

Evaluating the impact of Nature-based Solutions: A Summary for Policy Makers

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EVALUATING THE IMPACT OF NATURE-BASED SOLUTIONS

A Summary for Policy Makers

Independent
Expert
Report



Green space
management



Knowledge building
for sustainable urban
transformation



Place
regeneration



Health and
well-being



Participatory planning
and governance



Climate resilience



Biodiversity
enhancement



Water
management



New economic
opportunities and
green jobs



Natural and cli-
mate hazards



Air quality



Social justice and
social cohesion

Evaluating the Impact of Nature-based Solutions: A Summary for Policy Makers

European Commission
Directorate-General for Research and Innovation
Directorate B — Healthy Planet
Unit B3 — Climate and Planetary Boundaries

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EVALUATING THE IMPACT OF NATURE-BASED SOLUTIONS

A Summary for Policy Makers

Marcel Cardinali, Adina Dumitru, Sofie Vandewoestijne and Laura Wendling

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A HANDBOOK TO GUIDE YOU AND YOUR TEAM

The present publication provides a high-level summary of the detailed information available in [*Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*](#). The handbook aims to provide practitioners with a comprehensive impact assessment framework for nature-based solutions and a robust set of indicators to assess the impacts of nature-based solutions across 12 societal challenge areas: Climate Resilience; Water Management; Natural and Climate Hazards; Green Space Management; Biodiversity; Air Quality; Place Regeneration; Knowledge and Social Capacity Building for Sustainable Urban Transformation; Participatory Planning and Governance; Social Justice and Social Cohesion; Health and Well-being; and, New Economic Opportunities and Green Jobs. The accompanying volume, [*Evaluating the Impact of Nature-Based Solutions: Appendix of Methods*](#), provides a brief description of each cited indicator of nature-based solution impact and recommends appropriate methods to measure specific impacts, along with guidance for end-users about the appropriateness, advantages and drawbacks of each method in different local contexts.

The handbook and accompanying appendix of methods are intended to serve as a reference for relevant EU policies and activities, orient urban practitioners in developing robust impact evaluation frameworks for nature-based solutions implemented in different socio-economic contexts and at different scales, and provide a comprehensive suite of indicators and methodologies to help build the European evidence base regarding the performance and impacts of nature-based solutions.

[*Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*](#) and [*Evaluating the Impact of Nature-Based Solutions: Appendix of Methods*](#) are the outcomes of a unique collaborative effort of 17 EU-funded Horizon 2020 NBS projects and cooperating institutions such as the European Environment Agency (EEA) and the Joint Research Centre (JRC), as part of the European Taskforce for Nature-Based Solution Impact Assessment.



WHAT ARE NATURE-BASED SOLUTIONS?

Nature-based solutions provide integrated, multifunctional solutions to critical societal challenges. They are ***“solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services”*** (European Commission).

Nature-based solutions range from minimal or no intervention, such as establishing conservation areas, to the creation of new ecosystems, such as a community garden, an urban park, or a mangrove. Nature-based solutions represent an evolution of terms used to express similar ideas, such as urban forestry (UF), green and blue infrastructure (GI, BI), or the delivery of ecosystem services (ESS). Additional concepts and practices that can be broadly placed under the umbrella of NBS include ecosystem-based adaptation (EbA), ecosystem-based disaster risk reduction (Eco-DRR), green-blue infrastructure (GBI), low-impact development (LID), best management practices (BMPs), water-sensitive urban design (WSUD), sustainable urban drainage systems (SuDs), and ecological engineering (EE). These existing concepts are applicable across strategic, spatial planning, soft engineering, and performance dimensions of actions involving nature-based solutions (Figure 1).

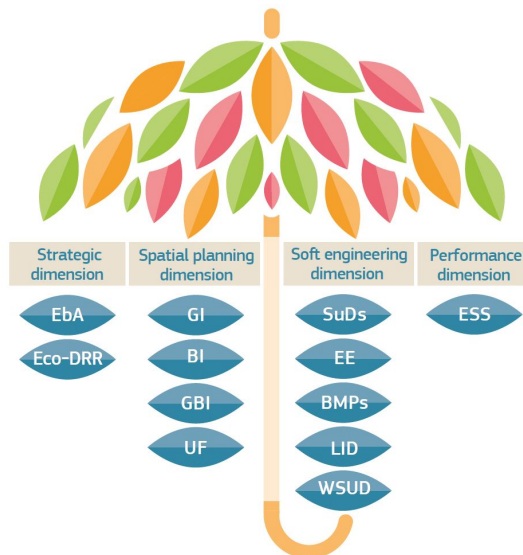


Figure 1: Nature-based solutions are an umbrella concept and encompass a number of existing concepts and practices. EbA = ecosystem based adaptation; Eco-DRR = ecosystem-based disaster risk reduction; GI = green infrastructure; BI = blue infrastructure; GBI = green-blue infrastructure; UF = urban forestry; SuDs = sustainable urban drainage systems; EE = ecological engineering; BMPs = best management practices; LID = low-impact design; WSUD = water-sensitive urban design; ESS = ecosystem services.

Nature-based solutions are a core element of the [European Green Deal](#) and recent major European policy initiatives, such as the [EU Biodiversity Strategy for 2030](#) and the new [EU Strategy on Adaptation to Climate Change](#). They play a key role in the new [EU Forest Strategy](#), the overarching [Water Framework Directive](#), and the [European Zero Pollution Action Plan](#) for air, water and soil. Nature-based solutions also contribute to objectives established as part of international agreements, such as the [Sendai Framework for Disaster Risk Reduction](#) and the [United Nations' Sustainable Development Goals](#). Through their role in the new European economy, nature-based solutions can also contribute to the targets established in the [EU Bioeconomy Strategy](#) and the [EU Circular Economy Strategy](#) and in the 'Fit for 55 package' on the transformation of the EU economy and society to meet climate ambitions. They are a key element of the transformative changes needed towards a sustainable future (Figure 2).



Figure 2: Nature-based solutions address numerous societal challenges (Image © European Union, 2021)

WHAT SOCIETAL CHALLENGES DO NATURE-BASED SOLUTIONS ADDRESS?



