MULTISOURCE

Practical Guide to Business Model Development for Urban Nature-Based Water Treatment Solutions

Deliverable 3.4

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EXECUTIVE SUMMARY

Nature-based solutions for water treatment (NbS^{WT}) can effectively address critical challenges such as stormwater management, flood mitigation, and wastewater treatment while delivering multiple important societal co-benefits. These include enhanced biodiversity, urban cooling, and improved public health, making NbS^{WT} an integral part of resilient, liveable cities. Despite their well-documented advantages, the implementation of NbS^{WT} remains largely limited to pilot projects due to challenges in governance, financing, and stakeholder alignment. This deliverable, developed under Work Package 3 of the Horizon 2020 MULTISOURCE project, provides a comprehensive guide to overcoming these barriers and scaling NbS^{WT} adoption.

Drawing on an extensive review of literature, 57 real-world cases, and insights from co-creation workshops conducted across Europe, the report offers practical recommendations for project proponents, municipal planners, and private sector stakeholders. It addresses the entire lifecycle of NbS^{WT} projects—from strategic development and planning to long-term operation and maintenance—while providing detailed frameworks for governance, financing, and stakeholder engagement. Through its systematic approach, the deliverable empowers stakeholders to integrate NbS^{WT} into urban contexts effectively and sustainably.

A Six-Stage NbS^{WT} Project Lifecycle Framework

The deliverable (chapter 2) structures the NbS^{WT} project lifecycle into six stages and offers targeted practical guidance for each one:

1. **Project Development**: This stage focuses on defining strategic objectives, identifying environmental, social, and economic value propositions, and co-designing implementation arrangements. Based on successful experiences in the Horizon 2020 NAIAD and MULTISOURCE projects, the report recommends group model-building techniques to build a shared understanding of the challenge and effective solutions among multi-sectoral decisionmakers, align priorities, uncover co-benefits, and address trade-offs. The report also highlights the importance of categorising NbS^{WT} services (e.g., public goods, private goods) to define the basic governance and funding strategies.
2. **Planning**: This stage covers assessments for optimal site and technology selection, and land use planning, as well as local stakeholder engagement to build a robust foundation for long-term project implementation. The report provides strategies for engaging diverse stakeholders, including municipal authorities, private sector actors, and local communities, to ensure buy-in and long-term collaboration.
3. **Design and Engineering**: This stage translates project concepts into technical designs that align with hydrological, ecological, and social requirements. This includes detailed engineering plans, designs co-created and/or endorsed by stakeholders, and financial models to balance CAPEX, OPEX, and expected returns. Participatory co-design methods can ensure solutions are locally tailored and foster community ownership. This can provide an important risk management measure to prevent damages or inadequate maintenance of NbS^{WT} in public (or private community) spaces.
4. **Construction**: This stage represents the physical implementation of NbS^{WT}, from site preparation and infrastructure setup to quality assurance testing.
5. **Operation and Maintenance (O&M)**: This stage involves routine maintenance, performance monitoring, and adaptive management to sustain NbS^{WT} functionality over time. Under this section, the report outlines roles for public agencies, private contractors, and community stakeholders in maintaining and operating NbS^{WT} systems. This stage also involves monitoring and evaluation mechanisms to communicate outcomes, allow adaptive management, and attract further investment.

6. **End-of-Life:** This stage refers to the decommissioning, repurposing, or ecological transition of NbS^{WT} once they reach the end of their intended service life. Key considerations include dismantling or retrofitting technical components, recycling or safely disposing of materials, and restoring or transforming the site for continued ecological or social value. Well-planned end-of-life strategies can reduce environmental impacts and capture residual value (e.g., reuse of substrates, biomass harvesting, material recovery).

Stakeholder Engagement and NbS^{WT} Value Chain Mapping

The NbS^{WT} value chain involves diverse actors, including public agencies, water utilities, private investors, NGOs, and local communities. The report emphasises:

- Early stakeholder engagement to build trust and secure long-term commitments.
- Clear role definitions and collaborative financing models to address multifunctionality and align incentives.
- Governance structures that facilitate cross-sectoral coordination and equitable cost-sharing.

Business Model Typologies for NbS^{WT}

Chapter 3 categorises NbS^{WT} business models into four families, illustrating the diversity of approaches required to accommodate varied urban contexts and stakeholder priorities:

- **Public-Public Models**: Collaborative funding and management of NbS^{WT} in urban public spaces involving multiple public actors.
- **Public-Private Partnerships (PPPs)**: Joint efforts leveraging private sector innovation and investment, such as involving municipal or metropolitan authorities and water utilities for the implementation of a treatment wetland for combined sewer overflow.
- **Public Service on Private Property**: Projects supported financially and/or in-kind by public entities but implemented on private land.
- **Purely Private Models**: Market-driven solutions fully funded and operated by private entities, such as industrial treatment wetlands for regulatory compliance, or bioretention systems on a private building compound to comply with rainwater discharge limits.

The description of each typology includes real-world examples, financing mechanisms, and practical recommendations for aligning stakeholder roles and responsibilities.

Decision Criteria for Designing Implementation Arrangements

Chapter 4 provides a framework for structuring main decision criteria for the design of implementation arrangements for NbS^{WT}. It describes five subsequent steps based on the Handbook for the Implementation of Nature-based Solutions for Water Security (Altamirano et al., 2021) and expanded upon within the MULTISOURCE project. These steps—defining strategic objectives, formulating funding strategies, developing financial arrangements, outlining procurement strategies, and planning for long-term management—can guide stakeholders through the complexities of NbS^{WT} implementation.

The chapter highlights the importance of aligning each stage with clear governance and funding structures. It emphasises the categorisation of NbS^{WT} services as public or private goods, providing the first step to precisely attribute costs and funding responsibilities to actors or budgets. The framework integrates insights, such as the necessity of dynamic financing mechanisms, the inclusion of adaptive management protocols, and the integration of cross-sectoral governance to manage NbS^{WT} over their lifecycle. These recommendations ensure that projects are not only well-designed but also sustainable, scalable, and aligned with local policy and community needs.

Practical Recommendations for Effective Project Development

Chapter 5 provides actionable insights for stakeholders involved in the development of NbS^{WT}, highlighting critical success factors to enhance scalability, sustainability, and stakeholder alignment. The chapter underscores the importance of fostering multi-actor engagement from the onset of project development, emphasising co-creation processes that unite diverse sectors and perspectives. Building a shared vision and value proposition is pivotal, requiring collaborative problem identification, clear role delineation, and integration of multiple co-benefits to secure alignment across sectors.

The chapter highlights the alignment with policy objectives as a foundational success factor for realising NbS^{WT} projects at scale, and for designing multifunctional interventions. Aligning NbS^{WT} initiatives with local and national strategies not only enhances their relevance but also secures institutional support. It also offers insights into leveraging existing policy frameworks to integrate NbS^{WT} into broader urban planning and water management agendas. Decision-makers are guided on how to build robust business cases, incorporating cost-benefit analysis to demonstrate economic viability and secure funding.

The deliverable also provides recommendations in relation to Cost-Benefit Analysis (CBA. The analysis highlights the importance of dynamic discounting to capture the long-term cumulative benefits of NbS^{WT}. Additionally, adaptive management strategies and regular performance monitoring are emphasised as essential components to ensure the ongoing functionality and resilience of NbS^{WT} systems. A key recommendation for acquiring funding partners, based on the feedback of decision-makers in the MULTISOURCE co-creation processes, is to link marginal costs to NbS services: Clearly attribute additional costs of enhanced designs to the specific services they provide, supporting cost recovery and providing a clear justification for actors to pay for services their budgets are mandated for.

Long-term operation and maintenance (O&M) is another focal point, with the chapter presenting proactive strategies to ensure the viability of NbS^{WT} over time. It identifies the need for structured governance models, sustainable funding mechanisms, and community engagement to reduce costs and build local ownership. Collaborative approaches involving municipalities, private actors, and citizens are highlighted as effective strategies to maintain infrastructure, address challenges, and adapt to changing conditions.

Practical Outcomes and Future Directions

This deliverable offers stakeholders a roadmap for overcoming the complexities of NbS^{WT} implementation. By addressing challenges in governance, financing, and stakeholder collaboration, it provides actionable tools to scale NbS^{WT} adoption across diverse urban contexts. Key takeaways include the importance of adaptive management, co-creation processes, and robust financial models to sustain NbS^{WT} projects over time.

The integration of NbS^{WT} into urban infrastructure presents a unique opportunity to enhance resilience, mitigate climate risks, and create more liveable cities. Through continued investment, innovation, and collaboration, NbS^{WT} can become a cornerstone of sustainable urban development, addressing water management challenges while delivering substantial co-benefits for communities and ecosystems.

Introduction

Nature-based solutions (NbS) are increasingly recognised as effective, sustainable alternatives to traditional infrastructure, providing multiple benefits that address societal and environmental challenges. When applied to water management, **Nature-based Solutions for Water Treatment (NbS^{WT})** span solutions such as constructed wetlands, raingardens, bioswales, green roofs, retention basins, permeable pavements, urban forests, and green walls. These systems are designed to tackle specific challenges like stormwater treatment, flood mitigation, and wastewater reuse, while also delivering co-benefits such as biodiversity enhancement, urban cooling, reducing health inequality, increased wellbeing, and recreational opportunities (see e.g. Jones et al, 2022; O'Sullivan et al., 2020; Duskova and Haas, 2020; Faivre et al., 2017).

Amid growing climate pressures, cities worldwide face increasingly severe environmental challenges, including extreme heat events, prolonged droughts, rising water pollution, and flooding Pasimeni et al., 2019; Pauleit et al., 2017). Addressing these issues requires innovative solutions that are sustainable, resilient, and cost-effective (Mayor et al., 2021; Petersen et al, 2024). NbS^{WT} provide essential water management services and multifunctional co-benefits, making them a promising alternative to traditional grey infrastructure (Wirth et al. 2023; Kirsop-Taylor et al., 2021). However, their implementation remains largely limited to pilot projects. Scaling NbS^{WT} requires new approaches that account for their multifunctionality, respond to sectoral budgetary constraints, and address governance complexities.

Urban stormwater and wastewater systems, traditionally reliant on underground infrastructure such as sewers and treatment plants, contrast with NbS^{WT}, which are often integrated in urban green spaces and the built environment of cities. The introduction of NbS^{WT} challenges traditional water management in both the design and implementation phase of local water policy measures. Designing water treatment and flood control services into the decentralised systems incurs initial additional costs, requires transformed policy ideas and approaches to urban planning, and demands negotiation among stakeholders to align motivations, objectives and interests, local or sectoral requirements, and budgetary constraints. Effective implementation requires viable business models that address challenges such as long-term financial sustainability, multi-stakeholder engagement, public-private engagements and governance (Mayor et al., 2021; Calliari et al., 2022).

NbS^{WT} are inherently multifunctional (please see section 1 below), offering a wide array of services, from water purification and flood management to habitat creation and recreation. Their realisation often spans multiple sectors including biodiversity, climate mitigation, transport and housing, health and wellbeing and social equality, affecting land use, public services, and economic activities. The **implementation gap** — the disconnect between the growing recognition of NbS^{WT} benefits and their limited large-scale adoption — can also be attributed to complexities in the value chain. The NbS^{WT} value chain involves diverse stakeholders, including municipal agencies, water utilities, private landowners, developers, and local communities, each with unique interests, capacities, and constraints. The multifunctionality of NbS^{WT} requires careful cost allocation and role definitions to align diverse motivations and responsibilities. This necessitates effective governance structures and collaborative financing models to ensure long-term viability and maximise urban resilience benefits. This report addresses this challenge.

Scope and purpose

This deliverable, developed within Work Package 3 "Business Models for Enhanced Natural Treatment Systems" of the **MULTISOURCE project**, provides a practical resource for stakeholders aiming to implement NbS^{WT} within urban water management frameworks. It addresses the challenges of aligning stakeholder roles, securing financing, and managing trade-offs across the NbS^{WT} project lifecycle and provides guidance on navigating the complexity of the NbS^{WT} value chain, focusing on practical strategies to engage diverse actors, allocate costs effectively, and design governance structures for long-term success. By consolidating, examining and synthesising best practices, literature, and results from co-design and co-creation carried out within MULTISOURCE, the report aims to support the development of financially sustainable, socially inclusive, and environmentally impactful NbS^{WT} projects.

The methodology is rooted in transdisciplinary research with stakeholders, ensuring that the perspectives and needs of various actors along the NbS^{WT} value chain are integrated. This approach not only captures theoretical knowledge but also incorporates experiential insights from decision-makers and practitioners actively involved in NbS^{WT} projects.

