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Fostering applied research on the synergies between biodiversity and climate

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Results from the BfN International Expert Workshop on 8-9 June 2022

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Content

Summary

The international online expert workshop “Fostering applied research on the synergies between biodiversity and climate” organised by the Federal Agency for Nature Conservation (BfN) on 8 and 9 June 2022 brought together around 30 leading scientists to exchange knowledge and perspectives on this topic, highlight good practice application examples, and identify existing gaps to prioritise future research. A particular focus was on exploring the potential of nature-based solutions (NbS) and ecosystem-based approaches to adaptation and mitigation to deliver multiple environmental, social and economic benefits. The second focus was on how applied research - in particular research using transdisciplinary and participatory approaches - can help in unlocking this potential. Key messages of the workshop included:

- More applied, participatory and transdisciplinary research that addresses the links between biodiversity and climate and considers the socio-ecological dimension – e.g. through NbS - is needed to help solve the climate and biodiversity crises.
- Participatory research can increase the relevance, legitimacy and uptake of research outcomes and offer promising opportunities to advance the current research and knowledge base as well as to move towards implementation of synergetic solutions through collaboration with stakeholders.
- Researchers need enhanced capacities to develop tailored, inclusive and effective stakeholder engagement practices within their research to deliver locally appropriate outcomes. On the other hand, research funding needs to accommodate/support these approaches.
- Targeted research can identify current barriers to the wider implementation of NbS and offer solutions to overcome them. Such barriers include e.g. institutional and legal arrangements, lack of political will and investments, perceived risk of trade-offs, lack of standardised approaches to monitoring benefits and impacts, and limited knowledge and capacity of public authorities in implementing such measures.
- Further research is needed on the potential of NbS (and other solutions) to address socio-ecological challenges, on associated costs and benefits as well as surrounding governance systems and the socio-ecological drivers, barriers and enablers for their wider mainstreaming.

These points were discussed both conceptually as well as on the basis of applied case study examples from across the world.

Zusammenfassung

Der vom Bundesamt für Naturschutz (BfN) am 8. und 9. Juni 2022 durchgeführte internationale Online-Expertenworkshop "Fostering applied research on the synergies between biodiversity and climate" (Förderung der angewandten Forschung zu den Synergien zwischen Biodiversität und Klima) brachte rund 30 führende Wissenschaftlerinnen und Wissenschaftler zusammen. Die Teilnehmenden teilten Forschungsergebnisse und Erfahrungen, zeigten Good-Practice-Anwendungsbeispiele, identifizierten bestehende Forschungslücken und Herausforderungen, sowie Prioritäten für die zukünftige Forschung. Aus den Diskussionen ergaben sich zusammenfassend folgende Kernaussagen:

- Um zu einer Lösung der Biodiversitäts- und Klimakrisen beizutragen, ist mehr angewandte, partizipative und transdisziplinäre Forschung nötig. Sie sollte sich mit den Zusammenhängen zwischen Biodiversität und Klima befassen und insbesondere die sozio-ökologische Dimension, z. B. durch naturbasierte Lösungen (NbS), berücksichtigen.
- Partizipativ durchgeführte Forschung kann die Relevanz, Legitimität und Akzeptanz von Forschungsergebnissen erhöhen und bietet vielversprechende Möglichkeiten, die derzeitige Forschungs- und Wissensbasis zu erweitern. Durch eine enge Zusammenarbeit mit den Betroffenen kann zur Umsetzung synergetischer Lösungen beigetragen werden.
- Wissenschaftlerinnen und Wissenschaftler benötigen mehr Kapazitäten, um maßgeschneiderte, integrative und wirksame Verfahren zur Einbindung von Betroffenen in ihre Forschung zu entwickeln und dadurch gemeinsam lokal angemessene Lösungen zu finden. Gleichzeitig sollte die Forschungsförderung diese Ansätze berücksichtigen und unterstützen.
- Gezielte Forschung kann aktuelle Hindernisse für die breitere Umsetzung von NbS aufzeigen und Lösungen zu deren Überwindung anbieten. Zu diesen Hindernissen gehören z. B. institutionelle und rechtliche Regelungen, mangelnder politischer Wille und unzureichende Finanzierung, eine Wahrnehmung des Risikos von Zielkonflikten, fehlende standardisierte Ansätze zur Messung und Nachverfolgung von Nutzen und Auswirkungen sowie begrenzte Kenntnisse und Kapazitäten seitens der öffentlichen Verwaltung bei der Unterstützung von Maßnahmen.
- Das Potenzial von NbS (und anderen Lösungen) zur Bewältigung sozio-ökologischer Herausforderungen, die damit verbundenen Kosten und Nutzen sowie die geeigneten Governance-Systeme und die Hindernisse und Voraussetzungen für die verstärkte Integration von NbS in Wirtschaft und Gesellschaft müssen weiter erforscht werden.