Climate resilience

Climate Resilience: Nature-based solutions can enhance resilience to the impacts of climate change by providing ecosystem services, and by increasing social awareness and actions to mitigate climate change. For example, nature-based solutions can:

- Remove carbon via storage in vegetation and/or soil
- Contribute to reduced greenhouse gas emissions through reduced energy consumption in buildings by passive cooling and/or insulating
- Reduce local temperatures, providing relief from heatwaves and urban heat islands



Water management

Water Management: Nature-based solutions can be used to effectively address both water quality and quantity (flooding, drought) issues, contributing to water security and environmental quality. Some of the water management benefits that nature-based solutions can provide include:

- Reduced surface runoff following rain events
- Increased surface water storage and/or groundwater recharge
- Improved water quality, including reduced pollutant loads



Natural and climate hazards

Natural and Climate Hazards: Nature-based solutions can reduce the risks associated with natural and climate hazards. They can mitigate risks related to both the increasingly frequent and intense storm events associated with climate change as well as other natural hazards, like landslides and avalanches. Nature-based solutions can, for example:

- Reduce the number of persons adversely impacted by natural disasters
- Reduce direct and indirect financial losses due to natural and climate hazards
- Mitigate risks to critical infrastructure



Green space management

Green Space Management: Green space management refers to the planning, establishment and maintenance of green and blue infrastructure in urban areas. Nature-based solutions can enhance the quantity, quality and accessibility of public green spaces, in particular, supporting the increased liveability of urban/peri-urban areas through:

- Increased accessibility of public green space for all citizens
- Increased total proportion of green space within built areas
- Improved quality of green, blue and green-blue spaces



Biodiversity enhancement

Biodiversity Enhancement: Biodiversity loss and ecosystem collapse are among the greatest threats our society faces in the near term. The implementation of nature-based solutions supports increased biodiversity, yielding benefits such as:

- Reduced fragmentation/increased connectivity of natural areas
- Increased number of native species, including pollinators
- Increased species diversity of both flora and fauna



Air quality

Air Quality: NBS based on the creation, enhancement, or restoration of ecosystems in human-dominated environments play a relevant role in removing air pollutants and carbon dioxide, reducing air temperatures, and increasing the ambient oxygen concentration. Some of the air quality benefits offered by nature-based solutions are:

- Reduced exceedances of air quality limits in the proximity of the nature-based solution, including airborne particulate matter, ground-level ozone, nitrogen and sulphur dioxides, carbon monoxide and polycyclic aromatic hydrocarbons
- A reduction in the proportion of the population exposed to ambient air pollution



Place
regeneration

Place Regeneration: Nature-based solutions support regeneration of the built environment by enhancing the quantity and quality of green space, fostering people-nature connections and by contributing to reductions in our environmental footprint. Some of the ways that nature-based initiatives can do this include:

- Reclaiming of derelict land for nature-based solutions
- Enhancing the place identity or “sense of place” among citizens
- Increasing the recreational and aesthetic value of public green spaces



Knowledge building for
sustainable urban
transformation

Knowledge and Social Capacity Building for Sustainable Urban Transformation: Environmental education opportunities can foster social connectivity and trust, and increase environmental knowledge and associational and volunteer involvement. Nature-based solutions offer collective opportunities for citizen involvement in stewardship actions, like community gardening and tree planting, intergenerational learning and collective decision-making, yielding benefits such as:

- Increased citizen involvement in environmental education activities
- Supporting social learning regarding ecosystems and their functions
- Enhancing pro-environmental behaviour among citizens



Participatory planning
and governance

Participatory Planning and Governance: Urban environmental transformation is a highly complex undertaking that requires open collaborative governance and robust capacities for participatory planning. Nature-based solutions require approaches to planning and governance that support accessibility to green spaces, while maintaining their quality for ecosystem services provision. Implementing nature-based solutions can support:

- Increased openness of participatory processes, and an increase in the proportion of citizens involved in these processes
- Increased sense of empowerment among citizens
- Increased trust in decision-makers and decision-making procedures
- Supporting social learning regarding ecosystems and their functions
- Enhancing pro-environmental behaviour among citizens



Social justice and social cohesion

Social Justice and Social Cohesion: Social cohesion is an important resource for long-term environmental sustainability. Nature-based solutions can foster social cohesion among typically-excluded social groups, and support social justice by providing equal access to neighbourhood green spaces. Some benefits derived from nature-based solution actions include:

- Improved quality of interactions within and between social groups
- Increased inclusion of typically marginalised social groups
- Increased tolerance and respect within the community



Health and well-being

Health and Wellbeing: Time spent in a natural environment promotes mental and physical health, and reduces the disease burden by providing psychological relaxation and stress alleviation, enhancing immune function, stimulating social cohesion, supporting physical activity, and reducing exposure to air pollutants, noise and excessive heat. Nature-based solutions support, for example:

- Increased physical activity leading to reduced obesity and reduced cardiovascular diseases
- Improved mental health and reduced chronic stress
- Reducing lung diseases and overall mortality by improving air quality



New economic opportunities and green jobs

New Economic Opportunities and Green Jobs: The adoption and implementation of nature-based solutions has the potential to create new economic opportunities and jobs in the green sector by enabling low-carbon, resource-efficient and socially inclusive economic growth. Benefits can include:

- Increased value of natural capital, including an increase in average land productivity and profitability
- Increased land or property value in proximity to nature-based solutions
- Increased retail and commercial activity in proximity to nature-based solutions

WHY DO WE NEED ROBUST IMPACT ASSESSMENT OF NATURE-BASED SOLUTIONS?

The need for a more “natural” living environment is increasingly recognised, with the importance of connecting with nature particularly highlighted during the COVID-19 pandemic. In addition to policy drivers, public demands for greater attention to biodiversity loss and climate change threats continue to grow at local to global scales. Assessing the impacts of nature-based solutions and associated activities is critical to understand their “effectiveness” in addressing targeted challenges.

Impact evaluation focuses on understanding the outcomes of interventions and provides a set of tools that stakeholders can use to verify and improve the quality, efficiency, and effectiveness of the nature-based solutions at various stages of implementation. Knowing which nature-based interventions are effective and at what cost is critical for decisions about the implementation itself, and whether a nature-based solution can be up-scaled up and/or replicated.

Monitoring is a continuous process that tracks both the process of creating nature-based solutions as well as their performance in relation to expected results and a reference situation of baseline conditions, in a specific place (territory), time and socio-economic context.

Evaluation is the periodic, objective assessment of planned, on-going or completed nature-based solution projects. Evaluation can answer descriptive (what is happening), normative (compared to what should happen), and cause-and-effect questions.