Structure of this report

The structure of this report is organised to guide stakeholders through the full lifecycle of NbS^{WT} project development, from initial planning to long-term operation and maintenance. Following this introduction, the deliverable outlines the **background and methods** used to compile the report, including insights from co-creation workshops, literature reviews, and case studies. It then describes the **six stages of the NbS^{WT} project lifecycle**, providing practical guidance for each phase:

1. **Large-Scale Planning**: Simulating solutions, assessing suitable sites, and engaging stakeholders.
2. **Building the Investment Case**: Developing funding and financing strategies, including revenue streams and cost recovery models.
3. **Technical Design and Engineering**: Translating concepts into actionable designs that meet regulatory and functional standards.
4. **Construction**: Implementing NbS^{WT} systems, quality assurance, and alignment with plans.
5. **Operation and Maintenance**: Sustaining long-term functionality through routine maintenance, monitoring, and adaptive management.
6. **End-of-life:** Decommissioning, repurposing, or ecological transition of NbS^{WT}.

Subsequent chapters map the **NbS^{WT} value chain** and its associated actors, providing insights into their roles, motivations, and capacities. The report also presents an overview of **business models for NbS^{WT}**, showcasing typologies such as public-public, public-private, and private-sector-driven approaches. Case studies and examples from the MULTISOURCE project and other initiatives are integrated throughout, illustrating successful applications of NbS^{WT} across urban contexts.

The report concludes with a synthesis of **key success factors** derived from multi-actor co-creation workshops and collaboration experiences and activities within the MULTISOURCE project. These insights aim to empower stakeholders to overcome implementation barriers, enable the scale-up of NbS^{WT}, and contribute to climate change adaptation and urban resilience.

1 Background and methods

MULTISOURCE - Modular Tools for Integrating Enhanced Natural Treatment Solutions in Urban Water Cycles

The MULTISOURCE project, funded by the EU Horizon 2020 programme, aims to support the development, implementation, and scaling of sustainable business models for nature-based solutions in urban water management. With seven pilots of Enhanced Natural Treatment Solutions, MULTISOURCE demonstrates the benefits of increased water quality, water storage, reuse, as well as the creation of valuable urban habitats and other important ecosystem services. The project develops innovative tools, methods, and business models that support city-wide planning and long-term operation and maintenance of NBS^{WT}, storage, and reuse in urban areas worldwide.

Developed within Work Package 3 'Business models for enhanced natural treatment systems', this deliverable provides practical guidelines for stakeholders seeking to implement NbS^{WT} in urban contexts. This deliverable seeks to provide actionable guidance to bridge the implementation gap for NbS^{WT}, ensuring that these solutions are not only recognized but realized at scale for more liveable, sustainable, and resilient cities. The content synthesizes insights from a review of good practices of real-world applications, literature on NbS^{WT} financing and operation, qualitative interviews, and lessons learned through NBS^{WT} business model co-creation processes involving diverse public and private urban actors in the cities of Oslo (Norway) and Girona (Spain), and the metropolitan regions of Milan (Italy) and Lyon (France), as well as co-creation involving multidisciplinary members of the consortium of the MULTISOURCE project[1].

Systematic review of literature and real-world cases

This practical guide builds upon an extensive review of literature and real-world cases, synthesising best practices in financing, governance, stakeholder engagement, and management models for NbS^{WT}. The results of this review are set out in the Deliverable 3.1 of the MULTISOURCE project (Wirth et al., 2023). A systematic literature review was conducted to allow for inclusion of insights on co-creative NbS implementation models from in disciplines beyond business models, and to ensure a structured, robust and focussed synthesis of findings (Malterud et al. 2018; Khan et al. 2003). The peer-reviewed literature was identified in academic search engines (ScienceDirect and Google Scholar), using search strings combining NbS business models, financing NbS, NbS for water management, NbS climate change adaptation cities, and the literature was screened for relevance (Khan et al., 2003). Relevant grey literature was identified through a snowball method online search and included outputs from EU Horizon 2020 and Horizon Europe projects, commercial reports, as well as international organisations. Overall, this yielded 57 cases of NbS implementation documented in literature. Drawing on insights from these 57 NbS cases implemented in diverse European urban contexts, the analysis explores innovative approaches to funding, multi-stakeholder collaboration, and long-term operation and maintenance. These cases provide valuable lessons on the challenges and opportunities associated with scaling NbS^{WT}, offering a rich knowledge base for project proponents.

The methodology for identifying the critical steps in establishing feasible business models for NbS closely follows the *Handbook for the Implementation of Nature-based Solutions for Water Security* developed under the EU Horizon 2020 NAIAD project (Altamirano et al., 2021), which incorporates the *Financing Framework for Water Security (FFWS)*. Developed by DELTARES and tested across NAIAD project locations in Europe, the FFWS applies a five-step approach that evaluates the strategic, economic, commercial, financial, and management dimensions of NbS implementation. This framework has been further applied and adapted in the MULTISOURCE project to guide co-creation activities across partner cities and metropolitan regions, in recognition of the local conditions for NbS and co-creative engagement, as discussed in Deliverable 3.3 of the MULTISOURCE project[2] (Wirth et al., 2024). Additionally, the knowledge base is enriched by insights from *Invest4Nature Deliverable 3.3* (Tedeschini et al., 2024), which provides complementary findings on NbS governance and financing.

Focusing on urban NbS^{WT}, this report extends the existing frameworks by integrating research conducted within the MULTISOURCE project. By synthesising the theoretical models with our findings from real-world processes, the methodology provides a robust foundation for understanding how to design, implement, and sustain NbS^{WT} projects that deliver both water management services and multifunctional co-benefits in urban environments.

Water management using NbS for sustainable cities

Over the past decade, awareness of the multiple benefits offered by NbS has been surfacing, and policy-makers increasingly recognize urban nature as presenting solutions to multiple societal challenges – and policy problems – concomitantly in urban and semi-urban contexts (Cohen-Shacham et al., 2016; Jones et al., 2022; Cortinovis et al., 2022; Kirsop-Taylor et al., 2022; Connop et al., 2016; Halbe et al., 2018),

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[1] Previous results can be reviewed in **Deliverable 3.1. Best Practices for Financing and the Operation & Maintenance of Nature-Based Solutions for Water Treatment** (Wirth et al. 2023) and **Deliverable 3.3. Descriptions of co-created business models for innovative NbS^{WT} and their integration in urban water systems** (Wirth, De Cesare, and Menconi 2024).

[2] Please also see Deliverable 3.3. for details on the results.

and the integration of NbS as policy idea in water measures increasingly represents a particular form of governance intervention (Pauleit et al., 2017, Kirsop-Taylor et al, 2022; Petersen et al., 2024).

Yet, the term NbS is often used interchangeably with others notions related to nature or ecological systems, such as urban ecosystem services (Almensar et al., 2021; Hekrle, 2022; Camps-Calvet et al., 2015; Halbe et al., 2018), green infrastructure (Jones et al., 2022; Pinto et al., 2023; Connop et al., 2016; Wiggering, 2020), green-blue spaces and urban greening (Baravikova, 2020), and natural infrastructure (Bennet et al., 2016; IUCN, 2016). Particularly since the late 2010s, the EU has centred on NbS as a strategic measure and policy idea in the Community's climate change strategy (Baravikova, 2020; Pasimeni et al., 2019). NbS hence increasingly form a keystone of climate adaptation in the EU, and Europe has seen an abundance of testing the benefits of NbS in in adapting to climate change (Kabisch et al., 2017; Seddon et al., 2020), especially concerning water, e.g. in Italy (Pasimeni et al., 2019), in Germany (Albert et al., 2021; Duskova & Haas, 2020; Frantzeskaki et al., 2017), in Denmark (Petersen et al., 2024), in Sweden (Suleiman et al., 2020), in the Netherlands (Dunn et al., 2017), in the UK (Connop et al., 2016; Frantzeskaki et al., 2020) and other countries (Baravikova, 2020; Camps-Calvet et al., 2015).

However, a more precise definition of the concept of NbS has been contested over the past decade, as the concept has received growing attention among policy makers (Dunn et al., 2017; Guerrin and Serra-Llobert, 2023) and in academic literatures (Kirsop-Taylor et al., 2022). In 2016, the International Union for Conserving Nature and Natural Resources (IUCN) provided a comprehensive definition of NbS, which stresses the joint bases of benefits for protection and/or increase in biodiversity, water management and a plethora of other aspects of the natural environment, while also emphasising the benefits of NbS for society and communities, and wellbeing of citizens in defining NbS as "[a]ctions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2016).

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> The European Commission (2020) defines NbS as:
>
> "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"

The definition of the European Commission builds on this agenda setting definition, and coins NbS to denote the "[s]olutions 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" (CEC 2024).

In parallel, United Nations Environment Programme (UNEP) adopted in their 2022 Assembly a definition of NbS, which closely aligns with the one proposed by IUCN, while furthermore stressing the fundamental role of the intergenerational perspective, the local-to-global scales, and the three basic dimensions of social, economic and environmental sustainability: "[N]ature-based solutions are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits" (UNEP, 2022:2).

The United Nations Environment Programme (UNEP) (2022) defines NbS as:

"actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits"

Consistent across the range of definitions is the potential of NBS for delivering solutions (Connop et al., 2016; Raymond et al., 2017a) that concomitantly benefits environmental policy objectives beyond biodiversity and in other sectors, including social and economic challenges, which is particularly attractive for many policy makers, i.e. that NbS has significant co-benefits (Petersen et al., 2024; Banzhaf et al., 2022; Aghaloo et al., 2024). The solutions offered by inclusive urban nature policies specifically benefit urban flood management and local restoration of increased precipitation, cooling, enhancing and restoring urban biodiversity and improving air quality (McVittie et al., 2018; Calliari et al., 2022; Debele et al., 2023; Curt et al., 2022). Equally important for the adoption and implementation of NbS, enhanced nature quality (and cover) and accessibility to nature in cities is that NbS can improve citizen wellbeing and health, strengthen community cohesion and reduce social stratification (Petersen et al., 2024; Jones et al. 2022; Borelli et al., 2021; Chabba et al., 2022; Curt et al., 2022). This wide range of benefits have stimulated a growing literature on frameworks (Raymond et al., 2017; Sowińska-Świerkosz and García, 2021), which often stress the interdisciplinary nature of NbS (Banzhaf et al, 2022; NessHover et al., 2017; Perz et al., 2010; Frantzeskaki et al., 2017) and typologies of NbS (Jones et al., 2022; Price, 2021; Ommer et al., 2021; Yang et al., 2023; Aghaloo et al., 2024), the latter most often departing from quantifying benefits of NbS measures (Raji et al., 2024; Ommer et al., 2022; Jones et al., 2022; Calliari et al., 2022).

For policy approaches to integrated management of water in the EU member-states, NbS has shown to offer additional benefits for effective and sustainable urban water policy (Krause & Wagner, 2019; Davis and Naumann, 2017; Baulenas and Sotirov, 2020; Schaub et al., 2021; Papparlardo and La Rosa, 2020), such as using NbS for reducing water pollution in in semi-urban areas in Italy (Liquete et al., 2016) or in providing communal gardens or community green spaces as part of integrated water management approaches (Kirsop-Taylor et al., 2022; Dorst et al., 2019; van der Jagt et al., 2017).

Moreover, recent studies stress how adoption of NbS approaches in policy making can induce change of policy ideas or paradigms (Kauark-Fontes et al., 2023; Moreau et al., 2022; Jensen et al, in review) and prompt institutional innovation (Faivre et al., 2017; O'Sullivan et al., 2020; Suleiman et al., 2020) or learning (Petersen et al., 2024), including towards managing the difficult task of policy integration. Significantly, the social benefits of NbS measures also cover the policy making around NbS and has led to co-creation activities and attention to the perceptions of NbS and their value among citizens and stakeholders (Banzhaf et al., 2022; Hekrle, 2022; Viti et al., 2024), and the role and form of public participation in local government's NbS activities (Pagano et al., 2019; Giordano et al., 2020; Hardiman et al., 2024), including as co-creation (Wirth et al., 2023).

Significantly, NbS is promoted as a measure that has lower costs and higher benefits than technological/'grey' solutions (Droste et al., 2017; le Coent et al., 2021), which has fuelled a wider interest in funding and financing models for NbS (Baroni, Nicholls, Whiteoak, 2019; Calliari et al., 2022; Banzhaf et al, 2022; Bennett et al, 2016; Liquete et al., 2016; Brears, 2023; Sekulova et al., 2021, Mayor et al., 2019) and business models (Coles et al., 2019; Coles and Tyllianakis, 2019; Maciulyte et al., 2018; Mayor et al., 2021; Mok et al., 2019; Wilk et al., 2020; McQuaid, 2019).