Diese Punkte wurden sowohl konzeptionell als auch anhand von Fallstudienbeispielen aus verschiedenen Weltregionen erörtert.

1 Background information

The human-induced biodiversity and climate crises are increasingly threatening planetary biodiversity and dependent livelihoods (IPBES, 2019; EEA, 2022). While the linkages between these two crises are already widely recognised by science and policy, they are still often considered in isolation from one another in practice. In this situation nature-based solutions (NbS) have a particular potential to address these crises to secure biodiversity conservation and climate change mitigation and adaptation, among other objectives. NbS can be understood as an 'umbrella concept', encompassing a range of established approaches that aim to build on nature and healthy ecosystems to address societal challenges while simultaneously providing environmental, social and economic benefits. Such approaches include, for example, green and blue infrastructure, ecosystem-based disaster risk reduction, natural water retention measures as well as ecosystem-based approaches to climate change adaptation and mitigation (see Box 1).

In this report the term NbS is used encompassing the different approaches listed above. The focus during the workshop was indeed on NbS, though it had been acknowledged that other solutions also exist.

Box 1: Definition of NbS

Nature-based Solutions (NbS) have gained recent recognition as systematic, cost-effective and multifunctional interventions. It is understood as an umbrella concept for actions relying on natural ecosystems and their delivery of environmental and social benefits to address biodiversity loss and climate change. According to the first multilaterally agreed definition adopted at the Fifth Session of the United Nations Environment Assembly (UNEA-5) in March 2022, 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).

NbS encompass a variety of approaches stemming from different sectoral and geographic backgrounds across policy, practice and academia. One concept of such is **Ecosystem-based adaptation (EbA) / ecosystem-based mitigation (EbM)** (short form for ecosystem-based approaches to climate change adaptation and mitigation) as a concept pre-dating NbS. EbA aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change, while also generating significant social, economic and cultural co-benefits, contribute to the conservation of biodiversity and build on the traditional knowledge and practices of indigenous people and local communities. EbM supports healthy, well-managed ecosystems to increase their climate change mitigation potential, for example, through the sequestration and storage of carbon in healthy forests, wetlands, and coastal ecosystems.

The potential of well designed and implemented NbS to jointly support biodiversity and climate ambitions is increasingly recognised. To this end, the Fifth Session of the United Nations Environment Assembly (UNEA-5) has made a resolution on adopting a multilaterally agreed definition of nature-based solutions in March 2022 (see Box 1).

By addressing multiple sectoral goals in parallel, NbS can create a new momentum to overcome often fragmented policies, funding and activities and adopt more systematic efforts. Transdisciplinary approaches and participatory methods are needed to harness this potential and bring climate and biodiversity actors together from science, politics and practice in order to create a common framing and exploit synergies. Applied scientific research is further needed to comprehensively answer open research questions about the biodiversity and climate nexus, as well as about participation, corresponding processes and their improved integration for engaging society in developing and implementing solutions to tackle the twin crises. Relevant research topics include, for example, exploring variations in the influence of the socio-political context between different urban/rural as well as geographic regions, governance system design, cost effectiveness of solutions, co-benefits associated with human well-being and health, societal desirability of actions, or the identification of effective NbS mainstreaming measures. Another important topic is how to avoid trade-offs that can arise in trying to jointly address biodiversity and climate objectives. These can emerge, for example, between different land use interests (such as agriculture, forestry, housing, energy) or between biodiversity conservation and carbon sequestration or storage measures.

The international online expert workshop “Fostering applied research on the synergies between biodiversity and climate” organised by the Federal Agency for Nature Conservation (BfN) on 8 and 9 June 2022 brought together around 30 leading scientists to exchange knowledge and perspectives on these topics, highlight good practice application examples, and identify existing gaps to prioritise in future research. Taking into consideration the workshop results, the BfN will implement an international project to support research institutions in carrying out application-oriented, participatory research exploring the synergies between biodiversity and climate protection and adaptation. The participants represented a wide variety of regions worldwide and different disciplines including social and political science, ecology, environmental psychology, biodiversity and water management and urban planning.