THE KNOWLEDGE BOOTH: BENEFITS OF IMPACT ASSESSMENT

Robust impact assessment supports practitioners in making evidence-based policy decisions. Impact assessment:

- Enables objective and transparent evaluation of the benefits and trade-offs of specific nature-based interventions
- Supports evidence-based policy making and policy learning
- Enables flexible adaptations to sustain nature-based solution performance and maintain the delivery of multiple benefits over time
- Supports the case for investments in nature-based solutions
- Over time, supports decision-makers to more precisely tailor nature-based interventions to local needs and desires



THE GOLDEN STANDARD: EARLY AND WELL EQUIPPED

Impact evaluation is often neglected due to lack of resources such as time or expertise. It is thus essential that impact evaluation is designed at the early planning phases of an NBS intervention, in order to allocate necessary resources, develop an effective stakeholder engagement strategy and fully integrate the selected monitoring and evaluation methods (including citizen science, where possible) within the overall process of nature-based solution creation, implementation and management.

DEVELOPING YOUR THEORY OF CHANGE

Strategic objectives in a particular city or region are normally implemented by establishing more specific, local goals, and by identifying challenges that call for specific policy interventions. Developing a theory of change entails making these relations explicit with some degree of formalisation, by providing answers to the following questions: which local goals are targeted; what city or regional strategic objectives they address; what nature-based solution/s and actions will address them; what specific outcomes are expected at different stages of the change process, and what are the assumed linkages or pathways between nature-based solution actions and expected outcomes. Stakeholders should also spend some time reflecting on potential interactions between outcomes that might lead to both positive synergies and unwanted trade-offs. Structured reflection supports practitioners in establishing context-appropriate rationales for nature-based solution implementation and establishing impact assessment objectives.



THE KNOWLEDGE BOOTH: MAPPING YOUR ASSUMPTIONS

OUTCOMES are the concrete results sought through the implementation of an NBS (e.g., reduce air temperature or increase mental health and wellbeing).

OUTPUTS are the visible part of nature-based solution interventions necessary to fulfil the outcomes (e.g., create an urban green park; implement a participatory process of nature-based solution design).

INTENDED IMPACTS are the effects or changes that are not only desirable but are explicitly targeted through the nature-based solution action.

UNINTENDED IMPACTS are the (usually) negative, unforeseen results of NBS implementation.

SYNERGIES: interrelations of positive effects (e.g., creating large tracts of urban green spaces favours biodiversity but also offers spaces for physical activity),

TRADE-OFFS: interrelations of "negative effects" (e.g., creating parks that improve the perceived quality of urban environments, which in turn contributes to gentrification, and the exclusion of some groups).



THE GOLDEN STANDARD: THINKING BEYOND INTENDED IMPACTS

Explicitly mapping the expected causal chain by which nature-based solution implementation achieve strategic objectives is useful in anticipating what may be missing in the design. Mapping causal pathways also allows for early detection of situations where all the envisioned outcomes may not be achieved, and beginning to ask the right questions about why that may be the case. It is also useful to identify other factors that might influence outcomes in a given location and time period, as well as the relationship between nature-based solution actions and outcomes. Local teams should reflect upon and identify the possible intended and unintended impacts, as well as synergies and trade-offs that may occur across the causal pathway.



Get inspired by the journey
of other cities and regions

TAMPERE

Finland

1. Climate Resilience

2. Water Management

4. Green Space Management

5. Biodiversity

7. Place Regeneration

The City of Tampere is one of the largest inland cities in the Nordics and the second most populated urban area in Finland. Located on a narrow isthmus between two large lakes, Näsijärvi and Pyhäjärvi, Tampere has been an important landmark for Finnish industry due in part to the rapids formed by the lakes. Tampere is one of the fastest growing regions in Finland, and it strives to align city planning with climate change adaptation and care for the environment. The city's investment in climate adaptation, both from municipal sources and support of the Horizon 2020 funding scheme, have resulted in the implementation of a variety of nature-based solutions. The primary aim and the driving force for nature-based Solution implementation in Tampere was preservation of the water quality of the surrounding lakes, which have been impacted by on-going urbanisation. Maintaining and enhancing biodiversity and devoting efforts to mitigating urban flooding were among other challenges identified as critical. Despite having multiple green areas, Tampere identified densification as an important concern for the newly developing urban areas, so spaces for enhancing cohesion and wellbeing were additionally considered.

Tackling the challenges with Nature-based Solutions

The primary NBS demonstration sites in Tampere are located in the Vuores Urban Living Lab (ULL), a newly developed green residential area. Vuores features an extensive stormwater management system comprised of several NBS, including a retention pond, biofilter, and alluvial meadows for managing runoff quality and quantity. A second Tampere ULL site is located in Hiedanranta, a former industrial area transformed into a residential area for 25 000 people. Selected nature-based solutions demonstrated in Vuores may be replicated in Hiedanranta. Nature-based solutions in Hiedanranta include a biofilter for treating landfill leachate and a microalgae system to recover nutrients from wastewater. Tampere have also implemented several supporting measures to enhance environmental awareness, access to green spaces, social cohesion through shared spaces and activities, and wellbeing.



MAIN OBJECTIVES	NBS ACTIONS	EXPECTED IMPACTS
Improve quality and reduce quantity of runoff to protect surface water bodies and address flooding	Stormwater management system. A retention pond, bioswale and alluvial meadows complement a restored stream	Benefits: improved runoff quality, reduced flow rates and less urban flooding, enhanced biodiversity
Treat seepage waters (leachate) from old landfill	Vegetated biofilter with biochar, peat and expanded clay media	Benefits: improved water quality, enhanced biodiversity
Raise environmental awareness among citizens, including children	Places that support nature exploration (nature trail), urban community gardens and NBS information signs. Engaging schoolchildren in water quality monitoring and macroinvertebrate sampling.	Benefits: increased environmental awareness, increased physical activity and improved wellbeing, enhanced access to nature and outdoor recreational opportunities
Strengthen social ties	Urban community gardens funded via nature-based innovation vouchers	Benefits: strengthened social inclusion and cohesion, support for voluntary community actions, activation of unconventional funding mechanisms, enhanced place identity, increased access to nature and outdoor recreational opportunities
Remove and recover nutrients from wastewater	Pilot-scale microalgae system	Benefits: innovative nutrient recovery via integrated urban water management, reduced CO ₂ emissions
Enhance biodiversity in urban areas	Bioswale, alluvial meadows, biofilter, and urban community gardens	Benefits: enhanced biodiversity, reduced flooding, increased access to urban nature and outdoor recreational opportunities