Interviews and online workshops with NbS^{WT} value chain actors

To capture firsthand insights from actors actively engaged in NbS^{WT} projects or representing enabling decision-makers, 25 semi-structured qualitative interviews were conducted with stakeholders across the NbS^{WT} value chain. The interview participants included representatives from water and wastewater utilities, regional water agencies, municipal and metropolitan government departments of environment, urban greening, roads, social housing, and sewer system, as well as private sector investors, implementation partners such as architects, landscape architects, NbS^{WT} suppliers, environmental NGOs, and academia. The interviews focused on identifying the actors across the NbS^{WT} value chain, as well as their motivations, capacities within funding and implementation arrangements, constraints, and available solutions.

In two online workshops, the multi-actor group of MULTISOURCE consortium partners provided their inputs to the results, validating results and identifying differences in experiences, regional communalities and differences, as well as information gaps among the interview partners and results. This served to further strengthen the overview of potential customers, project sponsors, and implementation partners, as well as their roles in the NbS^{WT} project lifecycles and value chain.

Co-creation workshops with diverse urban actors

To diversify input and allow for insights from the project partners, we supplemented the co-creative stakeholder workshops with an in-person workshop in Milan. At the Milan workshop, the project partners worked on five selected MULTISOURCE pilots, namely the Metropolitan Area of Milan, Oslo, Girona, metropolitan Lyon, and Leipzig. The groups each created one of five parallel qualitative group models to address urban challenges and evaluate the strategic alignment of selected NbS^{WT} within the specific contexts of the five pilots. These models analysed system dynamics and framed NbS^{WT} services by incorporating perspectives from multiple sectors and disciplines, and while this dominantly involved expert knowledge, practitioners' experience-based knowledge was also included. Pilot and local authority partners participated actively in the group relevant to their respective pilot context, while other MULTISOURCE partners contributed insights across thematic areas.

In addition, following after the Milan multi-pilot workshop, four individual, local multi-actor co-creation workshops were held in Milan, Lyon, Oslo, and Girona. Each workshop included 10-30 participants, representing a range of sectors, including municipal planning, environmental agencies, stormwater and wastewater managers, community groups, and private sector stakeholders. These workshops explored collaborative NbS^{WT} solutions and implementation arrangements that align with each city's unique environmental challenges, governance structures, and water management needs. The co-creation workshops facilitated open discussions on the NbS^{WT} project lifecycle, focusing on the planning, investment, design, and maintenance stages. Participants worked together to address strategic considerations, such as attribution of costs and role distribution, and to explore potential co-benefits of NbS^{WT} such as urban heat mitigation, drought management, and education. Outputs from these sessions were analysed across the specific themes and directly informed practical insights on business model considerations and effective co-creation processes described in this deliverable.

2 Six stages of the NbS^{WT} project lifecycle

The multifunctionality and multi-benefit nature of NbS^{WT} as well as the composite network of policy makers and stakeholders in the urban implementation context with diverse capacities and highly fragmented yet closely linked responsibilities constitute a complex system. The development of NbS^{WT} requires careful consideration of all stages in the project lifecycle to ensure scalability, sustainability, and stakeholder alignment. Each stage plays a critical role in addressing urban water challenges, integrating multifunctional benefits, and ensuring that NbS^{WT} can provide the intended services in the long term, in alignment with stakeholder interests.

This chapter outlines the six stages of the NbS^{WT} project lifecycle – Project Development and defining the investment strategy, Planning, Design and Engineering, Construction, and long-term Operation & Maintenance (O&M) – and offers insights into the key activities, outputs, and considerations at each stage, in particular from the MULTICOURCE activities in the five pilots.

Rationale

When intended for a long-term existence and service provision, the NbS^{WT} project lifecycle, as well as the wider NbS and water infrastructure project lifecycles, comprise fundamentally the steps of project initiation, planning and design, construction, and long-term management. The project lifecycles of NbS and water infrastructures are structured in varying ways across literature. The stages as presented below were synthesised as a result of the MULTISOURCE co-creation processes with public and private decision-makers, and experts, conducted in the MULTISOURCE project cities and metropolitan regions, which aimed to define actor roles and sources of funding specifically of NbS^{WT} projects at the scale of cities or metropolitan regions. Therefore, with the purpose of assisting NbS^{WT} project developers, decisionmakers, and partners to define the implementation and funding arrangements, this report has identified the following six critical stages:

Stage 1: Project Development

Stage 2: Planning

Stage 3: Design and Engineering

Stage 4: Construction

Stage 5: Operate and Maintain

Stage 6: Decommission or Repurpose

Figure 1. The six stages of a long-term NbS^{WT} project

Figure 1 outlines the six stages of a long-term NbS^{WT} project, from project development with the five dimensions comprising the full investment case based on the *Handbook of for the Implementation of Nature-Based Solutions for Water Security* (Altamirano et al., 2021), to planning, design and engineering, construction, and operation and maintenance (O&M). The six stages are characterised below.

2.1 Stage 1: Project Development

The project development stage focuses on identifying water management challenges and aligning the proposed NbS^{WT} with strategic objectives and stakeholder needs. It provides a foundation for initiating discussions with stakeholders and securing preliminary support.

Project Initiation

Key activities include **problem identification**, such as identifying hydraulic risks, pollution hotspots, and urban heat challenges using tools such as GIS mapping, citizen science, modelling and pollution monitoring (Altamirano et al., 2021). Problem identification involves agenda setting in the polity and prioritization between the range of topical problems identified, where attention to specific problems and their position on the public or policy agenda can be accelerated by extreme events or external pressure, e.g. EU's Adaptation Strategy or high-profiled public debates. Stakeholder consultations and involvement at this stage help to validate priorities and ensure local relevance (Wirth et al., 2024; Hui and Smith, 2021). Likewise, identified urban challenges, such as climate risks or water pollution, as well as policy strategies and goals, can raise an interest in NbS^{WT}.

Stakeholder mapping and engagement forms the first step: Identify key actors, including enabling decision-makers among municipal government actors, water utilities, and public and private landowners. Actors at local level are diverse and each bring different interests, capacities and forms of expertise into the process of implementing NbS^{WT} , and an understanding of the enabling actors is thus necessary to build a collaborative framework to achieve the realisation of NbS^{WT} in the multi-actor urban space as well as to build a project that effectively addresses cross-sectoral challenges (i.e., realises multiple or co-benefits).

Urban climate change adaptation plans, flood risk mitigation plans, or wider urban development plans often raise the need for multi-sectoral solutions. Many cities have established multi-stakeholder groups that meet periodically to align their actions, share perspectives and practices to co-develop solutions. These represent important *enablers* for multifunctional and efficient solutions, such as NbS, and provide a strong starting point for developing such projects at scale.

City of Oslo – Decentralised NbS at city scale for the treatment of urban runoff to improve water quality in the Oslo Fjord: Multi-actor co-creation of the strategic and economic dimensions of the intervention.

In Oslo, the participants included policymakers from the Agency for Urban Environment's units for rivers and water bodies, and road planning and road maintenance, as well as the Agency for Planning and Building Services' representatives responsible for stormwater planning. These were supplemented by representatives from the Oslo water and sewerage company and from the research organisation NIVA. Additionally, participants identified the national road agency, private developers, educational sector actors and local citizens residing in the area as relevant to engage with for the planned NbS^{WT} project.

The problem definition centred on the drivers of the polluted Oslo Fjord, which were identified to include physical, regulatory and planning, as well as conflicting institutional goals at the municipal level. The physical dimension concerns mainly the flow of polluted urban road runoff to urban watercourses that lead to the Oslo Fjord, as well as contamination from polluted soil that reach the groundwater. The existing zoning plans in Oslo were identified as outdated and lacking sufficient guidelines for effective stormwater management. In the municipality, the challenge of division and siloed operations is prominent, affecting both the agency level and the Oslo city council departments, notably those responsible for urban development and water, environment, and community centers.

The participants pointed out NbS as a strategy to intercept water pollution before it reaches the rivers and the Fjord, while also enhancing urban living quality and sustainability, reducing traffic and increasing recreational space. Specific solutions, such as green roofs, permeable pavements, and raingardens could alleviate pressure on the city's sewerage systems. Captured rainwater could simultaneously be used for tree irrigation, alleviating water stress during drought periods. Moreover, the restoration and reopening of enclosed streams were proposed as environmental strategies. Wastewater treatment plants must be considered as a complementary measure to NbSWT, ensuring a comprehensive approach to water purification.

The adoption of NbS^{WT} within Oslo's Action Plan for Stormwater Management reflects a commitment to sustainable urban development, and the Cross-sector Stakeholder Group on Polluted Groundwater facilitated by the City of Oslo provides an important forum for multiple decisionmakers to align actions for common goals.

Building the Investment Case

The project development stage also establishes the investment case, demonstrating how the proposed NbS^{WT} optimally use limited resources while maximising value for money. This stage ensures strategic, economic, commercial, financial, and management viability, following the Framework for Water Security (Altamirano et al., 2021). This Framework adopts the **Five Case Model**, which combine the five critical dimensions – "cases" – for business cases: the Strategic case, the Economic case, the Commercial case, the Financial case and the Management case, and is recognized globally as a best-practice for managing public investments (Altamirano et al., 2021). The five cases of the model fall in two consecutive stages.

In the first stage, comprising the Strategic case and the Economic case, the strategic fit for the context as well as economic and social values of the project are defined. These aspects provide the strategic and economic justifications for the "preferred option" in public sector investment to be effectively articulated.

This provides a solid foundation for the second stage, consisting of the Commercial case, the Financial case, and the Management case, which involves detailing a feasible and sustainable financing and implementation arrangement.

The five cases provide the following information along the guiding questions summarized in figure 2.

1. **Strategic Case**: Analyse the fit of NbS^{WT} within city-specific challenges and environmental contexts.
2. **Economic Case**: Evaluate cost-effectiveness, including societal and environmental gains versus expenditures.
3. **Commercial Case**: Assess private sector capabilities and risks in implementation.
4. **Financial Case**: Analyse financial feasibility, revenue streams, and funding availability.
5. **Management Case**: Propose governance structures and operational plans for NbS^{WT}.

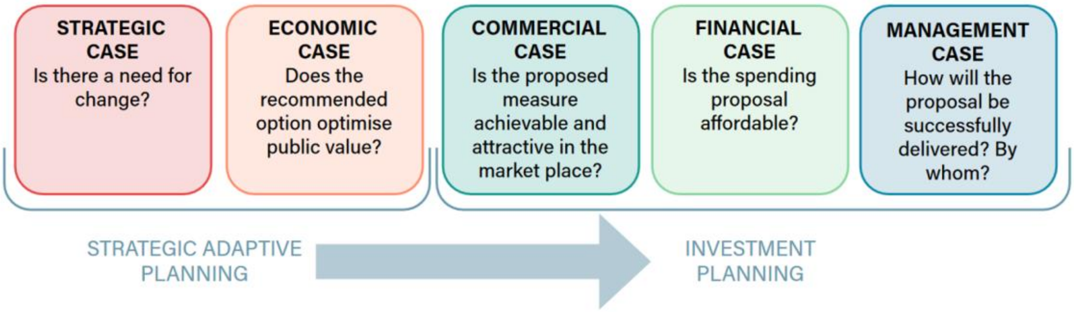


Figure 2. Five dimensions of a full business case (Altamirano et al. 2021. NAIAD project D7.3)

The project development stage is the stage at which the funding, financing, and implementation arrangements are elaborated. All these five dimensions (or "cases") must be defined, together with relevant actors, to build a business case with the information necessary to gain funding for all the further stages of the NbS^{WT} project lifecycle, and to realise and manage it over time.

Building multifunctional projects

The first step in developing a multifunctional NbS^{WT} project is to **identify its possible value propositions in a multi-stakeholder setting**, from among environmental, social, and economic benefits, as well as any associated trade-offs. For example, NbS^{WT} can address flood management, wastewater treatment, urban cooling, and biodiversity enhancement, and social cohesion, providing benefits that extend across multiple sectors. Insights from MULTISOURCE Deliverable D3.1 highlight these possible value propositions and the importance of balancing trade-offs to optimise the multifunctionality of the solutions (Wirth et al., 2023).

