilex* L.), the climax species in the area, as well as the hydraulic-forestry arrangements on watercourses, the reconstruction of dry stonewalls and the restoration of abandoned historic terraces for agriculture. The monitoring and evaluation of these measures comprise the collection and analysis of existing and new data sets and providing them to managers.

NBS projects often have a lack of sound environmental monitoring programs, and these programs are often based on very few indicators that provide poor information about ecosystem functions and services. Ultimately, many co-benefits of NBS remain largely undetermined. In Andrés et al., the authors suggest a set of applicable indicators for monitoring NBS. These allow the assessment of the ecosystem responses to restoration actions and monitoring the ecosystem resilience to climate change with a focus on providing information about the soil response, which is one of the key elements of interest in many NBS measures. The authors develop a methodological framework to monitor the co-benefits of NBS designed for hydro-meteorological risk reduction based on the environmental services provided by soil and vegetation. A set of soil and vegetation indicators are suggested as a keystone when establishing and monitoring NBS using tests and samplings in two locations of the French and Spanish Pyrenees.

2.2. Stakeholders in NBS Co-Design Processes

A key element for the successful implementation of NBS is a continuous stakeholder involvement to overcome a lack of cross-sectoral collaboration and implementation. The paper written by Lupp et al. reflects on an intensive collaborative planning process named Living Labs. Research and policies promote them as a new, highly creative and innovative approach for in-depth stakeholder involvement to create or find new, innovative solutions. In addition, the authors examine in-depth two award-winning good practice examples that were forerunners of NBS implementation that use Living Lab approaches. These examples are located in Southern Germany, namely the Isar River Restoration in Munich and the Mountain Forest Initiative ("Bergwaldoffensive") in the Bavarian Alps. The case analysis identifies the following key success factors: openness, knowledge development, learning processes for all participants, and meeting on equal ground, including the ones starting such a process. A key success factor is to enable the most affected stakeholder to play a levering role in the planning processes. More generally, the authors further value the Living Labs approach for creating an atmosphere of trust between the stakeholders and for increasing understanding for finding and implementing solutions. Key success factors can also be demonstrated from the forerunner cases; broad involvement of civil society, open-mindedness of administrations and a new understanding of authorities and decision makers as facilitators, enablers, and partners to build trust and confidence, and to meet on equal ground.

In the work by Zingraff-Hamed et al., the authors underline the importance of a systematic stakeholder identification as a starting point for involvement processes such as Living Labs. Without such recruitment, decisive stakeholders can be missing in the process which leads to bottlenecks, thus slowing down planning processes or, ultimately, leading to failure or abortion of NBS projects. For this purpose, the authors analyze 16 NBS case studies from two EU H2020 sister projects RECONECT and PHUSICOS. Real-life constellations are compared to theoretical typologies and a systematic stakeholder mapping method to support cocreation is presented. Five different types of stakeholder groups are identified: "affected silent stakeholders", "officials moderately concerned", "observers", "wise and active stakeholders" and "stakeholders in charge". While different typologies of stakeholders already exist in other fields, the presented classification is inductive and based on the examined real-life NBS cases.

2.3. Knowledge Transfer and Valuing NBS

Data platforms can contribute to building the knowledge of stakeholders and making the outputs of research accessible to end-users, thus promoting learning from other cases. The paper by Baills et al. describes the development of a dedicated platform for the EU H2020 project PHUSICOS. Projects included address mountain specific risks such as flash floods, landslides, mudslides, rock falls, soil erosion or avalanches. An inventory of existing NBS platforms was conducted and an initial set of examples was put on the platform. More examples will be added over time. The tool is designed to explore the dataset in three different modes: database interface, map view and heat map. Using a comprehensive framework designed for the PHUSICOS case site measures, it serves to analyze the performance of the examples presented in the data bank. Pictograms and color codes provide a quick overview in a qualitative assessment for criteria related to the ambit categories of risk reduction, technical and economic feasibility, environment, society and local economy.

With the explicit aim to provide multiple benefits, the challenge is to assess the value of NBS for society. Most of the many goods and services provided by implemented NBS have no market value, and to demonstrate their relevance, it is necessary to make use of tools such as monetarization approaches. Using the example of floodplain restoration in the Danube, the paper by Perosa et al. demonstrates the implementation of the TESSA toolkit. There are a number of existing tools for specialists to estimate the benefits of NBS. However, TESSA is a PDF-based platform that aims to enhance stakeholder engagement. Three cases were selected for in-depth analysis of benefits derived from NBS implementation. Both local, national and international stakeholders were involved in identifying relevant ecosystem services to be assessed. Together, they chose carbon storage, greenhouse gas sequestration, flood protection, nutrient retention, cultivated goods, and nature-based recreation for an economic valuation. The authors demonstrated that provisioning ecosystem services with market prices, e.g., revenues gained by crops, would decrease in all study areas when implementing NBS, while regulating and cultural services without or with little real market values were increasing significantly. The calculated annual benefits of NBS were between 3.1 million and 237,000 USD for the studied cases.