Theory of Change ►► Tampere

Capturing the change: Key Indicators

Challenge	Indicators
CLIMATE RESILIENCE	<ul style="list-style-type: none">• Total carbon removed or stored in vegetation and soil• Daily average and maximum temperatures• Energy and CO₂ emissions savings from reduced volume of water entering sewers
WATER MANAGEMENT	<ul style="list-style-type: none">• Surface runoff in relation to precipitation quantity• Time to flood peak/Peak discharge• Height of flood peak• Water quality: pH, electrical conductivity, total suspended solids, dissolved oxygen content, nitrogen and phosphorus concentration, concentration of metals
GREEN SPACE MANAGEMENT	<ul style="list-style-type: none">• Green space accessibility• Total area and distribution of public green space
BIO-DIVERSITY ENHANCEMENT	<ul style="list-style-type: none">• Number of species within a defined area• Species diversity within a defined area• Pollinator species presence
PLACE REGENERATION	<ul style="list-style-type: none">• Perceived quality of urban blue-green spaces• Number of scenic sites and landmarks created

Collecting information: Methods



Sensor Network



Manual Sampling



Meteorological Station



GIS Processing



Observation



Surveys



Citizen Science

Table of Indicators and Methods Tampere

Image: Vuores Central Park, Tampere – Photo © City of Tampere

Results

1. Climate Resilience

Meteorological stations have been installed to determine the cooling effect of nature-based solutions on hot days. A carbon footprint assessment of the Hiedanranta biofilter showed that materials were the most significant source of carbon emissions. The microalgae system effectively removed nutrients from source separated urine, and the harvested algal biomass can be used to produce energy (biomethane).

2. Water Management

The suite of NBS comprising a stormwater management system successfully retain solids and nutrients, and buffer runoff flow rates to receiving waterbodies. The nutrient content of NBS effluents is similar to that of an uncontaminated runoff.

4. Green Space Management

A recent survey among Vuores residents highlights that the local NBS are easily reachable – on average, citizens ranked accessibility at 4.7 out of 5. A GIS evaluation will link the perceived accessibility with the actual distribution of green spaces in the area for a more holistic interpretation.

5. Biodiversity

Biodiversity field campaigns demonstrate an increasing trend in the abundance of pollinator species during summer in the area surrounding the NBS. Further campaigns will provide insights into habitats and native plant species abundance.

7. Place Regeneration

According to surveys, local residents appreciate the multifunctional nature-based solutions and perceive them as increasing the attractiveness and unique characteristics of the area. On average, perceived safety of the area was ranked 4.1 out of 5. The citizens' average rank for the area's pleasantness for observing nature, landscapes and biodiversity was 4.5 out of 5.

Get inspired by the journey
of other cities and regions



POZNAN

POLAND

1. Climate Resilience

7. Place Regeneration

8. Knowledge and Capacity Building

10. Social Justice and Social Cohesion

11. Health and Wellbeing

12. New Economic Opportunities and Green Jobs

The city of Poznan, located on the axis of Warta river valley in west-central Poland, is a city with a wedge-ring system of forest and greenery, connected to a wider regional green system. Although the city is relatively rich in green spaces, they are not equally distributed, especially in the city centre and dense residential areas, creating less opportunities for social and physical activities. Poznan has set out to improve quality of life in these highly populated areas, while addressing adverse climate change effects such as heat waves and episodic flooding from intense rainfall (especially flash floods). The high rate of soil sealing in the city centre and densely built-up residential areas has resulted in unfavourable thermal conditions and limited potential for water retention. Poznan is also future-proofing the city, by taking care of its younger generation. The city is building its future social capacity by offering opportunities for children and adults to have increased access to and contact with nature for physical and mental health, as well as contexts for social interaction and learning about nature and biodiversity.

Tackling the challenges with Nature-based Solutions

To tackle these challenges, Poznan has implemented NBS such as pocket parks, gardens open to the public and nature-oriented playgrounds at preschools, which are important green spaces in neighbourhoods. This last intervention has stood out for its transformative nature. The modernization of the playgrounds was complemented by ecological education programmes to strength the relation of Poznan’s (youngest) citizens with nature. To date, 20 preschools have nature-oriented playgrounds, and 41 are endowed with ecological equipment. By increasing the biologically active area and permeable surfaces, storing rainwater, and introducing new plantings, nature-oriented playgrounds contribute to rainwater management and microclimate mitigation, while also enhancing biodiversity in nearby green spaces; providing social and health benefits for children through increased contact with and play in nature; increasing ecological awareness and nature education; and promoting entrepreneurship and professional development for the design and implementation of nature-based solutions.



MAIN OBJECTIVES	NBS ACTIONS	EXPECTED IMPACTS
Unsealing of the hardened surface	Breaking asphalt / concrete from the preschool area and / or creating diverse natural surfaces (e.g., grass, sand)	Benefits: increasing the biological active surface; improving rainwater infiltration, reducing surface runoff and air temperature regulation
Increasing the green area in the garden	New plantings of plants and shrubs	Benefits: mitigation of air temperature in these areas in summer Co-benefits: improving the aesthetics of the garden
Raising ecological awareness among children	Creating places in the garden enabling the cultivation of own plants, caring for greenery (ecological demonstrators)	Benefits: improving ecological education in preschools Co-benefits: caring for the common good
Facilitating collaborative design with teachers and pre-schoolers	Inviting future recipients of the preschool garden to jointly create a garden design	Benefits: strengthening social participation; Co-benefits: a jointly designed garden that will serve us all
Improving health, activity and physical fitness among children	Enriching space for children for performing physical activity	Benefits: enabling children to come and play sports in a safe and green playground; Co-benefits: improving health and well-being
Strengthening social ties	Enriching a space for playing and relaxing with other children, sharing the preschool green space with residents from the neighbourhood	Benefits: social inclusion Co-benefits: strengthening the sense of identity with the place
Enhancing biodiversity in the preschool garden	Building houses for insects, bird feeders, creating flower meadows	Benefits: improving biodiversity in the garden; Co-benefit: improving the possibility of observing birds and other animals, creating animal-friendly places in the city

