Nature-Based Solutions Implementation Handbook: A Summary for Practitioners

Authors

Maria Dubovik Ville Rinta-Hiiro Malin zu Castell-Rüdenhausen Laura Wendling Arto Laikari Johannes Jermakka Zarrin Fatima	*VTT Technical Research Centre of Finland*
Kristen Jakstis Leonie K. Fischer	*University of Stuttgart*
Piersaverio Spinnato	*Engineering Ingegneria Informatica*
Ana Ascenso Ana Isabel Miranda Peter Roebeling Ricardo Martins Rita Mendonça	*University of Aveiro*
Silvia Vela Margherita Cioffi Sara Botto Eleonora Gambucci	*RINA Consulting*
Sophie Mok	*Fraunhofer Institute for Industrial Engineering*

About UNaLab

The UNaLab project is contributing to the development of smarter, more inclusive, more resilient and more sustainable urban communities through the implementation of nature-based solutions (NBS) co-created with and for local stakeholders and citizens. Each of the UNaLab project's three Front-Runner Cities – Eindhoven (NL), Genova (IT) and Tampere (FI) – has a strong commitment to smart, citizen-driven solutions for sustainable urban development. The establishment of Urban Living Lab (ULL) innovation spaces in Eindhoven, Genova and Tampere supports on-going co-creation, demonstration, experimentation and evaluation of a range of different NBS targeting climate change mitigation and adaptation along with the sustainable management of water resources. The Front-Runner Cities actively promote knowledge- and capacity-building in the use of NBS to enhance urban climate and water resilience within a network of committed partner cities, including seven Follower Cities – Stavanger, Prague, Castellón, Cannes, Başakşehir, Hong Kong and Buenos Aires – and the Observers, Guangzhou and the Brazilian Network of Smart Cities. Collaborative knowledge production among this wide network of cities enables UNaLab project results to reflect diverse urban socio-economic realities, along with differences in the size and density of urban populations, local ecosystem characteristics and climate conditions. Evidence of NBS effectiveness to combat the negative impacts of climate change and urbanisation will be captured through a comprehensive monitoring and impact assessment framework. Further replication and up-scaling of NBS is supported by development of an ULL model and associated tools tailored to the co-creation of NBS to address climate- and water-related challenges, a range of applicable business and financing models, as well as governance-related structures and processes to support NBS uptake. The results of the project will be a robust evidence base and go-to-market environment for innovative, replicable, and locally-attuned NBS.

Partners

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1. NATURE-BASED SOLUTIONS FOR URBAN CHALLENGES

Nature-based solutions (NBS) have emerged as an umbrella concept that encompass and build upon previous concepts that aimed at actions for enhancing climate change adaptation (CCA) and disaster risk reduction (DRR). These concepts include but are not limited to Ecosystem-based Adaptation (EbA), low-impact development (LID) and sustainable urban drainage systems (SUDS), ecological engineering, green infrastructure and ecosystem services. The distinguishing feature of NBS is simultaneously providing economic, social and environmental benefits and co-benefits. Many definitions of the NBS concept have been developed over the years, including those by IUCN and European Commission and the latest definition by the UN.

> *"… 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 and resilience and biodiversity benefits."* - *Fifth Session of the United Nations Environment Assembly (UNEA-5)*

The lifecycle of an NBS project comprises six equally important steps or phases (Figure 1). The lifecycle begins with a framework identification phase, which will be adopted first in the project, and which will drive the implementation of the next actions. The following phases of identifying the relevant NBS given the identified urban pressures and challenges and the key performance indicators (KPIs), and developing a monitoring scheme to capture the change from the baseline conditions – are crucial for evaluating the NBS performance and impact. Once the monitoring scheme is defined and monitoring equipment is tendered, a prolonged period of NBS monitoring begins. The monitoring outputs are continuously reviewed to assess NBS performance and impact, and to ensure the soundness of the equipment and the methods of data acquisition. Ideally, NBS monitoring should span several years for critical evaluation of NBS performance and impact to support future development proposals. Several phases of the NBS project lifecycle directly contribute to the NBS Knowledge Base, which can be perceived as a collection of good practices regarding NBS implementation across the EU Member States.