A highly effective method for this process is **group model building**, which facilitates collaboration among stakeholders from diverse sectors. This approach helps build a shared understanding of the complex challenges at hand, enables the identification of co-benefits and trade-offs, pools expertise and supports the co-development of integrated, multifunctional solutions. As demonstrated in MULTISOURCE Deliverable D3.3 (Wirth et al., 2024) as well as the NAIAD Deliverable D7.3 (Altamirano et al., 2021), group model building is particularly effective in aligning stakeholder priorities and fostering innovative, cross-sectoral NbS^{WT} designs.

The multifunctionality of NbS^{WT} projects provides an opportunity for leveraging multiple funding sources and revenue streams. However, as mentioned previously, this also makes funding responsibilities unclear and complicates project development. Like the need for context-specific technical design of NbS^{WT}, the **design of funding and financing strategies need to be customised to the specific context**. This is in terms of benefits the NbS^{WT} provide to local and regional beneficiaries and ecosystems, as highlighted by participants of co-creation processes in the MULTISOURCE project. To build multifunctional projects by design, minimise trade-offs, and secure funding, it is essential to demonstrate how the proposed NbS^{WT} will make optimal use of limited public and/or private resources, as well as that investments can be made in line with regulations on the specific uses of public budgets.

For example, laws governing the use of water tariffs may mandate that budgets of water utilities to be spent only on improving the value of water infrastructure and water services. Budgets of sewer managers may only be permitted to fund specific (underground) wastewater infrastructure. Similarly, the budgets of water agencies may only be permitted to fund measures to improve water quality of receiving water bodies. These budgetary constraints can form a barrier for implementation and must be considered when building the economic case of the NbS^{WT} project. It is crucial to provide proof that the investments and their procurement will maximize value for money. Understanding the priorities and constraints of potential funding and implementation partners is essential for effectively negotiating the attribution of costs to funding partners and secure funding.

Figure 3. Group model building exercise at a workshop in Oslo, Norway, with the Cross-Sector Stakeholder Group on Polluted Groundwater facilitated by the City of Oslo, conducted in April 2024 within the MULTISOURCE project.

2.2 Stage 2: Planning

The planning stage sets the foundation for the subsequent stage 3 with technical design and engineering of the NbS^{WT} by addressing water management challenges, assessing potential intervention sites, and building a collaborative framework with stakeholders, which is centered around the implementation of specified NbS^{WT} projects in identified, local sites. By integrating ecological, social, and regulatory considerations, this phase ensures that NbS^{WT} projects are both effective and context-specific.

Large-Scale Planning

At the core of spatial planning is large-scale visioning of the NbS^{WT} project and the participants' anticipations for its output, which involves site selection and technology selection based on impact analyses, such as computational simulations of hydraulic risk, urban heat, biodiversity, and water quality. Social and community benefits can also be included, e.g. mitigating heath inequality and promoting community cohesion. The specific integration with existing blue-green spaces and grey infrastructures also takes place at this stage. The planning process must align with administrative tasks, policies and strategies at local and urban level managed by actors such as municipal or metropolitan public authorities and river basin organisations. A coordinated vision at these levels can serve as a vehicle for communicating the importance of NbS^{WT}—such as raingardens, or natural treatment systems for combined sewer overflow—across the metropolitan territory and encouraging collaboration among municipalities and private landowners to allocate suitable land.

Spatial planning begins with a comprehensive assessment of environmental and social challenges:

- **Hydraulic Risk Management**: Use hydrological and hydraulic modelling to identify flood-prone areas and design adequate solutions, such as wetlands or bioswales, that mitigate risks at the metropolitan scale.
- **Ecosystem Services Assessment**: Quantify the ecosystem services that NbS^{WT} can provide, such as stormwater retention, urban cooling, and biodiversity enhancement. This step often involves established NbS typologies (see section 1), builds confidence among stakeholders and sets the groundwork for replicable design principles.
- **Site Suitability Analysis**: Evaluate potential sites by integrating GIS mapping, pollution pathway analysis, and stakeholder input. This process considers factors such as land ownership (public vs private), existing infrastructure, and local ecological conditions.
- **Output – a Comprehensive Feasibility Study**: A pre-feasibility study may have been conducted in Stage 1, which is further refined with insights generated in Stage 2. Ecosystem services can also be quantified more accurately.

Site assessments may lead to diverse implementation approaches, such as the implementation on land owned or managed by public authorities or agencies, such as parks or utility-owned spaces, or on private properties, such as the installation of raingardens, promoted by financial, information-based or regulatory measures, or technical and expertise assistance, and supported by communications campaigns.

Feedback loop to the financial and management cases

The specification of the NbS^{WT} project in terms of spatial planning feeds back into an adaptation or further specification of the financial and management cases defined initially at Stage 1 (Project Development).

Stakeholder engagement at this stage serves to access local knowledge and foster buy-in to build a more robust project, manage risks, and minimise trade-offs. Local knowledge and relationships with local actors, including public and private decision makers and citizens, provide important knowledge for site selection and technical and financial considerations for the engineering, construction, and operation and maintenance arrangements (Araos, 2023). This ensures long-term collaboration and project ownership (Sang et al., 2024).

By quantifying ecosystem services in the context of specific sites, project proponents can more accurately define the financial and task contributions of different stakeholders. For example:

- **Shared Costs in Public Parks:** The additional costs of integrating water treatment or hydraulic capabilities into a public park can be funded by wastewater managers, while the base costs of park development remain the responsibility of the municipality.
- **Collaborative Solutions for Parking Lots:** Multifunctional NbS implemented on parking lots can involve funding from both private owners and public authorities, reflecting the shared benefits.

2.3 Stage 3: Design and Engineering

Stage 3 is the Technical design and engineering stage, which translates the technical requirements specified at Stage 2 into detailed technical designs and plans for construction and operation & maintenance provisions and manuals. By combining technical expertise with co-creative and/or participatory design, the technical design and engineering stage ensures that NbS projects are robust, feasible, and context-specific. Key activities at this stage can include:

Technical and Ecological Design: This involves developing site-specific designs that account for local hydrology, soil conditions, and water flow dynamics, to ensure adequate drainage, retention, and treatment capabilities, while also aligning with regulations and permitting requirements. Maintenance considerations inform the design of monitoring systems and protocols as well as vegetation selection, such as native and resilient species that could reduce maintenance needs. **Output – Detailed engineering plans:** Comprehensive designs with technical specifications, ecological guidelines, and construction instructions outline the physical components of the NbS^{WT}, from water flow systems to planting schemes.

Participatory Co-Design: Workshops with key stakeholders, including municipal authorities, community representatives, and technical experts allow stakeholders to provide input on design preferences, operational concerns, and integration with community goals. Stakeholder insights at this stage can still feed into iterative design revisions to build ownership and address local needs and constraints. **Output – Stakeholder endorsed designs:** Designs validated through co-creation processes, ensuring alignment with stakeholder needs and fostering long-term buy-in, or even active participation in construction and long-term maintenance.

Detailed Financial Modelling: A comprehensive financial plan can be finalised at this stage, that includes capital expenditures (CAPEX), operational expenses (OPEX), and projected revenue streams from ecosystem services or cost savings. This financial modelling helps balance costs with expected returns, such as reduced treatment costs or enhanced property values. **Output – Comprehensive financial plan.**

Examples of practical considerations

- **Pollutant Removal Efficiency**: Select appropriate filtration media and vegetation to maximise pollutant removal in urban runoff systems, ensuring resilience and effectiveness.
- **Adaptive Design**: Incorporate flexibility in designs to accommodate future modifications or expansions, responding to evolving environmental or urban needs.
- **Social and Environmental Synergy**: Balance functional goals (e.g., water treatment) with social benefits (e.g., recreation, aesthetics) to create multifunctional spaces.

2.4 Stage 4: Construction

The construction stage involves site preparation and infrastructure set-up or installation, built to design specifications. The initial step in NbS^{WT} construction is thorough site preparation. This includes activities such as grading, soil amendments, and ensuring proper drainage to create a stable foundation for the NbS^{WT} elements. Infrastructure setup follows, where core components like water retention basins, drainage systems, and vegetation-supporting structures are installed.

The output of the construction stage is the operational NbS^{WT} infrastructure, fully installed and ready for commissioning. **Plants need a start-up phase to establish, during which the vegetation reaches its full functional capabilities**. This requires closer attention and potentially engineering and construction adaptations carried out by the same participants as the Stage 4. This phase usually also forms part of short-term funding instruments, such as grants. For these reasons, the start-up phase is attributed to the construction phase, before transitioning into the long-term O&M (Stage 5).

Figure 4. Installation of the GRETA® green wall for greywater treatment and reuse in St. Quirze, Barcelona, Spain - Social Housing, one of the pilots of the MULTISOURCE project (images 1 and 2 from the left, photo credits: ICRA)

and construction of the compost heating system (image 3, photo credits: alchemia-nova) to heat the vertECO® wastewater treatment system for water reuse (image 4, photo credits: alchemia-nova), a demonstration site of the HOUSEFUL project.

2.5 Stage 5: Operation & Maintenance (O&M)

The long-term success of NbS^{WT} depends on effective operation and maintenance (O&M). This phase ensures that infrastructure remains functional, resilient, and capable of delivering intended ecosystem benefits such as water quality improvement, flood mitigation, and biodiversity enhancement. Proactive O&M strategies, including routine upkeep, adaptive management, and stakeholder coordination, are essential to sustain NbS^{WT} over time (Cross et al., 2021).

Who is in charge of maintenance? Who is in charge of routine checks? Who communicates maintenance needs and failures, and how, to whom? are key guiding questions for developing long-term implementation arrangements (Wirth et al., 2023). Actors such as the public administration's urban parks department are typically already institutionally tasked with the routine maintenance of urban green spaces. Solutions for them to maintain the NbS^{WT} adequately may be essential to ensure reliable intended service provision, e.g., for runoff treatment. Routine O&M maintenance can be carried out by public urban green spaces management, while specialised inspections and repairs may require technical experts (suppliers of NbS^{WT}). Building of expertise in specified sections of the local public administration, and technical trainings of routine maintenance personnel by the suppliers can be planned to ensure adequate handling.

A strong benefit of NbS^{WT} in contrast to grey infrastructures is the opportunity for adaptive management. While the modification or deconstruction of high-impact concrete canals are associated with high financial and environmental costs, NbS can be modified more easily, such as replacing vegetation or substrates, expanding the green space and/or its functionalities, or changing O&M practices. Implementing an adaptive management system allows to respond to performance data, environmental changes, or evolving community needs. This includes communication protocols for reporting maintenance needs and failures, and feedback mechanisms into the management of the NbS^{WT} project. For examples, maintenance teams can report issues to municipal authorities through digital dashboards or regular updates, as can digital platforms for collecting citizen feedback.

Where possible, **community engagement** that builds on activities in previous stages in the project lifecycle can provide an important asset to resilient management of NbS^{WT}, where local residents or volunteer groups can more easily and frequently detect changes and carry out simple maintenance tasks.

2.6 Stage 6: End-of-Life

The end-of-life stage addresses the point when an NbS^{WT} installation has reached the conclusion of its intended operational period, either because it no longer provides the designed level of service, or because urban planning, regulatory, or ecological conditions have changed. Unlike conventional grey infrastructure, which typically requires dismantling and disposal at high environmental and financial costs, **NbSWT often allow for flexible and adaptable end-of-life pathways that can retain ecological value and reduce lifecycle impacts** (Turner et al., 2022; Seifert et al., 2025).

It is of particular value to highlight the end-of-life stage, as its consideration—especially in cost-benefit analyses (CBAs)—demonstrates a core advantage of NbS^{WT} as a "soft" infrastructure (ibid). In contrast to rigid grey systems, NbS^{WT} can be adapted, decommissioned, or repurposed with lower sunk costs. This flexibility becomes increasingly important as climate hazards intensify and shift in location, frequency, and magnitude. Under such conditions, the functional service lifecycles of protective measures are becoming shorter, and the adaptive, modular nature of NbS^{WT} translates into lower long-term costs and greater long-term sustainability compared to hard infrastructure alternatives (Seifert et al., 2025).

Key activities at this stage include:

- **Assessment of functional decline and decision pathways:** Regular monitoring in Stage 5 informs whether a system should be decommissioned, repurposed, or retrofitted. Decisions must account for residual ecosystem functions, stakeholder needs, and future land-use priorities (Cross et al., 2021).
- **Decommissioning or repurposing of assets:** Technical components such as pumps, liners, or monitoring devices may need safe dismantling and recycling. Organic components, such as vegetation and substrates, may be composted, harvested for biomass, or reused in other NbS applications. In some cases, NbS^{WT} can be transitioned into urban green spaces or biodiversity habitats, ensuring a “soft landing” rather than abrupt removal.
- **Material recovery and circularity:** End-of-life planning provides opportunities to integrate circular economy principles. Substrates, biochar, or engineered soils can be recovered and re-applied; harvested biomass can be valorised as compost, mulch, or bioenergy feedstock.
- **Site restoration or transformation:** If deconstruction is required, sites can be restored to natural states or transformed into new functions such as recreational areas, ecological corridors, or upgraded NbS^{WT} systems. In urban contexts where land is under pressure, repurposing ensures the continued provision of ecosystem services while responding to evolving community needs. Rather than being removed entirely, NbS^{WT} can often be adapted to new landscape features or habitats that extend their ecological and social benefits beyond the original project scope.