Capturing the change: Key Indicators

Challenge	Indicators
CLIMATE RESILIENCE	<ul style="list-style-type: none">Land surface temperatureAir temperature reduction
PLACE REGENERATION	<ul style="list-style-type: none">Quantity of blue-green space (as a ratio to build form)Perceived quality of urban blue-green spaces (accessibility, amenities, natural features, incivilities and recreational facilities)
KNOWLEDGE & SOCIAL CAPACITY BUILDING	<ul style="list-style-type: none">Children involved in environmental educational activities
SOCIAL JUSTICE & SOCIAL COHESION	<ul style="list-style-type: none">Availability and equitable distribution of blue-green space
HEALTH & WELLBEING	<ul style="list-style-type: none">Self-reported mental health and wellbeingPerceived restorativeness of public green space/ NBSConnectedness to naturePrevalence of attention deficit/ hyperactivity disorder (ADHD)
NEW ECONOMIC OPPORTUNITIES	<ul style="list-style-type: none">Net impact on public expenditure from NBS implementation

Collecting information: Methods



Satellite Images

GIS

GIS Spatial Analysis



Observation



Survey

Table of Indicators and Methods  Poznań

Image: Kindergarten, Poznań - Photo © Piotr Bedliński, City of Poznań

Results

1. Climate Resilience

The cooling effect of preschool gardens designed as nature-oriented playgrounds could be estimated at 0.9-2.5o C (e.g. Preschool No. 42). Moreover, tree shade can lower surface temperature on average by 4.4o C in the case of a stony surface and by 7.0o C in the case of lawns.

7. Place Regeneration

Unsealing of 22% of paved surface in Preschool No. 42 allowed for transformation of the 882m2 area into a biologically active surface. In 2020 as much as 73% of 94 preschools in Poznań expressed an interest in transforming their playgrounds into nature-oriented ones.

8. Knowledge and Capacity Building

The city of Poznan equipped preschools with eco-demonstrators that support children's education during outdoor classes. In 2018, with 1274 pre-schoolers from 10 preschools received 50 eco-demonstrators, thus increasing opportunities for environmental education. In 2019, 2658 pre-schoolers from 20 additional preschools received 84 eco-demonstrators. In 2020, 44 more eco-demonstrators were deployed in 11 preschools serving 1130 children.

10. Social Justice and Social Cohesion

The share of green infrastructure varies across the city subdivisions from 8.3% to 73.4%, reflecting inequalities in opportunities for contact with nature. Nature-oriented playgrounds are particularly valuable for pre-schoolers from areas with a low share of green space.

11. Health and Wellbeing

The survey carried out in preschools with nature-oriented playgrounds and control preschools with traditional playgrounds shows that the overall quality of natural playgrounds is assessed as much higher by both teachers and parents of pre-schoolers. 87% of teachers and 80% of parents of children using natural playgrounds assess their quality as good or very good, while in the control kindergartens, traditional playgrounds were assessed as good or very good by slightly more than 58% of teachers of these kindergartens and 50% of parents. In both types of kindergartens children use playgrounds very often (a few days a week or higher) more than a few days a week), but 78 % used the natural-oriented playgrounds everyday as opposed to 58 % in the traditional playgrounds.

12. New Economic Opportunities

Considering the baseline 0 (2017) of expenditure in złoty (PLN), between the years 2018 and 2020 there was an investment in 20 nature-oriented playgrounds of PLN 1 871,600 and PLN 314,000 was spent on eco-demonstrators in 41 kindergartens. In total, PLN 2 185, 600, or approximately 478,900 EUR have been invested.

KEY PRINCIPLES IN ROBUST IMPACT ASSESSMENT

Good evaluation can be the basis for effective nature-based solution implementation, enable evidence-based policymaking, support policy learning and facilitate flexible decision-making, via adaptive management, to ensure the sustainable performance of nature-based solutions over time. A robust assessment process is scientifically sound, practical and straight-forward, uses reference conditions and baseline assessment to measure change, aligns with policy principles and reporting obligations, and is based on a trans-disciplinary approach.



THE KNOWLEDGE BOOTH: KEY PRINCIPLES

Be scientifically sound: Impact evaluations measure the change in an outcome that is attributable to a defined intervention, so requires a credible and rigorously defined study design to control for factors other than the intervention to establish cause and effect relationships.

Be practical and straight-forward: Since every nature-based solution project is unique, measuring of impact/outcome needs to be adjusted to the specific project and context.

Use reference conditions and baseline assessment: Baseline data are important for measuring pre-intervention outcomes (reference conditions) to be used in the assessment process for before-and-after comparison.

Align with policy principles and reporting obligations: To assure relevance and cost-effectiveness, it is important to seek alignment with key policy objectives. This can be done through a strategic review of policy alignment between local/regional/national strategic objectives and potential benefits of nature-based solutions.

Be based on a transdisciplinary approach: monitoring and evaluation plans should be co-produced in collaborative actions to achieve the best balance between local needs, values and knowledge, and interdisciplinary scientific knowledge.



THE GOLDEN STANDARD: INVOLVING CITIZENS

Monitoring and evaluation can benefit from collaborative approaches. Co-production is different from consultation or information provision, in that stakeholders are involved from the beginning in the development of monitoring and evaluation plans. The knowledge, expertise and lived experience of a wide range of stakeholders is relevant when deciding what outcomes to evaluate, identifying local needs, implementing monitoring strategies and gathering relevant data. Using well-designed collaborative approaches can also reduce costs and enhance nature-based solution ownership. Even for the most technical parts of monitoring and evaluation, using a collaborative approach can ensure that residents are knowledgeable of the reasons for it, and they can contribute to equipment maintenance and/or safety.

KEY PERFORMANCE INDICATORS

Key indicators of nature-based solutions' performance and impact provide information about their relative effectiveness in comparison with defined objectives. The selection of appropriate indicators of performance and impact is an integral part of impact assessment. The selected indicators will provide credible evidence regarding whether a particular nature-based solution has achieved, or is achieving, the envisioned outcomes.

Selected indicators should reflect the main outcomes sought in each of the challenge areas identified as important for a particular local context. Appropriate indicators help to clearly pinpoint those impacts that are attributable to the nature-based solutions implemented and contribute to a solid evidence base to inform further (nature-based) interventions and policy decisions. Chapter 4 of [Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners](#) lists a wide range of relevant indicators across each of the 12 main societal challenge areas. Information about how each of these indicators are assessed can be found in the accompanying [Evaluating the Impact of Nature-Based Solutions: Appendix of Methods](#).