This report gives an overview of the topics discussed and the results of the discussions. As such the report addresses the following topics: state of the art in biodiversity-climate research, and the needs and opportunities for participatory research with a focus on research to address socio-ecological issues, on working with NbS in applied research, and on developing capacities for enhanced transdisciplinary research. Case studies presented by participants are used to provide specific examples for the topics discussed.

2 State of the art in biodiversity-climate research

It is widely agreed that the climate and biodiversity crises are mutually reinforcing and can only be solved jointly. Nature currently absorbs more than 50 % of anthropogenic CO_2 emissions through photosynthesis and carbon storage (Pörtner et al., 2021; EEA, 2022). Yet, nature as a dynamic complex is also a main contributor to climate change as a result of human conversions of natural habitats (e.g. forests and wetlands) into productive land and by having exceeded critical tipping points in the climate system (e.g. melting of permafrost).

During the workshop, participants discussed a variety of ongoing research activities that seek to build evidence on the biodiversity-climate nexus in key areas such as urban dynamics, policy processes, sectoral stakeholders' involvement and the analysis of climate processes and natural systems. Some of these research topics are listed below:

- In urban contexts, there are several research initiatives aiming at mainstreaming NbS into urban design, planning and policies. Some examples include: the formulation of urban greening plans, strategies for improving ecosystem resilience in peri-urban areas, the inclusion of sustainability criteria in urban regeneration processes and the implementation of co-production and co-creation approaches (see also an exemplary case study from Costa Rica below).
- In relation to policy, participants mentioned research focusing on mainstreaming integrated approaches on nature and climate, fostering alternative financing mechanisms for NbS and improving the quality of strategic policy analysis such as environmental assessments.
- The research on sectoral actors revolves around the analysis of economic barriers that can be used to build synergies. This includes exploring incentives for the infrastructure business to incorporate biodiversity criteria and promoting local businesses engagement in climate action.
- Regarding climate adaptation, participants highlighted research on the effectiveness of NbS for increasing climate resilience of ecosystems and thus resilience of human society, and the benefits of using crowd mapping and co-production approaches for that purpose. Regarding climate mitigation, there is a focus on understanding the potential for carbon storage and broader ecosystems services and benefits of different land use systems. In this context, also ecological constraints such as existing threats to ecosystems' health as well as climate change and their impact on the effectiveness of NbS need to be considered.

Key topics around natural systems included water and grassland resilient management, agriculture and land use, the potential of NbS for reducing hydrometeorological risk, fostering costal ecosystem restoration and promoting reforestation.

CASE STUDY: Corredor Biológico Interurbano María Aguilar (CBIMA), Costa Rica

Erika Calderon, CBIMA

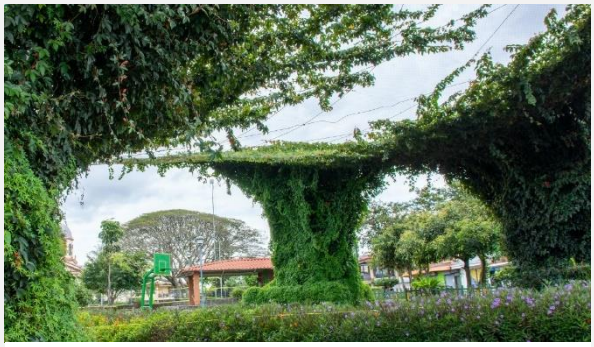

Figure 1: Corredor Biológico Interurbano María Aguilar © CBIMA

The Corredor Biológico Interurbano María Aguilar (CBIMA), established in 2009, comprises five municipalities in the Greater Metropolitan Area of Costa Rica. The inter-institutional and multi-level governance body CBIMA seeks to highlight the role of protected river areas and public green spaces as fundamental elements of a sustainable and inclusive city via citizen participation. Through this aliance scientific research on biodiversity is also developed.

Aim: The María Aguilar Interurban Biological Corridor (CBIMA) is a participatory conservation strategy established by the National System of Conservation Areas (SINAC) to enhance the quality of life and well-being of the population living in the Great Metropolitan Area of Costa Rica (GAM).

Results: Management and conservation of biodiversity and ecosystem services of the María Aguilar River basin through an intersectoral and multidisciplinary work between the various public and private stakeholders.