A clear end-of-life strategy and transition plan ensures that NbS^{WT} contribute positively even after their operational period ends. This includes financial planning for dismantling, guidelines for safe disposal or reuse of materials, and strategies for ecological continuity.

The end-of-life stage closes the NbS^{WT} lifecycle while creating opportunities for ecological renewal, circular material flows, and continued community benefits. By embedding this stage into business models and governance frameworks from the outset, project proponents can ensure that NbS^{WT} remain sustainable and cost-effective throughout their full lifecycle, avoiding stranded assets and reinforcing their role in resilient urban water management.

3 Designing implementation arrangements for NbS^{WT}

3.1 Actors along the NbS^{WT} value chain

This section addresses the actors and participants in the six stages. Effectively implementing NbS^{WT} in urban settings requires navigating a complex system of multiple sectors and fragmented responsibilities across a wide range of stakeholders, including municipal governments, water utilities, private landowners, environmental NGOs, and local communities, each with unique interests, perspectives, priorities, capacities, expertise, and responsibilities. Ensuring active participation, alignment of goals, and equitable distribution of costs and benefits requires significant time, effort, and negotiation, as well as sensitivity to the context and the particular constellation of public and private stakeholders, including citizens.

The value chain of NbS^{WT} encompasses all six stages of the project lifecycle, from project development to long-term operation and maintenance (O&M). Key actors play varying roles across these stages, contributing to project design, financing, implementation, and sustainability. Figure 5 on the NbS^{WT} value chain illustrates these stages and highlights the roles of facilitators, participants, and beneficiaries in each phase.

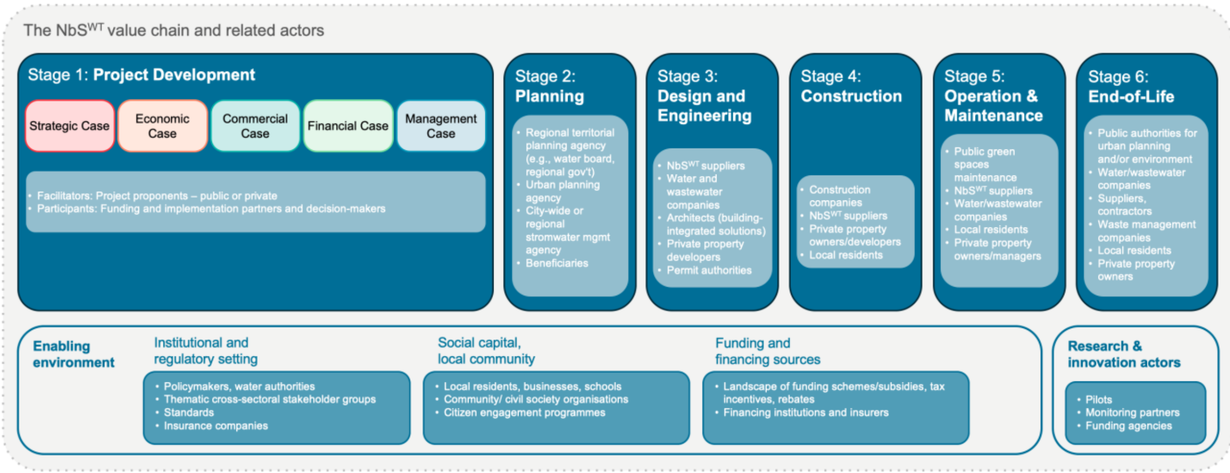


Figure 5. The NbS^{WT} value chain and related actors.

The table below lists facilitators, participants, and elements of the enabling environment at each of the five stages of the NbS^{WT} project lifecycle (or value chain), as well as cross-cutting roles and support.

Facilitators are key actors responsible for driving and enabling specific stages of the NbS^{WT} value chain. They play a leadership or coordinating role, ensuring that activities are aligned with project goals, regulatory frameworks, and stakeholder priorities. Facilitators often have a central role in decision-making and serve as connectors among different stakeholders, providing resources, expertise, or strategic guidance to advance the project.

Participants are stakeholders who actively contribute to the design, implementation, or maintenance of NbSWT projects. While they may not lead the process, their involvement is essential for ensuring the project's success. Participants provide input, resources, or labour, and often collaborate with facilitators to meet shared objectives. They can also include actors directly impacted by the project, such as local communities or private landowners.

Table 1. Main relevant facilitators and participants, as well as factors of the enabling environment at each stage of the NbS^{WT} project lifecycle

Project stage	Facilitators	Participants	Enabling environment
Stage 1: Project Development	• Project proponents, including public or private actors, lead the process of defining governance, funding, and long-term management strategies.	• Funding and implementation partners, such as regional planning agencies, water utilities, and public-private partnerships, provide strategic input. • Community stakeholders provide local insights and contextual knowledge.	• **Regulatory Settings:** Clear guidelines for land-use planning, permitting processes, and environmental compliance. • **Financing Facilities:** Availability of initial funding mechanisms like grants or subsidies. • **Innovation Actors:** Research institutions offering tools for feasibility studies, cost-benefit analysis, and co-design workshops.
Stage 2: Planning	• Urban planning agencies and stormwater management authorities coordinate assessments and prioritise sites. • Municipal governments oversee the alignment of NbS^{WT} with local development plans.	• Permit authorities, architects (for building-integrated NbS), and regional governments contribute technical and regulatory insights. • Communities and the success of projects likewise benefit from transparent decision-making processes and well-sited projects.	• **Spatial and Hydrological Data:** Access to GIS maps, hydrological models, and pollution pathway analyses. • **Policy Support:** Policies that regulate or incentivise private-sector participation and promote multifunctional green infrastructure. • **Community Engagement Mechanisms**: Frameworks for

			ensuring local input during site selection and planning.
Stage 3: Design and Engineering	• Environmental engineers and project designers create site-specific technical and ecological plans. • Municipal water authorities ensure the integration of NbS^{WT} into existing water management infrastructure.	• NbS^{WT} suppliers and landscape architects collaborate to provide materials and refine design specifications. • Stakeholders, including community representatives, validate designs through participatory workshops.	• **Regulatory Validation:** Regulatory agencies approve designs to ensure compliance with safety, environmental, and urban planning standards. • **Research and Innovation Support:** Universities and research centres provide data-driven recommendations on vegetation, hydrology, and infrastructure compatibility. • **Technical Resources:** Access to design tools, construction templates, and performance benchmarks.
Stage 4: Construction	• Construction companies and technical contractors oversee the implementation of NbS^{WT} components (e.g., wetlands, bioswales). • Project managers monitor construction timelines and resource allocation.	• Permit authorities ensure construction complies with relevant permits and regulations. • Local workers and contractors execute site preparation, infrastructure installation, and vegetation planting.	• **Permitting Processes**: Streamlined processes for approving construction plans and activities. • **Financial Backing**: Access to construction-phase funding through public-private partnerships or loans. • **Community Support**: Local participation and buy-in to minimise disruptions and ensure project acceptance.
Stage 5: Operation & Maintenance (O&M)	• Public green space maintenance departments or water utilities manage routine maintenance tasks. • Monitoring agencies track performance indicators like pollutant removal efficiency and ecosystem health.	• Local community members engage in maintenance activities, such as vegetation care or debris removal. • Private contractors address specialised technical maintenance needs.	• **Ongoing Funding Mechanisms**: Sustainable financing sources such as Payments for Ecosystem Services (PES) or municipal budgets. • **Adaptive Management Tools**: Technologies like performance monitoring dashboards and real-time data collection systems. • **Training and Capacity Building**: Workshops or certification programmes to train maintenance teams in NbS-specific skills.
Stage 6: End-of-Life	• Municipal or metropolitan authorities coordinate end-of-life planning, ensuring alignment with long-term urban development strategies. • Water utilities and regulators oversee compliance with waste, water, and safety standards.	• Technical suppliers and contractors manage dismantling or refurbishment of NbS^{WT} components; • Waste management and recycling companies recover materials; • Communities and NGOs advocate for ecological repurposing; • Private property owners decide on future land use where applicable.	• **Policy and Regulatory Frameworks:** Standards for safe decommissioning, recycling, and ecological restoration. • **Circular Economy and Waste Recovery Facilities:** Infrastructure for substrate reuse, biomass valorisation, and recycling of technical components. • **Financial Mechanisms:** Allocation of costs in business models and CBAs. • **Community Engagement:** Mechanisms for involving residents in repurposing and stewardship of transformed sites.
Cross-Cutting Roles and Support	Across all stages of the NbS^{WT} value chain, certain factors in the enabling environment are critical: • **Policy and Regulation:** Establishing clear and supportive frameworks to streamline processes and encourage adoption. • **Innovation and Research:** Tools, technologies, and frameworks that optimise design, monitoring, and management. • **Funding and Financing:** A diverse range of funding instruments, including grants, green bonds, and blended finance models.		

3.2 Types of collaborative business models for NbS^{WT}

This section provides an overview of business models that have been developed in European NbS cases for different types of NbS^{WT}. Urban stormwater and wastewater management represent public services in most European cities, while other services, such as regeneration, liveability or cooling, may be provided by either public or private actors, as greenery may increase private property value. The increased frequency and scale of flood events and the vast coverage of private property across the surface of a city prompt a rising need for extending decentralised stormwater management to land area in private ownership, by promoting the construction of treatment raingardens on privately owned green spaces. The type of services provided, the sites targeted, and the land ownership and management models applied there are just a few of the key considerations when developing NbS^{WT} and defining funding and implementation arrangements for the business case.

NbS^{WT} business models are as diverse as the urban contexts they aim to improve. Public-public models excel in addressing broad societal goals, where public-private partnerships can bring additional efficiency into operations. Public service on private property expands implementation possibilities in space-constrained areas, and purely private models highlight market-driven solutions. The examples provided below demonstrate how these typologies can be adapted to various challenges and settings, promoting sustainable and scalable NbS^{WT} projects. Each business model type is illustrated with examples and implementation insights drawn from the MULTISOURCE deliverable 3.1 on *Best Practices for Financing and the Operation & Maintenance of Nature-Based Solutions for Water Treatment* (Wirth et al., 2023) as well as the deliverable 3.3 on *Descriptions of co-created business models for innovative NbS^{WT} and their integration in urban water systems* (Wirth et al., 2024), showcasing the diversity of approaches used to fund, govern, and sustain NbS^{WT} projects.

Families of implementation arrangements for NbS for water security

The *Handbook for the Implementation of Nature-Based Solutions for Water Security* (Altamirano et al. 2021, NAIAD project deliverable 7.3) groups four families of implementation arrangements:

- Public procurement
- Private water stewardship
- Collective watershed investment vehicles
- Environmental markets

Types of collaborative business models for NbS^{WT} in cities

Focusing on a subgroup of **business models,** namely for the **urban context, collaborative NbS^{WT} projects, and geared towards stormwater and wastewater management**, the review of existing business models (Wirth et al., 2023), as well as the co-creation processes carried out in the MULTISOURCE project (see Wirth et al., 2024) revealed a range of practices that can broadly be categorised into four types of partnerships, elaborated below:

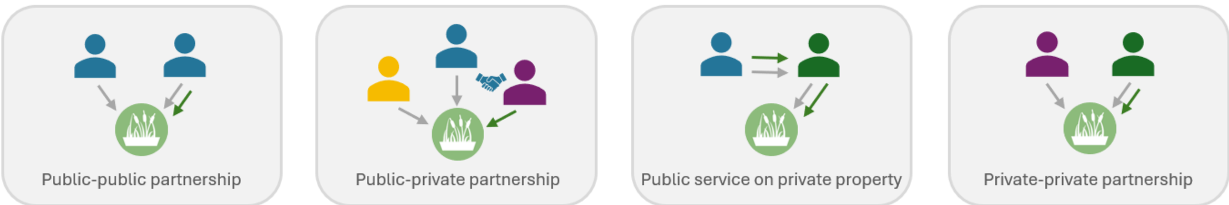


Figure 6. Four types of collaborative business models for NbS^{WT}

3.2.1 Public-public partnerships

Two or more public actors collaborate to plan, finance, implement, and maintain NbS^{WT}. Project management, funding, and ongoing O&M may involve one or multiple different municipal agencies and/or regional authorities. Funding comes from the public sector and may involve pooling from multiple public budgets.