THE KNOWLEDGE BOOTH: INDICATORS OF NATURE-BASED SOLUTION PERFORMANCE AND IMPACT

Adequate indicators should allow for the assessment of *both performance and process*, and thus answer the following questions:

- Does the nature-based solution operate as designed?
- Are outcomes consistent with the planned theory of change?

Outcome indicators: refer to particular outcomes, accomplishments or impacts (e.g., improved mental health).

Process indicators: refer to the characteristics of the nature-based solution implementation process, such as efficiency, quality, or consistency of specific procedures employed to achieve the desired goals (e.g., number of stakeholders involved in the initial NBS design stage).

Recommended or Core indicators – indicators of performance or impact that are central to the assessment of main expected outcomes.

Additional indicators – other useful indicators of performance or impact that may be necessary to evaluate specific targets, or desirable when additional resources are available for monitoring and evaluation.



THE GOLDEN STANDARD: A COHERENT FRAMEWORK

Together, the selected indicators should provide a coherent framework of expected benefits and co-benefits aligned with the developed theory of change. As nature-based solutions are multifunctional, the selected indicators should encompass environmental, social and economic aspects. In some cases, it is difficult to choose and measure all the desired outcomes and process features outlined in the previous steps, due to financial, personnel and time constraints. Therefore, in collaboration with local stakeholders, indicators can be ranked to establish priorities.

VALLADOLID

Spain

1. Climate Resilience

2. Water Management

4. Green Space Management

5. Biodiversity

7. Place Regeneration

9. Participatory Planning & Governance

Valladolid is a municipality and a city located in the Northwest part of Spain. The municipality of Valladolid is the capital of the autonomous region of Castilla y León and has an urban agglomeration of 301,876 inhabitants (INE, 2016) and an area of 19,250 Ha. The main urban challenges that Valladolid is facing are mostly related to the environmental quality. The focus is on the loss of air quality, characterized by the emissions of atmospheric chemical pollutants from urban traffic; the increased noise levels, having a high percentage of population in the city affected by levels above 55dB; regarding water quality, the Pisuegra river incorporates urban and industrial wastewaters, occasionally exceeding the legal limits for some chemicals; the hydrological risks are associated with natural flooding processes in Pisuegra river and heavy drainage of water for irrigation in the Esgueva river. Other challenges the city is facing are the decrease availability of water due to long periods of drought, high consumption of soil and energy and the permanent requirement of the use of the car.

Image: Green shade structures, Valladolid - Photo © Valladolid City Council



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Tackling the challenges with Nature-based Solutions

Valladolid is implementing a series of NBS grouped in three main demo areas (sub-demos). Sub-Demo A seeks to provide important ecosystem services for urban biodiversity creating an Urban Green Corridor promoting sustainable transport with new green resting areas, pollinator’s modules and planting trees over smart soils among other solutions. Sub-Demo B is deployed in the City Center of Valladolid and includes different types of Green Infrastructure adapted to high-urbanized areas like green façades, green roofs and shelters and green shady structures that along with an Urban Garden Bio-filter aims to reduce heat island effect, increase relative humidity and reduce air pollutants. Sub-Demo C includes a set of NBS with high ecological value and low maintenance costs, developing an Urban Carbon Sink as an urban woodland with high capacity of carbon sequestration to provide co-benefits to Climate Change such as biodiversity, quality public spaces, health, and wellbeing for citizens.



MAIN OBJECTIVES	NBS ACTIONS	EXPECTED IMPACTS
Improve the accessibility and distribution of urban green spaces	Increasing Green Vertical Infrastructures through green facades	Benefits: renewing the image of the facade adding aesthetic values to a grey area, energy and carbon saving from reduced building energy consumption, air quality improvement and climate regulation
Introducing biodiversity in the City Centre	Increasing Horizontal Green Infrastructures through Green Roofs and Green Covering Shelters.	Benefits: pollinator species increase, more permeable surfaces, reducing run-off and reusing rain water, air quality improvement and climate regulation
Improving citizens well-being and comfort in public spaces	New Green Shady Structures	Benefits: reducing high temperatures and increasing humidity levels in summer, adding aesthetic values to a grey street
Reducing air pollutants in sensitive areas	Installation of an Urban Garden Bio-Filter connected to a subterranean parking area	Benefits: air pollution reduction/ air quality improvement, filtering the polluting particles that are emitted to the outside, improving health and well-being, monetary value of air pollution reduction
Reducing the over accumulation of carbon dioxide in city’ atmosphere	Installation of an urban woodland as an Urban Carbon sink	Benefits: high capacity of carbon storage and sequestration; Co-benefits: new green areas, improving its accessibility and distribution to citizens
Improving quality of urban areas	Increasing urban tree population in new and existing urban areas	Benefits: enabling connectivity between green urban areas and green infrastructures, improving water retention and environmental quality, strength citizens perception about urban nature
Improve health and promote physical activity	New green recreational areas and green paths and cycle lines in the Green Corridor	Benefits: enabling healthy habits and a sustainable and safe mobility, improving health and well-being, landscape connectivity between green areas

Capturing the change: Key Indicators

Challenge	Indicators
CLIMATE RESILIENCE	<ul style="list-style-type: none"> • Total carbon removed or stored in vegetation and soil • Heatwave incidence. Days with temperature >90th percentile • Urban Heat Island (UHI) incidence • Mean or peak daytime temperature (Direct measurement)
WATER MANAGEMENT	<ul style="list-style-type: none"> • Surface runoff in relation to precipitation quantity • Infiltration rate • Rainwater or greywater use for irrigation purposes
GREEN SPACE MANAGEMENT	<ul style="list-style-type: none"> • Green space accessibility • Public green space distribution
BIO-DIVERSITY ENHANCEMENT	<ul style="list-style-type: none"> • Structural connectivity of urban green and blue spaces • Pollinator species presence
AIR QUALITY	<ul style="list-style-type: none"> • European Air Quality Index • Trends in emissions of NO_x and SO_x • Monetary values of air pollution reduction, urban forests including air quality, run-off mitigation, energy savings, and increase in property values. • Air quality parameters. NO_x and PM. • Concentration of particulate matter (PM10 and PM2.5), NO₂, and O₃ in ambient air • Concentration of particulate matter (PM2.5 and PM10) at respiration height along roadways and streets
PLACE REGENERATION	<ul style="list-style-type: none"> • Quantity of blue-green space (as a ratio to build form) • Perceived quality of urban blue-green spaces (accessibility, amenities, natural features, incivilities and recreational facilities) • NBS incorporated in building design / incorporation of environmental design in buildings

Collecting information: Methods



Sensor Network



Manual Sampling



Meters



Meteorological Station



Surveys



GIS Processing



Smartphone App



Observation

VALLADOLID

Expected Results

1. Climate Resilience

A reduction of urban temperatures is expected, both in terms of reduced mean and peak daytime temperatures and in reduced heatwave risk. An increase in carbon removal and storage is also anticipated.