2.4. NBS Governance

Realization of NBS heavily depends on a governance framework to enable these measures. Since implementation of NBS is on a voluntary basis in many countries and in the EU, this leads to fragmented applications of NBS at present. Drawing lessons from the three case studies of Nocera Inferiore (Italy), Munich (Germany) and Wolong (China), the work of Martin et al. identifies the most important governance enablers. Understanding the supporting contextual preconditions, policy processes and institutions that have contributed to a successful realization of NBS help to better implement, upscale, replicate or stimulate a broader application of NBS. The favorable preconditions that were identified were the following: availability of funds, incentivizing other actors to contribute to maintaining NBS in the public domain, windows of opportunities, already existing cross-sectoral alliances of interest groups together with expert communities and authorities, and characteristics of polycentric governance that break administrative silos which are often typical for public administrations. Finally, citizen involvement, social inclusion and public acceptance also act as key NBS enablers.

The case study analysis of the city of Flores, Costa Rica performed by Neumann and Hack provide a closer look at barriers to NBS implementation. The main barriers to broader NBS implementation are a lack of policy guidelines and few demonstration projects from institutional and political settings. Additional obstacles are identified in urban planning and in the social context. Using the case study example, the authors propose a new single tool to better endorse NBS policies for the replication of good practice examples. This tool combines two concepts: the urban experiment and the policy feedback cycle (PFC). The PFC tool serves to extract the strategies in order to transfer policy insights into the implementation case. For Flores, the New York City Green Infrastructure plan served as the guiding urban experiment. Key elements identified for successful NBS implementation and uptake were continuous stakeholder participation, community involvement, and consideration of external trigger events resulting from the climatic conditions and climate change. Finally, environmental and socioeconomic issues also act as barriers for broader NBS implementation. The main recommendations suggested by the authors are a revision of local regulations and a better integration of NBS into intermunicipal and cross-departmental goals. Other points that were mentioned were technological knowledge transfer and the implementation of demonstration projects.

2.5. Experiences from Practice—Barriers in NBS Implementation and Innovation Processes

The paper by Solheim et al. provides insights from a practice-oriented perspective when implementing NBS in real-life settings in the EU-H2020 project PHUSICOS case sites. The authors discuss barriers that were encountered to the practical implementation of NBS for dissemination and learning. Despite the importance of successful NBS governance models to enable NBS implementation and upscaling, a number of political, institutional and knowledge-related resistances among stakeholders, such as technical and economic issues, proved to be difficult challenges to overcome. The case study analysis highlights insufficient political willingness and long-term commitment, a lack of sense of urgency among policymakers, the missing supportive policy and legal framework to promote implementation, and little public awareness and support as well as property ownership complexities. Specific project-related barriers are time for public procurement, economic reasons, risk aversion, more trust in traditional grey technical solutions even with their experienced failure, resistance to change, and the perceived high costs of NBS measures. To overcome these barriers, the authors recommend stakeholder involvement starting right from the beginning of the project design, design in favor of co-benefits, a quantification of values of the co-benefits over time, much knowledge transfer using information and success stories as learning cases, time for procurement or new and innovative forms for planning and implementation procedures.

Finally, in the contribution of Strout et al., innovation strategies in NBS are presented. According to their work, while NBS and nature as a source of inspiration often are not entirely new, many processes around the co-design, knowledge generation and evaluation, and assessing and monitoring of potential NBS solutions tailored to the site-specific needs can be innovations. They state that innovation can produce tangible benefits, satisfying the needs and wants of relevant users or stakeholders in terms of societal benefits, promoting sustainability and resiliency, improved quality of life, and economic benefits. They further explain that innovations can be technological, social or related to services. Innovation may also include scaling (upsizing) of existing solutions, sharing of tools and knowledge across national borders, and converting experiences and knowhow into shareable knowledge. In research, innovation is often stepwise and a culmination of these steps. Incremental innovations may not be recognized as such. From the researcher´s perspective, these innovations may seem minor or inconsequential, while for others, it might be of great importance. Dissemination of the results and different channels are important for reaching potential markets or users beyond the traditional academic dissemination channels of researchers.

3. Concluding Remark

In conclusion, the papers published in this Special Issue show the variety and breadth of topics related to NBS. Working in research and practice with implementation of NBS not only requires technical skills in risk reduction, but the willingness to work across disciplines and levels to address the challenges related to a broader implementation and acceptance of more solutions that are according to, and inspired by, nature.

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