Characteristics:

- **Governance:** Fully public; managed by local or regional government authorities, e.g. agencies.
- **Funding:** Municipal budgets, a mix of national-local and/or sectoral funding, regional/national/EU subsidies, or grants.
- **Stakeholder Roles:** Municipalities handle planning, funding, and implementation. Private actors including citizens when projects involve public participation and/or co-creation.

Example: Public-public business model for a green wall for greywater treatment and reuse installation at a public school in Girona, Spain

Table 2 summarises the set of values and objectives behind the selection of the solution, as well as the actors actively involved in the development and implementation of the project. This implementation arrangement was co-created in a workshop with the actors listed here, with the goal to specify co-management and operation & maintenance roles and tasks for the installation at the public school Escola Àgora and to define a model that could be replicated to other sites at public infrastructures in the municipality of Girona and other municipalities.

Installed on the façade of a public school, this project treated and reused greywater while promoting environmental education. The municipality and an EU grant funded the installation, while the school handles basic operation & maintenance. A public research institution provides specialised monitoring and maintenance.

Table 2. The main NbS services and the implementation arrangement co-designed by involved decisionmakers for the greywater treatment green wall project in Girona, Spain.

<table>
<tr><th>Values/ objectives</th><th>NbS services</th><th colspan="2">Actors providing financial or in-kind resources (e.g. site, time)</th><th>Actors conducting work</th></tr>
<tr><td>Increased water availability</td><td>Greywater treatment for reuse</td><td>Girona City Council: Climate Action department</td><td>Funding, procurement (tendering)</td><td rowspan="3">Planning and installation:
• ICRA (supplier, supervision)
• Producer of green wall (supplier/contractor)
• Contractor for construction/installation

O&M:
• School staff (daily routine checks, urban farming)
• ICRA (bi-weekly checks, water quality monitoring, specialized maintenance)
• Urban gardeners (urban farming)</td></tr>
<tr><td>Extreme heat mitigation</td><td>Ambient cooling</td><td>Girona City Council: Climate Action and Urbanism departments</td><td>Funding, procurement (tendering)</td></tr>
<tr><td>Citizen awareness and education (water reuse, NbS, urban farming)</td><td>Installation at school, safe design</td><td>• Girona City Council: Education department
• Escola Àgora
• University of Girona, ICRA</td><td>• Hosting the green wall
• School conducts routine checks and O&M in-kind
• Facilitation, knowledge transfer</td></tr>
</table>

3.2.2 Public-private partnerships

Public-private partnerships (PPPs) enable shared risks, resources, and responsibilities, blending public oversight with private sector innovation and investment.

Project finance model: The public actor collaborates with private investors who provide the upfront capital for the NbS^{WT}. The private investors are repaid over time, often through revenue from water utilities, environmental taxes, or ecosystem services generated by the NbS^{WT}. This model allows public administrations to implement large-scale projects with limited upfront funding.

Concession model: The public sector grants a private company the right to finance, construct, and operate an NbS^{WT} for a specified period. The private company collects fees from end-users or public subsidies in return for the NbS^{WT} services. After the concession period, the ownership and management may revert to the public administration.

Characteristics:

- **Governance:** Shared between public authorities and private companies.
- **Funding:** A mix of public funds (e.g., equity, grants) and private investment (e.g., green bonds, equity).
- **Stakeholder Roles:** Public actors ensure regulatory compliance and provide partial funding or land. Private actors contribute capital, technical expertise, and operational management. May involve citizens.

Example: Public-private partnership for the SPARK Park in Aarhus, Denmark

Challenged by increasing precipitation, higher risks of flooding and a growing health sector and budget, the Department for Climate Adaptation and the Centre for Use of City Spaces at the City of Aarhus in collaboration with the regional Public health and hospital services, the water company and through engaging local residents and patients in rehabilitation designed a local park – the SPARK Park – to have multi-functionalities, with water storage and cleaning, and rehabilitation in natural environments after brain trauma as the two major objectives. As outcome of the co-creative processes, the park also hosts urban gardens for nearby residents, training facilities including for children and Renaturing urban nature-sections (Vild med Vilje). Due to the explicit multi-functionality and the high priority by the health authorities and the climate adaptation department, the funding and responsibility for management of the park are split between the regional public health agency and the municipal climate adaptation authority and involves different departments in public administration. The park is furthermore supported by a private foundation.

Example: Public-private business model for the Sponge City Milan project, Italy

The Sponge City Milan project (Città Metropolitana Spugna) was developed and is facilitated by the Metropolitan City of Milan, together with CAP Group (one of two water and wastewater utility companies serving the metropolitan region) and several local municipalities as well as regional agencies. They regularly convene within the stakeholder group of the NbS^{WT} Metropolitan Board. The table below summarises the main values and associated NbS services identified to address the main climate challenges impacting metropolitan Milan, as well as the actors involved in the funding and implementation arrangement with their roles. The table summarises results of a multi-actor co-creation process carried out within the MULTISOURCE project.

Table 3. The main NbS services and the implementation arrangement co-designed by involved decisionmakers for the realisation of NbS within the Sponge City Milan project in metropolitan Milan, Italy.

Values/ objectives	NbS services	Actors providing financial or in-kind resources (e.g. site, time)		Actors conducting work
Increased water availability	Greywater treatment for reuse	Girona City Council: Climate Action department	Funding, procurement (tendering)	Planning and installation: • ICRA (supplier, supervision) • Producer of green wall (supplier/contractor) • Contractor for construction/installation
Extreme heat mitigation	Ambient cooling	Girona City Council: Climate Action and Urbanism departments	Funding, procurement (tendering)	
Citizen awareness and education (water reuse, NbS, urban farming)	Installation at school, safe design	• Girona City Council: Education department • Escola Àgora • University of Girona, ICRA	• Hosting the green wall • School conducts routine checks and O&M in-kind • Facilitation, knowledge transfer	O&M: • School staff (daily routine checks, urban farming) • ICRA (bi-weekly checks, water quality monitoring, specialized maintenance) • Urban gardeners (urban farming)

Example: Gorla Maggiore Water Park, citizen co-management of water NbS in Milan, Italy

The following table describes a different public-private partnership business model, where actors at regional and city levels partnered with a private foundation to invest in nature-based flood protection and pollution control measures, and the City of Milan partners with private companies and citizens to co-management the green infrastructures. The water park, constructed in 2008 across 30,000 m^2, consists of several treatment wetlands and bioretention systems situated along the Olona riverbank. It includes sections of treatment wetlands designed for pollutant removal and a recreational park featuring revitalized riparian trees, expanses of green open space, and pathways for walking and cycling.

Key data	Value proposition	Key activities and resources	Cost structure and cost reduction
Location: Gorla Maggiore, Milan, Italy **Design scale:** Meso-scale: regional, metropolitan and urban level (project area 30000m^2 **Constructed:** 2008	**Primary values:** Flood protection (bioretention), pollution control (bioremediation, CSO treatment) **Additional values:** Recreational green space, biodiversity conservation, public engagement and education, health and wellbeing	• Planning and installation (landscape architecture and educational design, engineering, construction) • Maintenance of green spaces and furniture • Monitoring and maintenance of NBS^{WT}	**Cost for design and installation**: € 500,000 - €2,000,000 **Cost reduction:** Reduced financial cost for urban management

Main agents, key partners and governance	Value capture and long-term sources of financing
• Co-governance with government and non-government actors • Initiating organisation: Lombardia Regional Authority • Participatory approaches/ community involvement: Co-planning, Joint implementation (e.g. tree planting), community co-sponsorship • Engineering: IRIDRA (engineering firm)	**Capital investment**: Sponsorship of Lombardia Regional Authority (public regional budget) and co-funding by Fondazione Cariplo (private foundation/trust) **Funding of O&M**: City of Milan supports partnership with private or semi-private companies for the maintenance of its green areas; 'Adotta il verde pubblico' (Adopt a green area) is a city initiative to encourage local residents to become involved in the administration of green areas and to seek sponsorship to help the city's finances

3.2.3 Public service on private property

This model addresses land constraints by implementing NbS^{WT} on private properties while ensuring public service provision. Public actors promote or fund NbS^{WT} installations on private properties, such as raingardens or green roofs, by providing financial incentives, technical and expert support, or reduced fees. The private property owners may agree to maintain the NbS^{WT}, while the public actor provides oversight and technical support.

Characteristics:

- **Governance:** Public actors oversee design, funding, and operation on private land.
- **Funding:** Public funding with potential co-investment from landowners.
- **Stakeholder Roles:** Landowners provide access and may share minor maintenance responsibilities. Public actors manage installation, operation, and long-term maintenance.

Examples:

vertECO® treatment system for domestic wastewater reuse for agricultural irrigation at Cambium, Austria

In an apartment building with over 50 residents, an indoor constructed wetland (vertECO® system) was installed inside a greenhouse heated by a compost system. The NbS treats the liquid fraction of household wastewater, with the treated water reused for fertigation in an agricultural nursery. The initiative demonstrates an innovative and sustainable system with strong educational value, designed to be safe, aesthetic, and integrated into local resource cycles. The project was implemented through a two-year co-design process with the residents.

Figure 7. Left: vertECO® water recycling facility; Top right: Cambium residential building; Bottom right: collaborative construction of the compost heating unit.

Financial support & resources:

- Initial investment (ca. 73,400 €) covered by the building owners association and an EU grant.
- Long-term operation (ca. 1,500 € per year; plus 600 € per year during the first year for monitoring) financed by the building owners association as well as a reduction of the water tariff negotiated with the local council (ca. 700€ per year depending on wastewater treated). The tariff reduction was defined in proportion to the water recovered and used for irrigation, to compensate the reduction of wastewater produced and associated treatment costs in municipal wastewater treatment plants.

Actors & roles:

- Planning & installation: Residents (co-design and hands-on works), alchemia-nova (engineering, facilitation, permits, installation), and contractors (construction).
- Operation & maintenance: Residents carry out routine checks and operation; alchemia-nova provides specialised maintenance, troubleshooting, and commissioning support.

Sources: alchemia-nova and project documentation.

Catch the Rain campaign in Wroclaw, Poland: Rainwater retention systems on private property

To mitigate the impacts of heavy rain events, the City of Wroclaw provides funding to support home owners and residents to install rainwater harvesting systems such as raingardens, free-standing or underground tanks, and absorbing wells. The **project leader** is the Municipality of Wroclaw – Climate and Energy Division. They provide a combination of support and outreach:

- Financial support: Citizens can apply for grants to cover the cost of materials, transport and groundwork; co-funding of 80% of the costs (max. 1,133 €).
- Information catalogue and water calculator on their website.
- Outreach activities: Awareness raising about local climate change adaptation.

Total budget: first year 60,000 €, then 120,000 € per year, financed from municipality's budget.

In 2019, the total amount of grants (over 135,000 €) was used up within 3 weeks. Two-thirds of grants used for above-ground tanks, 16% for underground tanks, 3% for raingardens and absorbent wells, 1% for green roofs.

Sources:
Factsheet Risk Reduction Measures (Interreg Central Europe RAINMAN project).
Interview with Climate and Energy Division Wroclaw in 2022.

Hav-A-Rain Garden campaign for community raingardens in Philadelphia, USA

More than 100 private raingardens have been created since 2014 in the project led by the Pennsylvania Resources Council in partnership with local municipalities to accelerate the adoption of green stormwater infrastructure in Pennsylvania. The programme is being continued for the next decade.

The approach involves public demonstration on public and private property and a team of trained volunteers who assess, design, and install rain gardens on public parks and private properties. Property owners (including residents, non-profits, businesses) can request an assessment to be considered for the implementation of a raingarden. Selected properties get a team of volunteers to design and install the raingarden with hands-on help by the property owner. Calls to the public open for a few weeks (in summer for the following autumn), and specific to individual townships. The programme provides training and technical assistance workshops for volunteers from other communities interested in establishing their own rain garden teams.

Sources: https://prc.org/what-we-do/watershed-protection/rain-garden-initiative/

3.2.4 Private-private partnership

In a purely private model, a private company or landowner invests in and manages the NbS^{WT} for water treatment, often motivated by direct benefits such as reduced water bills, compliance with regulations, such as maximum limits for rainwater discharge to sewer systems by area; green standards, green budgeting or certification, or increased property value. The project operates independently of public sector involvement, with private actors handling all aspects from funding to maintenance.