2. Water Management

Increase in the rainwater retention capacity, reducing the number of litres entering the sewer system and decreasing the flow rates of surface runoff.

4. Green Space Management

An increase in the total area and surface area per capita of public green spaces, parks, and gardens in the city of Valladolid. This is expected to improve the distribution of green spaces and their accessibility to citizens, enhance citizens' quality of life and increase pollinator populations.

5. Biodiversity

The increase in the number and total surface area of green urban areas will improve the connectivity of blue and green infrastructure in the city, extending the habitat for native pollinator species and increasing populations of pollinator species.

6. Air Quality

Air quality is expected to improve in the vicinity of nature-based solutions, including reductions in NO_x , SO_x , PM, CO and other pollutants. The avoided costs associated with reduced air pollution will be estimated.

7. Place Regeneration

Energy savings are expected due to implementation of NBS, which provide insulating capacity and reduce use of energy for both heating and cooling. The increase in green areas is expected to increase the number of pedestrians and cyclists.



Learn more about the case at www.urbangreenup.eu

LA BRAGUE BASIN

FRANCE

1. Climate Resilience

3. Natural and Climate Hazards

4. Green Space Management

5. Biodiversity

12. New Economic Opportunities and Green Jobs

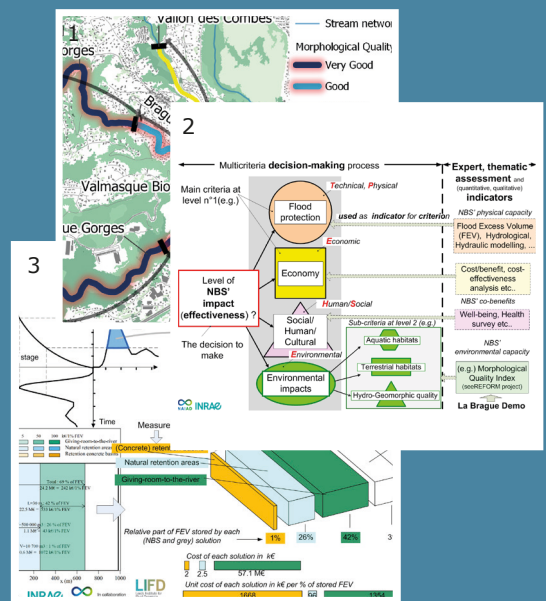
La Brague River basin (NAIAD project case study) is a 68 km² catchment located in the South of France along the French Mediterranean coast between the cities of Cannes and Nice. The Brague experiences flash floods sometimes carrying logs and tree trunks recruited by the fast flows. The Mediterranean climate causes heavy rains, mostly during the autumn, and the floods of the Brague are often devastating and sometimes deadly. Fourteen floods with heavy damage and eight deaths were recorded in the catchment during the period between 1970-2015. As an example, the insured damages of the October 2015 flood (return period greater than 100 years) amounted to more than 100 million € and four fatalities were recorded. After this event, several campsites located in the lowlands were closed by State decision as flood risk was considered too high but dozens of houses remain at risk.

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Image: Valmasque, La Brague tributary (Photo © C. Cheneval, CASA)

Tackling the challenges with Nature-based Solutions

Nature-based solutions to alleviate floods in the Brague catchment are integrated in a so-called “giving-room-to-the-river” strategy. Natural water retention measures using a series of small natural retention areas in the upper catchment were combined with widening of the river corridor in the lowlands enhanced by floodplain reconnection. Floodplain works consisted of several measures such as bed and bridge widening, forest corridor and wetlands restoration, and large woody debris management. Two levels of ambition, namely high and very high, are considered as well as a more classical grey scenario based on huge retention dams to provide a comparison point. A combination of technical, environmental assessment and decision aid methods, employing various physical, geomorphological and economic indicators, has been used to understand the effectiveness of the implemented nature-based solutions.



MAIN OBJECTIVES	NBS ACTIONS	EXPECTED IMPACTS
Reducing flood magnitude	Creating small natural retention areas in forests	Benefits: reduced water volume and flood hazard downstream, improved groundwater management
Reducing flood risk to people and assets	Giving room to the river: integrated management including river bed widening, restoration of in-stream vegetation and bank riparian forest, reconnection with wetlands in the floodplain, and some small grey measures such as racks to cope with drawbacks of wilder rivers, e.g., large woody debris	Benefits: protection of people and assets, increased risk awareness, more natural strategies addressed and considered in risk management strategies
Improving the natural status of the river	Developing a new cross-disciplinary approach to assess NBS efficacy in improving ecological status and reducing risk including participatory processes	Benefits: less artificial bed, improvement of hydro-morphological status, more shaded areas, improvement of river environmental quality, creation of natural habitats, improved landscape aesthetics
Demonstrating the benefits of alternative land use projects employing nature-based solutions	Reconnecting pedestrian and cycle paths along the river corridor, designing space for recreational activities, change in land use	Benefits: more comprehensive understanding of NBS capacities and limitations, increased discussion and cooperation among stakeholders, improved understanding of citizen risk perception
Improving landscape, welfare and promoting new activities and territorial use		Benefits: more accessible river corridor with an improved landscape to strengthen links between people and the river, development of new touristic activities and accompanying shift toward softer sustainable mobility