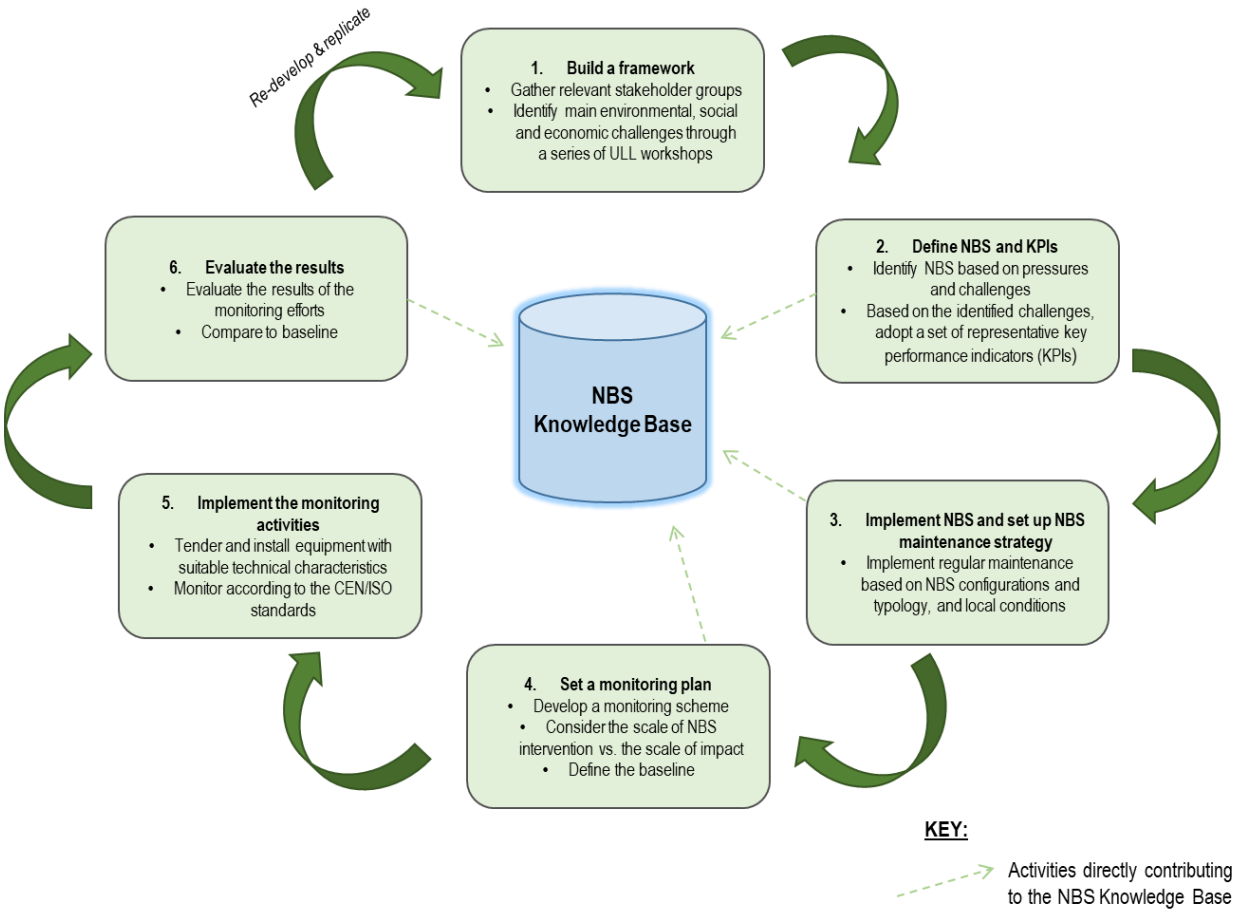

Figure 1. Lifecycle of an NBS project.

This publication presents a high-level summary of the highly detailed *Nature-Based Solutions Implementation Handbook*. The handbook aims to provide the key messages and outcomes of the NBS implementation process generated within the UNaLab project from co-identification of challenges and NBS co-creation via co-monitoring to co-maintenance and evaluating the impacts of NBS interventions. The knowledge and resources developed throughout the UNaLab project aim to serve as a reference for the NBS practitioners and other involved parties in developing, executing and evaluating the NBS projects in different socio-economic and climatic contexts.

2. NATURE-BASED SOLUTIONS IN THE POLICY CONTEXT AND GLOBAL AGENDA

NBS are essential elements in some of the major European and global policies and strategies that shape and direct the actions at building the structural, environmental and social resilience (Figure 2). European policies and the current development agenda generally support the implementation and uptake of NBS, and some directly mention NBS as means for achieving certain goals. International policies may not directly mention NBS but they all focus on CCA and DRR which is inherent to all NBS activities.