Characteristics:

- **Governance**: Fully private, focused on financial returns or regulatory compliance.
- **Funding**: Corporate funds, private equity or loans, or grassroots private resources gathered through fundraising and crowdsourcing.
- **Stakeholder Roles**: Private actors manage all aspects, including design, funding, and operation. Customers or end-users directly pay for services.

Example: NbS for greywater treatment & reuse in private real-estate project in Zürich, Switzerland

The vertECO® treatment wetland system was installed in a multi-party residential building compound (12 apartments) as part of a purely private real-estate development project in 2021. The table below summarise the business model of this implementation case.

Figure 8. vertECO® greywater treatment system in Zürich, Switzerland. Photo credits: alchemia-nova

Value proposition	Key activities and resources
Primary value: Innovative, sustainable solution, greywater reuse (service water) **Additional values:** Integration into building green space, aesthetic value, ambient cooling during hot summer days, water savings	• Engineering, construction and installation • Operation and routine maintenance (basic staff training needed) • Periodic maintenance once established, every 2-3 years cleaning of pumps and tanks, trimming and replacement of plants, perhaps change substrate in first plant batch • Troubleshooting • Monitoring of water quality
Main agents, key partners and governance	**Value capture and long-term sources of financing**
• Initiator: Real estate developer and architect • Local house technician: routine O&M • Service providers (alchemia-nova): specialized periodic maintenance and troubleshooting • ETH Zürich: periodic water quality control • Amt für Abfall, Wasser • Energie und Luft Zürich	**Capital investment**: Private equity (real estate developer) and loans (cost for design and implementation: € 20,000) **Funding of O&M**: Apartment owners **Revenue:** Sale and rent

4. Decision criteria for designing an implementation arrangement

Designing an implementation arrangement for nature-based solutions for water treatment (NbS^{WT}) is a critical step in ensuring that the project is governed, financed, and managed effectively. The process requires systematic decision-making, aligning the project's strategic, economic, and operational goals with its long-term sustainability.

Based on the findings from the MULTISOURCE co-creation processes and the literature review, the key decisions when defining the long-term management strategy were structured as follows into five steps. The structure into key decision steps is largely based on the *Handbook for the Implementation of Nature-based Solutions for Water Security* (Altamirano et al., 2021), and extended by the first step of defining the strategy and project clusters as well as the final step of defining a long-term management strategy. The steps to define the funding and financing strategies are described below in combination. This resulted in the following five steps that jointly provide a framework for designing robust and sustainable implementation arrangements for NbS^{WT}. This chapter provides main decision factors and considerations central to each of these five steps.

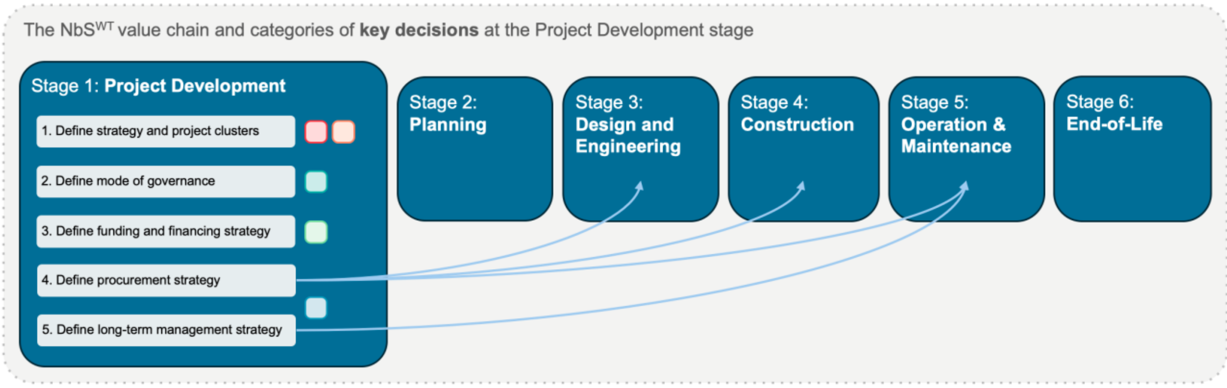


Figure 9. The five steps of defining the implementation arrangement, contributions of information to stages 3-5 of the project lifecycle, as well as relevance of the five dimensions of a full investment case (see section 2.1).

Step 1 Define strategy and project clusters is linked to the definition of the Strategic Case and the Economic Case in the framework of the Five Case model described previously. The co-creation process for these two Cases also directly represents, or at least informs, the Step 1. **Step 2 Define the mode of governance** provides some of the information to the Commercial Case, though its scope is largely different. **Step 3 Define the funding and financing strategy** corresponds to the definition of the Financial Case. **Step 4 Define the procurement strategy** and **Step 5 Define the long-term management strategy** correspond to the Implementation Case. The arrows indicate the flow of information from the steps 4 and 5 to the project lifecycle stages 3-5 and 5, respectively.

The following table 4 describes the guiding decisions and decision criteria for designing the implementation of NbS^{WT}.

Table 4. Guiding decisions and decision criteria for designing an implementation arrangement for NbS^{WT}.

Guiding decisions	Decision criteria
Define strategy and project clusters	The first step here consists of the definition of the strategic and economic dimensions of the NbS^{WT} project. This represents the foundation to designing the implementation arrangement. It also involves organising interventions into project clusters that can be delineated along the types of economic goods and public/private actors (see next step below), or spatially, e.g., along municipal or district boundaries. This step ensures alignment with broader water management and urban development goals, while enabling effective prioritisation of actions based on impact, feasibility, and stakeholder interests. **Key considerations** • Strategic alignment with local, regional, or national water management policies. • Integration of multifunctional objectives, such as flood risk reduction, water quality improvement, and urban cooling. • Identification of project clusters based on geographic, thematic, or functional connections.
Define a mode of governance	The **main services that the project will provide** can be categorised in the types of economic goods: Private goods, common goods, club goods, and public goods. The second main consideration is the **land and asset ownership** of the sites and infrastructures affected. These characteristics determine the applicability of public and private involvement, and thus the choice among the types of collaborative business models described above (public-public, public-private, or private-private). Figure 9 below showcases the four types of economic goods.

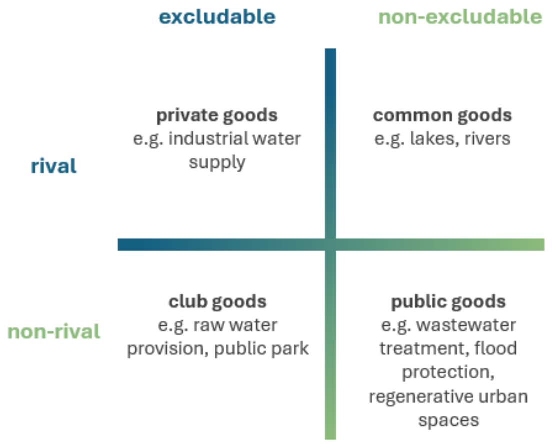
<table>
<tr><td></td><td>

Figure 10. Types of economic goods (based on Altamirano et al., 2021).</td></tr>
<tr><td>Define a funding and financing strategy</td><td>Funding relates to who ultimately pays for the project (mainly taxpayers, EU or private foundations or users), while financing addresses the instruments used to secure upfront resources that are repaid over time. A successful funding and financing strategy must balance capital expenditures (CAPEX) for project setup and operational expenditures (OPEX) for maintenance, ensuring long-term financial sustainability. Cost recovery mechanisms must align with the economic characteristics of the NbS^{WT} services (e.g., public goods or private goods). Public goods may rely on or involve taxes and transfers, while private or club goods can generate direct revenue from users or beneficiaries.

Diverse public and private funding sources can be explored, such as municipal budgets, grants, public subsidies, private investments, blended finance, or crowdfunding. The MULTISOURCE Deliverable 3.1 (Wirth et al., 2023) describes a multitude of funding and financing strategies and instruments, along with the main scope and project requirements.

Considerations for multifunctionality

NbS^{WT} projects often deliver multiple benefits, such as water purification, flood mitigation, biodiversity enhancement, and urban cooling. The multifunctionality of these solutions can attract funding from diverse stakeholders and sectors, but it also requires careful alignment of financing strategies with the interests of these groups. For example:

• Ecosystem services like groundwater recharge, or road runoff treatment, may be funded through Payments for Ecosystem Services (PES).
• Urban cooling benefits may attract energy efficiency grants or subsidies.</td></tr>
<tr><td>Define a procurement strategy</td><td>By establishing an effective procurement strategy, project sponsors can ensure that NbS^{WT} projects are delivered efficiently, meet their intended objectives, and remain resilient over their operational lifespan.

The procurement strategy outlines how services and resources will be acquired to design, construct, and maintain the NbS^{WT}. This step ensures that procurement processes are transparent, competitive, and aligned with project goals, balancing the roles and responsibilities of the project sponsor and third parties. For NbS^{WT} projects, which are often capital-intensive and create assets with long lifecycles, procurement choices significantly influence project delivery, cost efficiency, and long-term sustainability.

Key considerations in procurement

NbS^{WT} projects require procurement strategies that account for their multifunctionality, capital intensity, and ecological integration. For measures such as wetlands, bioswales, or green roofs, which involve significant upfront investment and long lifecycle management, procurement strategies must address both implementation and long-term functionality. Sponsors should weigh the benefits of retaining direct control over the efficiencies offered by private sector involvement.</td></tr>
</table>

	Project Sponsor Role: The project sponsor—typically a government agency or private actor—must decide whether to directly manage all phases of the project or delegate responsibilities to third parties through contracts. This decision depends on the project's complexity, the sponsor's capacity, and the desired level of control. **Asset Lifecycle Integration:** Given the capital-intensive nature of NbS^{WT} projects, sponsors must consider lifecycle impacts in procurement decisions, ensuring that the approach aligns with both short-term implementation goals and long-term O&M requirements. **Procurement approaches** **Traditional Procurement** • Public actors manage the design, construction, and maintenance phases independently. • **Advantages:** High control over the project and flexibility in choosing contractors for each phase. • **Challenges:** Requires significant internal capacity and coordination to manage separate contracts for design, construction, and O&M. may also be time consuming for large NbS projects, which must subject to public procurement procedures regulated by the EU frameworks. **Concession Models** • Private companies are responsible for financing, constructing, and operating the NbSWT under agreed terms. • **Advantages:** Reduces financial risk for the project sponsor and allows for private sector innovation and efficiency. • **Challenges:** Requires clear agreements on performance standards, cost recovery mechanisms, and public oversight. **Integrated Contracting (Design-Build-Operate)** • A single contract covers multiple lifecycle phases, such as design, construction, and operation. • **Advantages:** Streamlines implementation, reduces coordination challenges, and promotes accountability by integrating responsibilities. • **Challenges:** Requires detailed upfront planning to define performance benchmarks and ensure alignment with project goals.
Define a long-term management strategy	The final step in designing an implementation arrangement ensures that NbS^{WT} infrastructure remains functional, resilient, and impactful throughout its lifecycle, i.e. also beyond the project ends. NbS are inherently dynamic and require ongoing maintenance, monitoring, and adaptation to respond to environmental changes and evolving stakeholder needs. A comprehensive long-term management strategy addresses these requirements while aligning with the governance and financing decisions made in earlier steps. **Key considerations** **Assign clear responsibilities for O&M** to relevant stakeholders, such as public agencies, private contractors, or community groups. This includes both the attribution of long-term costs to funding partners/mechanisms and assigning clear responsibilities for carrying out routine and specialised O&M tasks. Consider the governance model chosen in earlier steps to ensure alignment: • Public-Public Models: Maintenance typically falls under municipal or utility services. • Public-Private Models: Private contractors may handle O&M under concession or integrated contracts. • Community-Based Models: Local stakeholders may play an active role in stewardship and routine upkeep.

Develop **flexible management strategies** to address environmental variability, such as seasonal changes, invasive species, or shifting water demands and supplies. Incorporate performance monitoring and feedback loops to refine O&M practices over time.

Delegation and management choices: The long-term management strategy must also reflect the project sponsor's approach to delegation. For capital-intensive NbS^{WT} projects, sponsors have two primary options:

- **Fully Integrated Contracts** cover multiple lifecycle phases, from design and construction to long-term O&M. The promote accountability and efficiency by assigning comprehensive responsibilities to a single party.
- **Phase-Specific Contracts** separate O&M responsibilities from earlier lifecycle phases, allowing specialised parties to manage long-term tasks. This approach provides flexibility but requires robust coordination and oversight mechanisms.