Capturing the change: Key Indicators

Challenge	Indicators
CLIMATE RESILIENCE	<ul style="list-style-type: none">• Total surface area of restored and/or created wetlands• Daily average and maximum temperatures (NO)
NATURAL & CLIMATE HAZARDS	<ul style="list-style-type: none">• Flood Excess Volume (FEV)• Availability of surface water resources (trend in piezometric levels)• Groundwater Exploitation Index• Morphological Quality Index (MQI)• Hazard, exposure and vulnerability indicators : peak flow variation, rainfall storage, flood peak reduction and delay, height of flood peak, runoff, potential population vulnerable to risk, risk to critical urban infrastructure• Citizens' perceived risk
GREEN SPACE MANAGEMENT	<ul style="list-style-type: none">• Green space accessibility• Total area and distribution of public green space
BIO-DIVERSITY ENHANCEMENT	<ul style="list-style-type: none">• Area of habitats restored• Ecological integrity• Functional connectivity of green and blue spaces
NEW ECONOMIC OPPORTUNITIES & GREEN JOBS	<ul style="list-style-type: none">• Economic valuation of NBS via integrated cost-benefit analysis• New activities/jobs created in tourism sector (indirectly assessed)

Collecting information: Methods





							
in situ sensors	Manual Sampling	Meteorological Station	Cost-Benefit Analysis	GIS Processing	Observation	Surveys	Interviews

Table of Indicators and Methods  La Brague

Image: La Brague river upstream A8 motorway

LA BRAGUE RIVER BASIN

Results

1. Climate Resilience

An integrated approach has been proposed including a hybrid design framework considering multi-factorial co-benefits and combining different disciplines to enhance resilience to the impacts of climate change, provide and take benefits of ecosystems services, and enhance social awareness through participative processes.

3. Natural and Climate Hazards

Integrated physical indicators such as the Flood Excess Volume (FEV) and Morphological Quality Index (MQI) were developed and applied to assess the proposed nature-based interventions. Scenarios were proposed and improved with local stakeholders to design and choose new flood management strategies in the area.

4. Green Space Management

Multifunctional green spaces/nature-based solutions are closely linked to risk management plans and local development planning. The technical specifications of proposed nature-based solutions provide support for a paradigm shift to both reduce risk and manage and preserve the environment.

5. Biodiversity

Improved quality of natural habitats is expected by the proposed solutions, which aim to give room to the river in a more natural way. A pragmatic and innovative analysis shows both the positive impacts of riparian forests but also its potential drawbacks during floods (woody logjams).

12. New Economic Opportunities

All stakeholders are involved in managing risk and developments on the area. NBS are proposed to support new plans in the area including economic activities but also re-naturing zones and changing the approach to tourism in the area. Projects include landscape quality improvement and the development of soft mobility options.

Learn more about the case at www.naiad.eu

OBTAINING AND USING DATA

Evaluating multiple nature-based solution benefits and trade-offs simultaneously can be data intensive. Understanding data requirements is critical to ensure both the efficacy and cost-effectiveness of the evaluation process. To establish robust and efficient impact assessment it is, therefore, important to generate data that are both suitable for the nature-based solutions implemented, and comparable with the preceding monitoring campaigns. The information needed to effectively evaluate the benefits and trade-offs associated with a given nature-based solution can take a variety of different forms and involve methods and concepts drawn from various disciplines of both the natural and social sciences. There are many different potential sources of data that can be used to quantify the impacts of nature-based solutions, ranging from in-situ measurements and earth observation techniques, to surveys and citizen science. Chapter 7 of [*Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners*](#) provides detailed guidance regarding available data sources and the development of a plan for the collection, management and use of data regarding nature-based solution performance and impact.



THE KNOWLEDGE BOOTH: DATA

Spatial data contain information about a specific location on the Earth's surface. Spatial data provide information on the exact location, shape, size, and orientation of a given entity (e.g., a forest or urban park).

Non-spatial data contain information which is independent from any geometric and/or topological consideration (e.g., survey data). However, this type of data can often be linked to a specific geographic location (e.g., location of sensor, address of participant) and thus enable a more precise impact assessment.

Scale of data collection is important to properly capture the range of impact. Although nature-based solutions are often relatively small, their area of effect can be significantly larger and should be considered carefully (e.g., at neighbourhood or district scale).

Baseline assessment means collecting data that describes the study area prior to any nature-based solution intervention. Depending on the expected impacts, baseline data should describe the site's biological and geo-morphological characteristics and/or socioeconomic conditions of potentially affected communities.



THE GOLDEN STANDARD: INTEGRATION WITHIN EXISTING DATA COLLECTION PROCESSES

Thoroughly reviewing available data, as well as attempting to connect data collection with existing and regular survey, monitoring and reporting efforts at regional, national or international levels will mean that monitoring and evaluation of NBS can become a regular practice and be maintained and enriched over time. Moreover, given adequate resources, and automatized forms of data collection (such as wearable or remote sensors, smartphones, etc.) data might be also collected at several times before, during and after NBS implementation, thus allowing for higher precision and the more precise assessment of changes.



LINKS:

[EC – Research Executive Agency – Nature-based Solutions](#)

[EC – Research & Innovation – Nature-based Solutions](#)

[Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners](#)

[Evaluating the Impact of Nature-Based Solutions: Appendix of Methods](#)

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La Brague river basin -Jean-Marc Tacnet, Guillaume Piton (Univ. Grenoble Alpes, INRAE, ETNA, Grenoble, France)

Poznan - Iwona Zwierzchowska, Piotr Lupa, Lidia Poniży, Katarzyna Fagiewicz, Łukasz Mikuła (Adam Mickiewicz University), Adina Dumitru, David Tomé-Lourido (University of A Coruña), Agnieszka Dziubała, Dominika Dymek, Agnieszka Osipiuk (City of Poznan).

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Assessing the impacts of nature-based solutions is essential to understand their effectiveness in addressing current interrelated societal challenges. Robust impact evaluation supports practitioners to understand and document the outcomes of nature-based solutions, resulting in improved quality, efficiency and effectiveness at various stages of nature-based solution implementation. Knowing which nature-based interventions are effective and at what cost is critical for decisions about the action itself, as well as for assessment of the up-scaling and/or replication potential of a given nature-based solution. This publication provides a summary of key principles in developing your impact evaluation framework, which includes the development of your theory of change, and the selection of appropriate indicators of impact and methods to obtain useful and high-quality data. Through the presentation of four European nature-based solution case studies, with diverse geographies and challenges, we illustrate how impact evaluation can be tailored to local contexts. We hope to inspire you to further explore the detailed information available in [Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners](#), and the accompanying [Evaluating the Impact of Nature-Based Solutions: Appendix of Methods](#).

Studies and reports