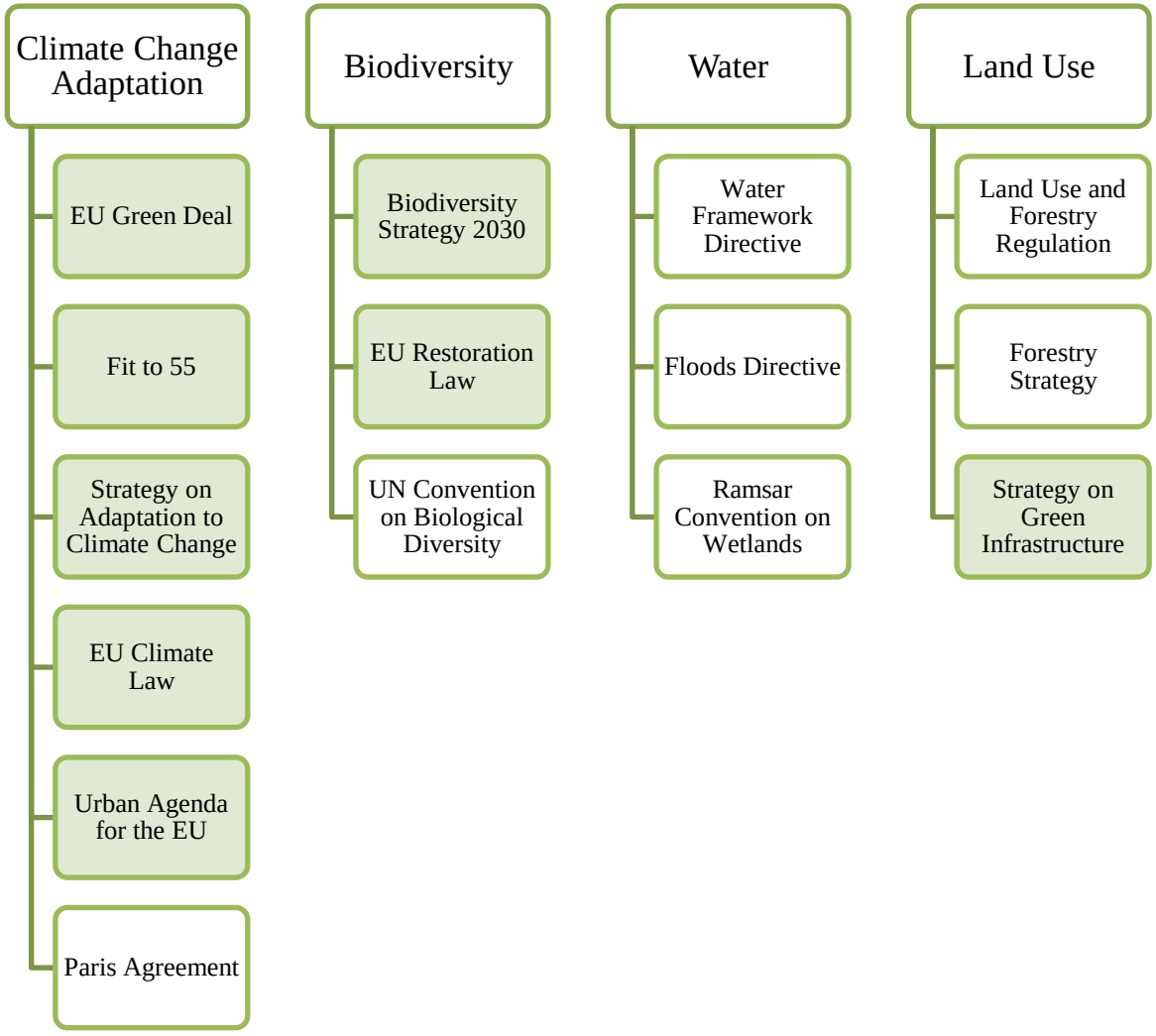

Figure 2. NBS in the European and international policy agenda. Green boxes highlight policy instruments that explicitly mention NBS.

The International Union for the Conservation of Nature (IUCN) recently released standards for the design and assessment of NBS in order to support mainstreaming of nature conservation and consistency of NBS application (IUCN, 2020). Whilst the IUCN standard lacks definitive thresholds, it provides a systematic framework to support consistency in NBS design and assessment based on solutions-oriented outcomes. The eight criteria and sub-indicators that comprise the standard framework for NBS design and assessment defined by the IUCN (2020) can be directly linked to specific quantitative indicators and methods of evaluation previously identified by the UNaLab project and/or the IEF Taskforce.

3. NATURE-BASED SOLUTIONS INITIATION AND CO-CREATION

NBS as socio-ecological-technological innovations are characterised by multiple uncertainties and require a participatory approach to account for them. Co-creation process requires supportive environments where experimentation and learning are part of the development process and where different stakeholders can safely engage and actively participate in a dialogue. Innovative solutions spring from the outcomes of complex co-creation process involving knowledge flows among all actors involved across the entire economic and social environment. Industry, academia, public authorities and citizens are part of the Quadruple Helix (Figure 3), where users are placed at the heart of the innovation ecosystem. The Urban Living Lab (ULL) approach provides a safe environment for providing stakeholders with opportunities to express their ideas and preferences and iterate the solutions.