Innovation: Implementation of a co-creation process creating citizen ownership by actively involving them in the project design and implementation.

2.1 Socio-ecological issues at the biodiversity and climate interface

Studying the biodiversity-climate interface requires an exploration of the linkages, synergies and trade-offs between climate and biodiversity objectives for different lands use types and regions and between different stakeholder groups. The workshop participants emphasised different (socio-ecological) topics at the core of such research, including:

- Understanding the socio-ecological drivers and barriers for mainstreaming NbS in urban areas, including work on co-creation of urban NbS, the exploration of the NbS and health nexus and the inclusion of gender and health perspectives in public space design.
- Regarding sectoral stakeholders, there are ongoing efforts for analysing the role of private enterprises in the implementation of NbS, current funding opportunities for ecosystem restoration and methods for the economic assessment of the NbS potential.
- In natural systems, there is a focus on promoting participatory ecosystem restoration and conservation and understanding the social and ecological impacts and opportunities associated with ecosystem restoration (see also an exemplary case study from Africa below). Other related topics included: the use of ancestral water management techniques and the role of UNESCO Biosphere Reserves in linking social and natural dimensions when addressing the biodiversity-climate crisis.

CASE STUDY: Rural nature-based solutions in Africa

Dr. Ermias Lulekal, Addis Abeba University & Dr. Sebastian Brandis, Stiftung Menschen für Menschen

The Wogdi Project was initiated in 2018 to promote intensive and integrated natural resource development works in the Wogdi area in Ethiopia.

Aim: To run community centered biodiversity conservation, ensuring development and sustainable use of natural resources (soil, water, flora and fauna) in the area.

Results: Species regeneration, improving biodiversity status in the restoration sites and fostering local economic development through, for example, the involvement of community members in bee keeping activities.

Figure 2: The Wogdi monitoring team © Wogdi project

Innovation: The project was successful in preventing ecosystems degradation, restoring biodiversity and at the same time improving community livelihood, with a focus on using indigenous tree species and plants with economic and medicinal benefits.

2.2 Role of Nature-based Solutions

NbS aim to comprehensively target biodiversity and climate perspectives, as well as social issues. Most urban and rural communities remain heavily dependent on traditional grey infrastructures and systems for water supply, heating, lighting, drainage, cooling and other services such as places to meet or relax (Wild, 2020). In light of global changes, these older systems and technologies may no longer be fit for purpose (Pörtner et al., 2021) and require alternatives. NbS – implying sustainable use of natural systems and processes – can pave the way for a more resilient future for both nature and society. In this regard, participants discussed the importance of promoting research on the potential of NbS to solve local challenges across the globe (with an exemplary case study from Asia below), as well as to help deliver the Sustainable Development Goals.

CASE STUDY: Mangroves as a nature-based solution for water and climate change issues in Macao, China: from scientific research to environmental education

Karen Araño Tagulao, University of Saint Joseph

Figure 3: Mangrove restoration © University of Saint Joseph

The Institute of Science and Environment (University of Saint Joseph) focuses in its research, among other topics, on mangroves conservation and restoration to help mitigate diverse environmental challenges in Macao region.

Aim: (i) To assess the role of wetlands in climate change mitigation and adaption through carbon sequestration and other related measures, (ii) To investigate the efficiency of the local mangroves for coastal protection (via wave attenuation) using laboratory-based experiments, (iii) to promote the importance of wetlands for climate change mitigation and adaptation through information campaigns and activities.

Results: Ecosystem restoration, collaboration with local stakeholders including local government and wide community involvement.

Innovation: Linking scientific research with environmental education with potential for transformation into citizen science practices.

3 Needs and opportunities for participatory research

The transdisciplinary and participatory collaboration of scientists and society – including practitioners – is necessary to clarify research questions, harness relevant knowledge and experience from diverse actors, and build collective knowledge (Bulkeley, 2020). Critical points relate to the meaningful involvement of non-academic participants and knowledge co-production, the integration of research methods across disciplines, addressing normativity and bias, and evaluating societal impact and effectiveness (Wickenberg et al., 2021; Holzer et al., 2019).

These and additional needs as well as opportunities for participatory research were introduced in five targeted expert presentations, including insights into implementation in Ecuador, Peru and Lebanon. A common thread was the importance of clearly defining the roles of local stakeholders to involve them more actively and inclusively and to define research questions based on local needs, processes and ongoing activities. The following sections provide insights into the discussions on the specific topics related to participatory research.