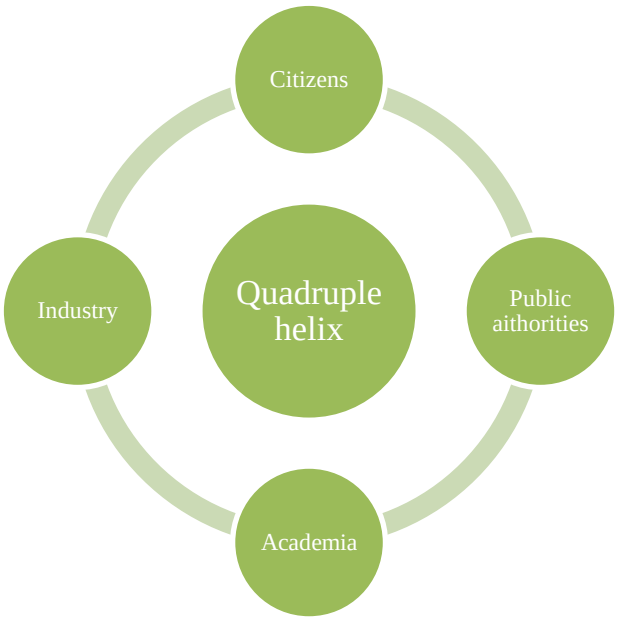

Figure 3. Quadruple helix approach to co-creating NBS innovations.

Within the UNaLab project, a series of Urban Living Lab (ULL) NBS co-creation workshops were organised in the UNaLab front-runner cities. The UNaLab front-runner cities are geographically widespread, representing diverse climates and cultures and having organisational differences. This resulted in different approaches by UNaLab front-runner cities to their co-creation workshops, evidenced by a mix of selected techniques, participants and results. Yet, because the co-creation process was coordinated through the UNaLab project, the execution and goals of the workshops were similar. The first workshops aimed at familiarising participants with the subject, UNaLab project methodologies and aims, and sharing views. In the second step, workshop participants mainly focused on creating NBS solutions to be implemented in the UNaLab project sites, and these were then evaluated in each of the third and final workshops.

Engagement through multiple channels

- Online & F2F meetings and workshops
- Training & DIY sessions
- Peer learning through webinars & open days
- Public events
- Partnerships with schools and universities

Each UNaLab FRC selected either the European Awareness Scenario Workshops (EASW) method or the Design Thinking method for use in their respective ULL co-creation workshops. The steps

followed by each of these methods are similar, as are the stakeholders that can be involved. In both methods, the groups get together to understand a problem, find solutions, and test them. The stakeholders that can be engaged in both cases are policy makers, technical experts, entrepreneurs/businesspeople, local citizens and designers.

Naturally, co-creation has its tangible outcomes. However, it is beneficial to evaluate and quantify its impacts on a variety of topics, including enabling participatory decision-making, inclusivity, social cohesion and justice, and gender dimension, to deeper explore the NBS impact on the social domain and the co-creation process, which is a critical part of the successful implementation of effective NBS. Co-creation is evaluated using the process-based indicators, which assess the efficiency, quality, or consistency of specific actions employed to achieve the goals. For evaluating the success of co-creation process, it is necessary to establish a pre-co-creation baseline capturing the degree of stakeholder involvement or other relevant aspects.

Two workshops involving representatives from the front-runner and follower cities, and a follow-up open-ended questionnaire aimed at refining the ULL concept based on the combined experience of the UNaLab front-runner cities. The resulting ULL Framework is based on theories and practices for Living Labs, Action Design Research, methods for co-creation and data from workshops with the front-runner cities.

The key components include the *governance and management structure* as the basis for the strategic and operational management and organisation of the ULL, which requires support from the local governments and decision-makers. The governance component is followed by *financing and business models* that create and deliver value for the ULL stakeholders and that are essential for running the ULL, including the vision and scope, risk management and dissemination. Business models determine who will finance the ULL activities and whether the commitment will be supported in the long term. The *urban context* defines a physical setting, in which NBS will be implemented (street, neighbourhood, or city). The physical setting should be considered in terms of ownership and responsibility, existing infrastructure and future development plans. The *Nature-based solutions* component should be innovative and address local challenges and pressures; here, the (co-)created NBS aims and values should be clearly identified. The innovation component is followed by the partners and users, or *key stakeholders*, adopting the Quadruple Helix approach. This approach uses the innovation and collaboration model of Triple Helix (academia–authorities–industry) whilst adding a fourth pillar – a citizen perspective, which leads to more transparent and end-user-friendly innovations. The *methods* and the *ICT infrastructure* components relate to the various data collection, analysis and tool to support and engage stakeholders in the ULL activities.

The best tips to engage people in the ULL workshops

- ✓ Citizen participation must be voluntary
- ✓ Adjust the length of the talks in the workshops, especially for children
- ✓ Connect the workshop to an existing (popular) event
- ✓ Go on walking tours
- ✓ Give detailed information in the invitation
- ✓ Work with maps
- ✓ Various communication channels are required
- ✓ If participants show hesitation about their presence, discuss this in the group
- ✓ Responsible people from the city should take part directly
- ✓ Beyond the workshops, involve the participants in site activities, managed and supported by planners and technicians
- ✓ Native language will facilitate the true engagement

4. NATURE-BASED SOLUTIONS GOVERNANCE AND FINANCING OPTIONS

Next to the potential of nature-based solutions to directly contribute to increased climate resilience in cities, their multifunctional nature can also provide a wide range of social, environmental and economic co-benefits. Whilst this diversity of benefits and the context-specificity of NBS performance make it difficult to capture and communicate the overall value, they also hold a great potential for engaging more urban stakeholders in the planning, implementation and financing of such solutions.

Behind this background, the UNaLab Value Model seeks to explore the multiple and often intangible values of NBS and enable a structured navigation through the complex issue of NBS valuation. The underlying assumptions are that the different technical functions of NBS (as outlined in the *NBS Technical Handbook*) can be translated into individual benefits of different urban stakeholders. Based on a given urban context and the actual type and performance of the NBS, different beneficiary structures will emerge. If the individual benefits are well communicated to those, their willingness to invest could be enhanced, opening the way to alternative co-investment and financing options. In *UNaLab Value Model* (Mok et al., 2019), these relationships and the underlying logic are further highlighted and explored. Additionally, it describes a potential clustering of different benefit types and discusses their value capture potential. For different types of NBS, it provides an overview of potential 'usual suspect beneficiaries' and hints at available evaluation tools for further value assessment. Figure 4 summarizes different financing options in relation to private, public and civil society actors.

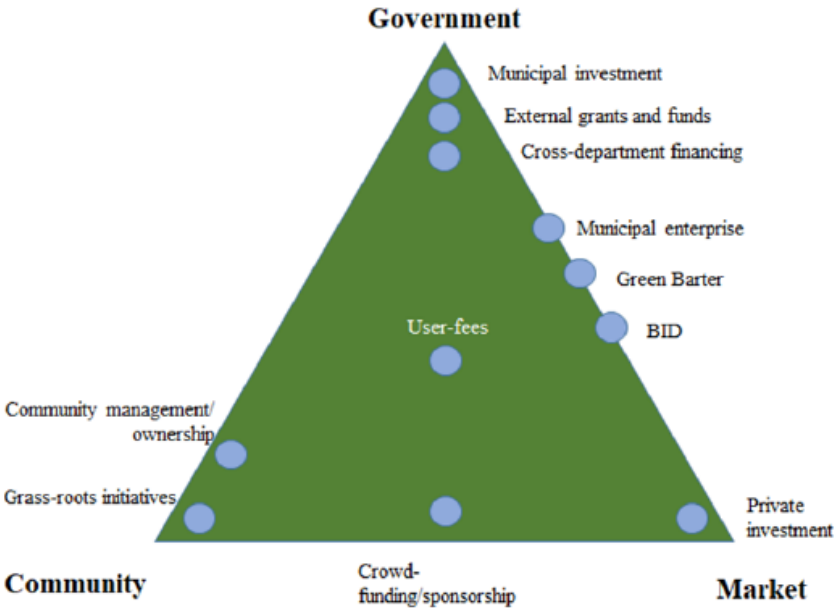

Figure 4. Financing options for NBS.

Traditionally, governance has been approached as a top-down process, where managing urban challenges was administered by the public authorities. The modern cities face the transformation by involving other stakeholders, such as citizens, companies and other actors, in the urban development. A combined effort of the emerging city actors can target topics such as climate change adaptation and sustainable urban development. Although viable in their nature, these actor networks require certain rules to steer the ways city actors can act to change governance structures to better facilitate the uptake of NBS. The four key areas, or themes,

considered include (1) cross-departmental communication and cooperation, (2) policies, (3) financing and procurement and (4) data governance.