3.1 Nature-based Solutions in applied biodiversity-climate research

The potential of NbS to contribute to both climate change and biodiversity objectives depends in part on appropriate political and financial framework conditions and increased public awareness and buy-in to prioritise NbS over or alongside traditional grey infrastructure. During the workshop, participants discussed different aspects related to this topic, including: key biodiversity-climate related issues and respective NbS measures that could effectively address these issues; barriers and enablers for the implementation of NbS on national and local level; and opportunities for applying participatory research for concrete NbS measures. The participants indicated a large variety of different **biodiversity-climate related issues and corresponding NbS measures,** listed in Box 2 below.

Box 2: Biodiversity-climate related issues and corresponding NbS measures

- Water-related issues connected, inter alia, to water scarcity (due to glacier retreat), water pollution and supply issues, or acid rock drainage. Respective NbS measures could include constructed wetlands for water storage and treatment (using native species)
- Soil-related issues such as drainage of organic soils that could be addressed by rewetting & protection or implementing paludiculture. Here, trade-offs and opportunities may arise in relation to biodiversity, carbon storage, and productive use of landscapes
- Forest-related issues such as forestry using non-native and poorly adapted tree species/monocultures. Respective solutions could include close-to-nature forestry and building up biomass as a carbon storage
- Urban-related issues such as uncontrolled urbanisation and associated environmental degradation (especially in the Global South) as well as the general reduction or loss of species in urban environments. Respective solutions could include urban greening at different scale, renaturalisation of urban areas and using native and climate-smart species when replanting
- Grassland and agriculture-related issues include, inter alia, the degeneration of natural and semi-natural grasslands, and food insecurity (especially in the Sahel). These could be addressed via the protection of grasslands or adapted grazing and mowing management, the restoration of habitats and natural barriers/green walls and , indirectly, the reduction of rural unemployment by creating green jobs (e.g. ecotourism)

Diverse barriers for implementing NbS were raised by the participating experts. Key hindrances include, for example, institutional and legal barriers, limited support from authorities as well as lack of commitment by policy makers to sustainability targets in the long term. In addition, lacking/unsuited investments or misdirected project designs can prevent long-term stewardship. Lacking monitoring can also lead, for instance, to a limited evidence base of positive NbS impacts and co-benefits. Other challenges include the lack or limited knowledge of the public relating to the benefits of NbS as well as potential lack of interest or motivation from locals in implementing such measures.

To address these and other barriers, a variety of **enabling factors for implementing NbS** were identified. One need is to effectively communicate and mainstream NbS concepts and successful experiences[1], also including a consistent communication and shared understanding of relevant terms. To increase the knowledge base, biodiversity-sensitive education in schools or capacity-building at government agencies have a large potential to increase action. Another important factor is the increased involvement of the local stakeholders, e.g. via communities of practice, shared responsibilities, citizen science initiatives, community-led NbS and co-creation/co-design processes. This further relies on adaptive project design with flexible management options, common objectives, or joint budgets. Modern technologies are also seen as potential enablers, e.g. to more closely model and monitor the possible benefits of NbS.

In this context, the workshop participants identified ample **opportunities for applying participatory research**. Participatory research is central to understanding the impacts of landscape management changes on land stewards/managers and the rural economy. Important social aspects of such research target questions on how to engage the civil society most effectively, how to consider age-old traditional practices, how the multi-functionality of NbS provides social and economic benefits, and how to best account for health and well-being considerations. Participatory monitoring is another important research focus, already leading to interesting applications (such as iNaturalist or eBird[2]) and practical solutions[3],[4].

3.2 Designing effective research to address socio-ecological issues

Participatory methods are valuable tools to comprehensively address research questions on the climate-biodiversity nexus, which are often of socio-ecological nature. During the workshop, participants discussed relevant research questions at the biodiversity-climate interface, experiences with participation approaches, benefits of applied research, type of stakeholders to be involved and the role of communication and outreach to increase recognition of applied research results among end users and policy makers. Box 3 below presents research questions mentioned by the participants.

[1] Such as identified by the NATURVATION project: https://naturvation.eu/atlas.html

[2] Both programs are open-source apps that addresses a wide public user group. Links: https://www.inaturalist.org/, https://ebird.org/home)

[3] In one example, participatory mapping in Colombia was conducted for urban wetlands and involved over 1000 volunteers. More information can be found in this book: http://repository.humboldt.org.co/handle/20.500.11761/32506

[4] Another interesting example of inclusive monitoring and nature communication is the example of soundscapes – developed as a reaction to the COVID19 pandemic. More information can be found in this article: https://www.researchgate.net/publication/349198292_Listening_to_cities_during_the_COVID-19_lockdown_How_do_human_activities_and_urbanization_impact_soundscapes_in_Colombia

Box 3: Relevant research questions at the biodiversity-climate interface

- How can NbS address pressing socio-ecological challenges? How can the contribution of NbS be measured and made comparable, to build the evidence base?
- How can the understanding and evidence on the costs and benefits of NbS (e.g. tackling flood mitigation) be improved?
- What are appropriate governance systems and measures to implement NbS across different regions, taking account of their local socio-political contexts?
- How can political commitment be increased to foster a more widespread, sustainable, and effective implementation of NbS?
- Which education and mainstreaming measures have been proven to be effective for reaching biodiversity and climate goals through the application of NbS? What tools have enabled a shared understanding of terms and concepts to be developed and to increase public awareness regarding associated opportunities and risks?
- How can research and implementation projects be more effective regarding inclusiveness, stewardship and deriving meaningful results based on addressing local needs and priorities?
- How to include the non-usual suspects and ensure good representation of relevant stakeholders in applied research?
- How to improve participation spaces to include different perspectives and those of the most vulnerable populations?
- How to avoid research fatigue, ensuring that external participants also benefit from research and do not only provide their knowledge and time?

A key component to address such research questions is the transdisciplinary and participatory collaboration of scientists and society – including practitioners, citizens, local business, and decision-makers. These societal actors often represent the beneficiaries and end-users of research outcomes. Such collaboration allows to harness relevant knowledge and experience from diverse actors, build collective knowledge (Bulkeley, 2020) and increase the uptake of research outcomes. **Participatory approaches** to conduct the research activities listed by the participants include envisioning foresight tools, participatory impact assessment, participatory Rural Appraisal, farmer exchange programmes, semi-structured questionnaires and focus groups for different target groups. In addition, approaches such as real and living labs, model regions or lighthouse projects can be used. Participants also highlighted the value of tools to map complex socio-ecological systems and relations between different system elements (such

as Fuzzy Cognitive Mapping[5], KUMU[6] or Cmap[7]) and for spatial visualisations of landscape values and assessing ecosystem services e.g. Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)[8], Co$tingNature[9], WaterWorld (UNEP-WCMC). Furthermore, participants stressed that the cultural competence of researchers is key to effectively engaging communities and recognising different worldviews, epistemologies, traditional, indigenous and ecological knowledge. The design of the research process should consider the root causes of socio-ecological challenges such as inequality, lack of social and spatial justice and discrimination; and create an ethical space so that the community feels free to participate.

The **application of practice-oriented/applied research** cannot only increase the relevance and uptake of research outcomes, but can also benefit the public and private sectors, which are addressed by the respective research projects. Such sectors may include, for example: urban development and housing, infrastructure, water management, environment (incl. disaster risk reduction and climate change), education, agriculture, forestry, fisheries or tourism**.**

To ensure feasibility of research project interventions as well as legitimacy, relevance and the uptake of research results, it is key to **involve relevant stakeholders**, which can vary across topics and depending on the local context (see an exemplary case study from the Netherlands below). These may include land managers (e.g. farmers, foresters), land vendors, dwellers from different neighborhoods, civil society, youth, decision-makers at different levels including ministries, indigenous groups and vulnerable and at-risk populations. The research must demonstrate an inclusive and targeted approach for stakeholder involvement across different stages of the research processes. This would encompass, for example, i) a stakeholder involvement in the design and planning of the research project to identify their needs and demands and to assess perceptions of the planned NbS interventions, their scope, and any potential conflicts; and ii) ongoing stakeholder involvement building upon previous projects and networks, regular interactions with stakeholders in the project throughout the research duration, setting up an efficient mode for collaboration, ensuring transparent working processes, and translating scientific findings into practice-relevant results. Proposals should thus also include effective measures to engage stakeholders and ensure sustained interest and mutual benefits from involvement and time invested.