The governance examination in UNaLab front-runner cities consisted of three parts:

(i) Municipal governance survey to identify the central governance-related challenges and conduct a preliminary assessment of potential key research points according to the four themes
(ii) High-level workshops to elaborate on the identified challenges and develop potential solutions for the four key themes on a more general level, and
(iii) Development and application of the assessment framework

The NBS development and uptake require a mix of policy instruments, both command and control mechanisms (e.g., binding regulations) and market-based instruments (e.g., tax incentives), which are also reflected in the planning tools and mechanisms to enhance the visibility of targets. Integration of policies from a variety of sectors (e.g., water, construction) was deemed beneficial to promote interdisciplinarity of NBS. The policy instruments may further prove a valuable asset for attracting private engagement and local business owners to develop and invest in NBS. Three enablers identified for the NBS-supportive policies included simple access to existing policies, good communication and stakeholder involvement, which also enables feedback mechanisms.

On data governance

The amount of data generated throughout the duration of the NBS implementation process, including co-creation, co-implementation, co-management, and monitoring of NBS performance and impact, is vast. Storage, management, ownership and access are among the critical issues for governing data at a municipal scale. To ensure the smooth management of data, municipalities should define a data management plan during the initial stages of NBS implementation.

5. NATURE-BASED SOLUTIONS CO-MONITORING AND IMPACT ASSESSMENT

In times of rapid urbanization and anthropogenic climate change, urban areas face an increasing number of extreme weather events and other environmental burdens such as water and air pollution. NBS are associated with distinct impacts on ecosystem services and improvement of a range of environmental aspects hindered by urban growth. However, a selection of NBS to address the identified challenges and pressures should demonstrate its impact and indicate whether the anticipated outcomes are achieved, including monetary and environmental targets, to consolidate the future investments into wider NBS implementation. Monitoring is one of the central factors determining the success of the NBS impact assessment as it provides quantitative and qualitative evidence of the impact generated by the NBS interventions (Figure 5).

NBS monitoring involves a collection of measurements used for assessing the state of environment and subsequently the change that signifies either its degradation or restoration. Prior to monitoring, goals and data analysis methods must be well defined to ensure accurate monitoring and understanding of physical, chemical and biological variables and processes occurring in the studied environment.

Figure 5. A 'recipe' for a successful monitoring strategy.

Co-definition of **NBS performance and impact indicators** can be viewed as an intermediate step between setting the goals and targets and formulating a sound plan for NBS monitoring (Figure 6). The first and foremost requirement for the NBS performance and impact indicators is to reflect the targets and objectives set in the beginning of NBS co-creation process.

Monitoring and impact assessment are supported by NBS performance and impact indicators over the biophysical, socio-economic and sustainability domains, which target the evaluation and, whenever possible, quantification of NBS effectiveness. They can be divided into three basic classes:

- **Structural indicators (S)** – refer to all the factors that affect the context in which NBS are implemented. This typically includes the supporting infrastructures and resources in place to achieve the desired goals (e.g., physical facilities, equipment, human resources, organisational characteristics, policies and procedures).
- **Process indicators (P)** – refer to the actions that are involved in NBS co-creation, co-implementation and co-management. These indicators are used to assess the efficiency, quality, or consistency of specific procedures employed to achieve the desired goals as well as the impacts of co-creation.
- **Outcome indicators (O)** – refer to all the effects of NBS. These include social, environmental and economic effects or impacts. Outcome-based indicators comprise the greatest proportion of all indicators.

There are numerous NBS performance and impact indicators, and selecting them can be challenging for an inexperienced person. The Task Force 2 handbook *Evaluating the Impact of*

Nature-based Solutions: A Handbook for Practitioners (Dumitru & Wendling, 2021a) and its *Appendix of Methods* (Dumitru & Wendling, 2021b) alone collects more than 400 recommended and additional indicators over 12 key societal challenge areas:

1. Climate Resilience
2. Water Management
3. Natural and Climate Hazards
4. Green Space Management
5. Biodiversity Enhancement
6. Air Quality
7. Place Regeneration
8. Knowledge and Social Capacity Building for Sustainable Urban Transformation
9. Participatory Planning and Governance
10. Social Justice and Social Cohesion
11. Health and Wellbeing
12. New Economic Opportunities and Green Jobs

Indicators of NBS performance and impact should be selected to reflect both primary benefits as well as any associated co-benefits.

It is equally important to **establish baseline** (pre-NBS) measurements for understanding the reference conditions and quantifying the actual impact, i.e., the change, further refining the NBS design Ideally, the baseline measurements should be ongoing prior to NBS implementation. Nevertheless, in cases, when the baseline measurements are not available from the area of interest, a similar reference area without NBS can be employed as a "baseline".