Tailored and effective communication and outreach are key to **increasing the recognition of applied research results** among end users and policy makers at different levels. Innovative ways of communication include, for example, social media to speak to youth in their language[10], policy briefs for advocacy work aligning with policy agendas, storytelling or ted talks,

[5] A fuzzy cognitive map (FCM) is a cognitive map within which the relations between the elements (e.g. concepts, events, project resources) of a "mental landscape" can be used to compute the "strength of impact" of these elements. https://en.wikipedia.org/wiki/Fuzzy_cognitive_map

[6] Kumu is a data visualisation platform that helps organise complex information into interactive relationship maps. https://kumu.io/tour

[7] Cmap software empowers users to construct, navigate, share and criticise knowledge models represented as concept maps. https://cmap.ihmc.us/

[8] InVEST is a suite of models used to map and value the goods and services from nature that sustain and fulfill human life. It helps explore how changes in ecosystems can lead to changes in the flows of many different benefits to people. https://naturalcapitalproject.stanford.edu/software/invest;

[9] Co$tingNature is a sophisticated web-based spatial policy support system for natural capital accounting and analysing the ecosystem services provided by natural environments, identifying the beneficiaries of these services and assessing the impacts of human interventions. http://www.policysupport.org/costingnature

[10] See example: Frontiers for young minds. https://kids.frontiersin.org/

but also on-site activities (visits, learning tours, outdoor activities). Moreover, multipliers such as teachers should be addressed to trigger behavioural change and increase awareness.

CASE STUDY: The Grensmaas - living lab for nature-based solutions, Netherlands

Dr. AP Andries Richter, Wageningen University

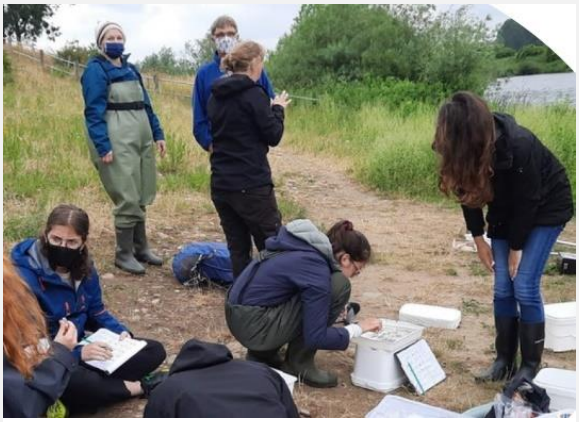

Figure 4: Living Lab Grensmaas © Wageningen University & Research

The 'Grensmaas' project is part of the research programme 'Living Labs in the Dutch Delta' and implements flood protection with a social and collaborative approach.

Aim: to develop and partly implement novel knowledge on how large-scale nature-based interventions can contribute to the resilience of the main water system in the Netherlands.

Results: Flood protection, sediment and gravel for economic gain, landscape restoration, support landscape quality and rewilding.

Innovation: involvement of societal partners and private sector by using decision support tool and considering different social, economic and ecological subsystems' interactions, deriving co-benefits with private sector engagement; provision of creative spaces to generate synergies, co-production and joint projects.

3.3 Developing capacities for enhanced transdisciplinary research

The potential of transdisciplinary research to help solve complex social-ecological challenges is widely recognised, yet a number of aspects remain challenging in practice (see e.g. Lawrence et al., 2022). Additional support in the areas of strategy (i.e. sharing of knowledge and resources), finances, and implementation (i.e. to build relevant capacities) is needed within the research community to enhance transdisciplinary research. During the workshop, participants discussed various facets of this topic, such as: how to effectively integrate critical stakeholders in transdisciplinary research, what types of resources and tools are available or still needed to support applied research, and what are potential funding opportunities**.** Critical points emerging from this discussion are summarised below.

A researcher's abilities to answer the questions of **how and when to effectively integrate stakeholders**, empower them with a meaningful role, and maintain these relationships during and beyond the research activities are essential to achieving credibility, relevance and legitimacy (Durham et al., 2014). The importance of long-term relationships with local stakeholders was raised. Experts underlined this point and cited a number of ideas to foster integration and relationship building in practice, which are listed in Box 4 below.