On data outputs

Granularity is different from *accuracy*, the degree of correctness of the outputs with respect to the true value, and from *precision*, the accuracy when the observations are repeated.

Instead, *resolution* is a specification of *granularity*, and it indicates the size of the minimum unit/area in a data output (e.g., spatial data).

Once the monitoring scheme is defined and set, establishing the **appropriate data acquisition** means will ensure careful data collection at relevant scales. A number of data acquisition options exist that could be employed for NBS performance and impact monitoring. In this Handbook, they are presented as the broad major categories comprising remote sensing and earth observations, ground (*in situ*) observations, statistical and legacy datasets, and citizen science. These monitoring means produce reliable quantitative and/or qualitative data only when applied at appropriate scales and periods of time.

On monitoring scales

The choice of scale and resolution/granularity is subjective and is typically informed by prior experience, but they should not be selected arbitrarily or haphazardly (Scholes *et al.*, 2013). Careful considerations for the suitability of scales and their interactions will produce the most reliable outcomes.

Considerations of the **scale of NBS monitoring** and the **frequency** of recorded intervals are of outmost importance due to their effect on the quality of monitoring efforts. Ranges of scales at which KPIs can be observed and quantified vary substantially, and usually the overall visibility of impacts associated with certain NBS are scale sensitive.

6. NATURE-BASED SOLUTIONS IMPACT ASSESSMENT

NBS impact assessment is the essential step when targets and objectives are evaluated against the measured performance during the NBS monitoring stages (Figure 6). Impact assessment identifies causalities and aids in determining the supporting or additional interventions necessary for achieving the goals. This makes the NBS implementation process cyclical enabling the adaptive management cycle of every NBS project.

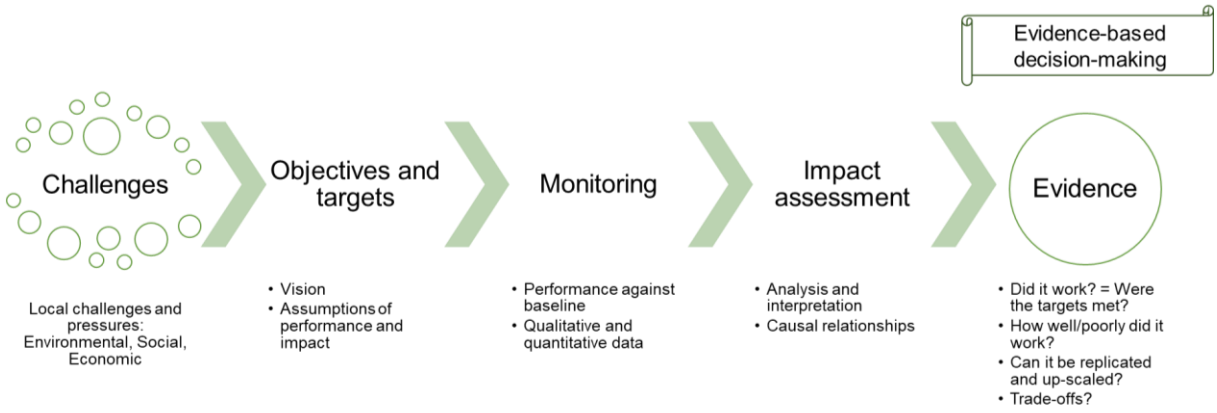

Figure 6. From challenges to evidence: setting targets and aligning monitoring activities to generate evidence of NBS performance and impact leading to evidence-based decision-making.

The UNaLab project used a highly participatory approach to produce evidence of NBS impact, including co-creation, co-development, and co-monitoring activities. In the NBS impact assessment process in the UNaLab front-runner cities first involved co-definition of NBS performance and impact indicators in an interactive way with a wide range of local stakeholders. After co-definition of indicators, the UNaLab front-runner cities iteratively co-developed the monitoring and evaluation strategies together with project partners and other technical experts to assess NBS performance and associated impacts in a cost-effective way.

The UNaLab approach to co-development of the monitoring strategy relied on a diverse group of participants, in terms of cultural and educational background and needs. Deep stakeholder engagement was important for identifying the local challenges and monitoring and evaluation needs and capabilities. The selection of suitable performance and impact indicators and identification of the monitoring needs were facilitated through engagement of a wide range of experts during NBS monitoring and impact assessment planning.

NBS impact assessment in UNaLab was facilitated by the development of an ICT platform and other NBS monitoring and evaluation tools developed by UNaLab project partners. Automated collection of NBS monitoring data from IoT sensors complemented by manual entries supports long-term NBS monitoring and impact evaluation.

7. NATURE-BASED SOLUTIONS CO-MAINTENANCE

As NBS remain to be a relatively new concept, there is an existing need for support and encouragement for the implementation of NBS. To date, knowledge gaps in NBS implementation and maintenance of different types of NBS still exist. This is especially true with respect to the costs of NBS maintenance. This and other knowledge gaps in the maintenance might be one of the barriers for the larger scale of NBS implementation.

Maintenance of NBS should be considered throughout the lifecycle of NBS. Maintenance should ideally be involved already in the planning process of NBS. Needs for maintenance might even affect the decisions whether the NBS should be implemented and which type of the NBS should be chosen. Usually, NBS do not have high maintenance needs. However, some NBS require a lot of maintenance for them to work properly. In each case, sufficient maintenance is desirable to enable proper functioning and long lifetime of NBS which is why long-term maintenance strategy should be created for each NBS. Naturally, some NBS require constant and extensive maintenance action whereas some NBS only need minimal maintenance. However, it should be noted that all types of NBS require regular maintenance.

Maintenance needs for NBS, including costs, are often smaller than they are for grey infrastructure solutions. Due to some lack of knowledge and missing technology in the NBS maintenance, there is a lot of potential to develop the technology (digitalisation and smart technologies) and methods for maintenance activities. This could potentially create more cost-effective solutions for the NBS maintenance.

NBS maintenance activities (Table 1) can have participatory and well-being aspects. For example, property owners can maintain vegetation and other green solutions around their houses. These kinds of activities can increase social interaction among the residents which can have positive impacts on the property maintenance in general and increase the flow of information. Increased social interaction and activities done outside can also have positive impacts on mental and physical well-being. In addition, proper maintenance can potentially impact positively on the property values.

Costs of the NBS operation and maintenance should be estimated for the whole lifecycle of NBS. The cost estimation should be done in the early phases of NBS design and the cost estimation should be updated when more data and knowledge are available, during design, construction, and operation of NBS. Update of the cost estimation is important due to the difficulty in estimating the accurate costs of many NBS during the design phase. However, some data and knowledge gathered from experiences in NBS maintenance exist, which can help in estimating the costs before the NBS implementation. This information could be received for example from designers or maintenance companies. Some publicly available data and guidelines already exist but it should be noted that there are many things affecting the maintenance costs and the initial cost estimations may differ from the realised costs.

Table 1. Typical maintenance activities of different NBS (modified from Woods Ballard et al. 2015).

	Green roof	Rain garden	Daylighted river	Bioswale	Trees	Residential park	Vertical greening	Infiltration basin	Permeable pavements	Wetland	Biofilter
Regular maintenance											
Inspection	x	x	x	x	x	x	x	x	x	x	x
Litter and debris removal	(x)	x	x	x	x	x	x	x	x	x	x
Grass cutting	(x)	x	(x)	x	(x)	x	--	x	(x)	x	(x)
Weed and invasive plant control	x	x	x	x	x	x	x	(x)	(x)	(x)	(x)
Shrub management	-	(x)	(x)	(x)	(x)	(x)	-	(x)	(x)	(x)	(x)
Shoreline vegetation management	-	-	x	-	-	(x)	-	-	-	x	(x)
Aquatic vegetation management	-	-	x	-	-	(x)	-	-	-	x	(x)
Vacuum sweeping and brushing	-	-	-	-	-	-	-	-	x	-	-
Checking mechanical devices	(x)	-	(x)	-	-	(x)	(x)	(x)	-	(x)	(x)
Irregular/occasional maintenance											
Sediment management	-	x	(x)	x	x	(x)	-	x	x	x	x
Vegetation replacement	x	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	(x)	(x)
Repairing maintenance											
Structure rehabilitation/repair	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
Infiltration surface reconditioning	-	(x)	-	(x)	(x)	(x)	-	(x)	(x)	-	(x)
Erosion damage control	(x)	x	(x)	x	(x)	(x)	-	x	-	(x)	(x)

Key:
x denotes "Required maintenance action"
(x) denotes "Possible maintenance action"
- denotes "Usually not needed"

Maintenance costs are dependent on the NBS type and size and are usually higher during the first years after construction or installation of maintenance. In most cases, smaller NBS require less maintenance work and budget for the maintenance works. There are also some specific cases that can increase the costs compared to standard NBS structures, for example special equipment used, challenging access of NBS or contaminated sediments that need processing after their removal. Besides functional requirements of NBS, also aesthetic requirements of NBS play a role in maintenance costs as more strict requirements (e.g., more frequent maintenance work) need greater maintenance budget.

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