Box 4: Options to foster integration and relationship building in practice

- Informing practitioners about how they can benefit from the research and what they can contribute with, i.e. making research significant to the participants.
- Considering the timing of processes in the research design.
- Identifying key actors in advance, but being flexible to update this as work progresses (snowballing) and expanding the concept of experience and expertise to be more inclusive (e.g. also accounting for the participation of stakeholder groups other than those readily identified as 'experts')
- Building relationships with local ambassadors from the start of the process that can help reach the general population and try to ensure a continuity of contact with these individuals (e.g. community elders, school teachers).
- Considering different approaches to engage with diverse stakeholder groups, e.g. youth, local community groups, vulnerable communities, private sector.
- Ensuring transparency of the process and making information available to the greatest extent possible, aiming to build collaboration based around trust and mutual respect

Several **resources and tools** were cited as well as growing networks and approaches to guide transdisciplinary research. Examples vary by topic, but include: the Analytical Hierarchy Process (AHP), serious gaming, living labs/pilot cases for testing NbS, citizen science approaches, PHUSICOS NbS assessment framework tool[11], Responsible Research and Innovation (RRI) Tools database and the RRI-Toolkit[12], and the InVEST for ecosystem services/functions assessment[13]. Additional points highlighted an increased awareness more generally about the importance of integrating different disciplines, the growing credibility of involved institutions, increasing networks, and recognition of the need to allocate sufficient time to build trust and begin research. One expert highlighted the remaining gap of simple and cost-effective tools and approaches for effectively including local stakeholders.

Despite these resources, **additional support and process optimisation is necessary – particularly in the context of funding**. Participants acknowledged a **number of critical barriers**, such as higher costs (particularly when stakeholder integration is viewed as a restriction rather than an opportunity and funders are not always convinced about return on investments) and complicated application forms for CSOs or NGOs to participate in projects. Strict regulations as well as a lack of understanding and flexibility by donors in the research process (e.g. in financing pre-feasibility assessments to engage with targeted stakeholders already to set the project objectives) can hinder research innovation and prevent local priorities from being taken into account in project design and implementation. Furthermore, typically short funding cycles (2-5 years) translate into short project durations which do not allow for building long-term relationships and trust.

[11] http://phusicos.eu/wp-content/uploads/2019/05/D4.1_Task4.1_UNINA_14052019_Final_withAppendicies.pdf

[12] https://rri-tools.eu/

[13] https://naturalcapitalproject.stanford.edu/software/invest

Nevertheless, a number of **existing (funding) opportunities** have begun to take these considerations into account. Examples provided by the participants include, amongst others: the Global Centre on Biodiversity for Climate (funded by the UK government); the German 'Internationale Klimaschutzinitiative' (IKI) and German Federal Ministry of Education and Research (BMBF) funding streams; Climate Adaptation and Resilience (CLARE) grants by the International Development Research Centre (IDRC); and carbon financing and lottery funding. Overall, participants encouraged funding organisations to develop programmes specifically for this type of research to increase research opportunities and effectiveness.

4 Conclusions

Applied research that addresses the link between biodiversity and climate in a participatory and transdisciplinary way – also considering the socio-ecological dimension – can make an important contribution to finding solutions for jointly addressing these crises. Targeted research can help to better understand the socio-ecological impacts and opportunities associated with ecosystem restoration, how NbS can address pressing socio-ecological challenges, and the associated costs and benefits. Additionally, the understanding of surrounding governance systems and the socio-ecological drivers and barriers for mainstreaming NbS across policy, sectors and regions can be elucidated.

Using action-oriented and applied research can also increase the relevance, legitimacy and uptake of research outcomes. In addition, participatory methods offer promising (research) opportunities, such as an increased capacity to engage volunteers in impact monitoring; comparing perceptions on the effectiveness of NbS versus conventional engineering solutions; engaging civil society in NbS activities that were initiated and managed by academic institutions or the government and co-designing new applied research projects together with broad range of stakeholders; studying the multi-functionality of synergetic solutions in terms of social and economic benefits; and acknowledging the biodiversity-climate solutions implemented by communities in informal settlements.

The realisation of the participatory research potential requires involving relevant stakeholders, which can vary across topics and depend on the local context. Research projects should thus demonstrate an inclusive and targeted approach for a genuine stakeholder involvement, considering different stages of the research processes, effective measures to engage stakeholders and ensure sustained interest and mutual benefits from involvement and time invested. This will also challenge researchers to decide how and when to effectively integrate stakeholders, establish long-term relationships and trust with stakeholders, and ensure that stakeholders also benefit from collaboration – thereby preventing research fatigue and ensuring the relevance of results.

5 List of workshop participants

List of workshop participants[14]	
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[14] The affiliation is indicated as of the workshop dates.

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