Figure 11. Impressions of the multi-actor co-creation workshop in Milan; and a treatment raingarden – intensive greening for rainwater capture, treatment, and ambient cooling (photo credits: Maria Wirth)

Table 5 below showcases an implementation arrangement co-designed at a multi-actor workshop in Milan, Italy, for the metropolitan scale Sponge City project (more information on the co-creation process, participants, and results is provided in MULTISOURCE Deliverable 3.3 by Wirth et al., 2024).

Table 5. Example of a public-private implementation arrangement co-designed at a multi-stakeholder workshop in Milan for a metropolitan scale Sponge City Milan project.

Project stage	Providers of funding and resources, and commissioners	Agents
Large-scale planning (territorial planning and identification of sites)	**Funding:** • Lombardy Region • CMM (urban redevelopment funds) • ERSAF • ATO (from tariffs) **Land:** • **Municipality:** Grants concession of area for raingardens as integrated stormwater service plants for a certain period to the stormwater manager (water utility)	• Strategic body (Lombardy Region, ATO, CMM)
Technical design and construction	**Public property development:** Funding and financing providers: • ERSAF • ATO (tariffs) • Municipality (e.g., for redevelopment of a car park) • External financier **Private property development:** • Private property owner (real estate developer) • Public subsidy	• Contractor (by tender)

	• Philanthropist **Commissioners:** • Metropolitan city manager, or • Municipality, or • Water utility (with funds from ATO) **In-kind provision of engineering services:** • Water utility	
Maintenance	• Municipality (from budget for managing park and green spaces, from fees users pay for the parking lot), or • Regional public authority for parks, or • Private property management funds • Maintenance training: nurseries (suppliers of raingarden plants)	• Municipality or regional public authority for parks • Water utility (water service manager) • Private actor if implemented on private property • Maintenance training: nurseries

5. Practical recommendations for effective project development

The insights synthesised and discussed above highlight different significant and critical aspects of implementing NbS^{WT} in urban contexts, which we have compiled on the basis of our work co-creation processes in the MULTISOURCE cities and regions, but which holds general insights for cities who aims to use and exploit the many benefits of NbS^{WT} and also other urban challenges and policy issues. The following recommendations support, build on and qualify the NAIAD guidelines, and synthesise the insights from good practices and from the workshops and interviews conducted in the five MULTISOURCE pilot cities and metropolitan regions.

Multi-functional solutions, such as NbS^{WT}, need multi-actor engagement from the start

After decision on and implementation and establishment of the NbS^{WT}, the green-blue spaces and infrastructures which are at the heart of NbS need to be maintained properly. Institutional and/or individual actors who are tasked with their maintenance – from putting up clear signage, over plant and pond care to monitoring, good instruction of community members and other citizens who use the green-blue spaces – should be engaged at early stages of implementation and should equally be considered in the business model stages 3-5 above, to reduce barriers in implementation and to plan for operational steps and solutions prior to these becoming barriers. Involvement of these actors in public-public and PPP business models include street level bureaucrats as well as business and community stakeholders. Here it is important to attribute costs in line with budgeting requirements and balance the financial capacity and involvement of the different actors, as required by multifunctionality and co-benefits of NbS. Furthermore, this requires understanding the different trade-offs and dedicating efforts to minimising them, in order to keep the legitimacy and acceptance among involved stakeholders and also the local public and community.

This highlights a critical insight, which concerns the attention given to and the resources invested in stakeholders, including citizens, engagement. Targeted and substantial participation of stakeholders within and beyond the public and private actors, who are formally assigned the task of developing and implementing the concrete NbS, qualifies the design and engineering of the NbS, allowing for the intervention to be adapted to local conditions and needs. Furthermore, when local stakeholders are involved early in the process of implementing the NbS, this supports the building of common understanding and ownership, which increases legitimacy and public (local) support, also in cases in which establishing the NbS comes with altering the use of urban spaces and, for example, implies the removal of other uses such as parking spaces or change of public park design, which may unleash conflicts over use of space or policy design. The findings from the MULTISOURCE cities and metropolitan regions and from the review of cases in Europe strongly suggest that investment in stakeholder and citizen engagement in the design, the planning and the operation and maintenance (O&M) stages of implementing NbS will increase the synergies and exploitation of co-benefits of the NbS^{WT}, and reduce long term risks by distribution of ownership and sustained public support.

This requires an early identification of critical and key stakeholders, which may include government actors or agencies, water utilities, local communities and citizens, private investors, and NGOs.

Alignment with national and local policy objectives

When NbS^{WT} are introduced and integrated in the public and private efforts to manage challenging water treatment, this takes place in a context which hosts existing policies and strategies related to water treatment and urban nature policy. This can involve political strategies and policy initiatives within climate adaptation, coastal protection, recreational urban nature, land use, urban farming, school and social care, health, and/or transport, and emphasises the co-benefits as a major asset of $NbS^{WT.}$

Alignment with the city's existing policy objectives and strategies during the project development, the *planning* and the *design & engineering* stages can help reduce administrative and practical barriers, and maximise the benefits for other. The case study review and the MULTICOURCE cities and metropolitan regions suggest to leverage multi-stakeholder groups that involve multiple public administration departments as a starting point and give them a central role as a foundation for co-developing a multifunctional, efficient, and sustainable NbS project. Inviting policy makers – with their deviating perspectives and objectives – from these departments in at an early stage can shed light on co-benefits and trade-offs, and enable dedicated resources across public budgets. This may be supported by formalisation of partnerships and dedicated tasks in the short- and medium-term time perspective. This must be revised periodically, in conjunction with how the NbS^{WT} evolve over time, also influenced by citizens and stakeholder engagement

Highlighting the relevant and supplementary policy objectives and strategies, which the NbS^{WT} can benefit, can additionally provide the basis for engaging public or semi-public bodies other than those tasked with water treatment issues in the implementation of the NbS^{WT} . Aligning with existing policy objectives and strategies – or harvesting additional benefits to comply with other policies – can bring opposing interests into line. Furthermore, it can lead to public-public shared ownership and the following division or sharing of responsibility and funding and pool resources, increasing expertise and opportunities for public funding.

How to build a common understanding of the complex problem, a shared vision, and a multi-sectoral value proposition across different types of actors and different (policy) sectors

The core of NbS business models is a compelling value proposition that highlights unique benefits: environmental, economic, social. These benefits cuts across multiple sectors and the specific design of co-benefits for the individual NbS^{WT} is linked to the design and the multi-stakeholders involved in the six project stages, while central aspects of the implementation are common for all.

The building of a common or aligned understanding of the problems, which the NbS^{WT} addresses and is designed to tackle, is central for the feasibility of the project. Recognition of potentially conflicting interests and uses of the green-blue spaces of the NbS^{WT}, understandings of the objectives and the relative priority of the individual benefits linked to the NbS^{WT} can develop mutual respect and reduce tensions. Also, the building of an inclusive vison for the urban nature or the location, where the NbS^{WT} is integrated can define and support the long-term viability and acceptance of the NbS^{WT} project. It is important to allow time and resources for the building of a common understanding through engagement with public and private stakeholders and citizens, including diverging and contested aspects and including the visions for the area.

To identify the trade-offs, it is critical to involve diverse stakeholders that benefit – or may lose out – from the implementation of the NbS^{WT}. A necessary step is here to highlight the potential risks and how to manage e.g. a local demand for equitable access, or distributional effects for housing markets. Furthermore, wider environmental justice and gender/diversity aspects should be considered, to mitigate a widening of social inequity and fragmentation of the city (see also the discussion of risks and environmental justice approaches in D3.1, Wirth et al. 2023).

Insights from cost-benefit analysis (CBA) for NbS^{WT} economic feasibility

Cost-benefit analysis (CBA) provides a framework for evaluating the economic feasibility of NbS^{WT}. A well-structured CBA underpins the economic justification for NbS^{WT} by quantifying their multi-dimensional benefits and costs. It empowers stakeholders to make informed decisions, fostering wider adoption of sustainable and resilient water management solutions in urban contexts. This section outlines practical recommendations for employing CBA to support decision-making in NbS^{WT} projects, integrating insights from MULTISOURCE Deliverable 3.2 (Panduro, Abate, and Jensen, 2023) and the NAIAD project framework (Altamirano et al., 2021).

A comprehensive CBA must include direct costs such as capital expenditures (CAPEX) and operational expenditures (OPEX). CAPEX covers initial investment requirements, including construction, engineering, and installation, while OPEX entails ongoing maintenance and operation costs. Internal benefits of NbS^{WT} are equally crucial; these include cost savings from reduced reliance on conventional water treatment facilities, improved water quality, and reduced flood risks. For example, hybrid constructed wetlands, detailed in MULTISOURCE Deliverable 3.2 (Panduro, Abate, and Jensen, 2023), provide tangible financial benefits through enhanced pollutant removal efficiency and extended infrastructure lifespan. Insights from the NAIAD Handbook (Altamirano et al., 2021) further emphasise that evaluating these internal benefits supports stakeholder buy-in and project scalability.

NbS^{WT} projects offer numerous indirect and external benefits that extend beyond immediate water treatment services. These include ecosystem services like biodiversity conservation, urban cooling, carbon sequestration, and public health improvements. These non-market benefits can be factored in to capture the full societal value of NbS^{WT} (Panduro, Abate, and Jensen, 2023).

NbS^{WT} often yield cumulative benefits over extended time horizons, making it essential to apply appropriate discount rates in CBA. Dynamic discounting reflects the time value of benefits, ensuring that long-term gains, such as sustained ecosystem services and resilience to climate change, are adequately valued. This approach aligns with recommendations from Altamirano et al. (2021), which suggests sensitivity analysis to explore varying discount rates and their impact on project feasibility. It also aligns with the methodology described in Invest4Nature Deliverable 3.3 (Tedeschini et al., 2024), which highlights the importance of applying flexible economic evaluation tools to capture NbS-specific benefits.

Several key recommendations for NbS^{WT} CBA are highlighted below.

Tailored Financial Metrics

Align financial indicators with project-specific objectives, focusing on metrics such as return on investment (ROI), payback period, and cost-effectiveness ratios (Tedeschini et al., 2024)

Attribute Marginal Costs to Specific Services

This aspect was highlighted multiple times during business model co-creation processes conducted in MULTISOURCE. Decisionmakers stated that projects must clearly identify and allocate the marginal costs associated with enhanced NbS^{WT} designs to the specific services they provide. For example, if additional design features are incorporated to improve flood control, urban cooling, or biodiversity, their costs should be attributed proportionally to these benefits. This clarity ensures stakeholders can assess the cost-effectiveness of specific enhancements, **justify investments**, and align funding sources with the services relevant to their mandates. By explicitly linking marginal costs to benefits, project proponents can foster transparency and attract sector-specific funding or co-financing arrangements.

Integrate Land Opportunity Costs

Assess the economic trade-offs of allocating land for NbS^{WT} by comparing its net present value (NPV) to alternative land uses (Altamirano et al., 2021). This ensures the optimal utilisation of land resources while justifying NbS^{WT} as the most beneficial option.

Comprehensive Benefit Categorisation

Clearly distinguish between internal and external benefits to present a complete picture of NbS^{WT}'s economic and societal contributions (Panduro, Abate, and Jensen, 2023).

Long-term viability requires proactive O&M planning

A critical aspect of implementing NbS^{WT} concerns the feasibility in time perspectives beyond the initial project phase. The review and the co-creative activities we conducted in the MULTISOURCE cities and metropolitan regions revealed that the operation and maintenance (O&M) stage to be of central importance. Previous stage of the project lifecycle can be funded by a large number of different investment instruments, such as grants, or one-off funding upon availability. The long-term management, however, needs to be integrated into existing institutional practices, or a self-sustaining long-term business model needs to be developed.

Especially the establishment of clear responsibilities for the different actors involved in the NbS^{WT} is influential for the projects viability, including for sustaining local and pubic support and acceptance of the NbS^{WT} . In addition, and linked to the distribution of responsibilities, the allocation of clear roles for different actors across the public administration and its involved departments, local communities and different types of private stakeholders, including local businesses shoved to complex and challenging but also with a great influence on the NbS^{WT} project's viability.

Additionally, the findings highlight the importance of paying attention to innovative models and forms for operation and maintenance (O&M). The co-creative design and processes with integration of stakeholders and citizens in the NbS^{WT} implementation, as discussed above, can lead to models for community-led maintenance or citizen co-management. Furthermore, the multi-stakeholder design of the NbS^{WT} and the networks created during the co-creation processes can stimulate co-funding models, either between multiple departments in the public administration or other public agencies, or involving private companies, developers, housing associations or community organisations.

Moreover, the multi-stakeholder arrangement and the co-creative processes in the *operation and maintenance (O&M)* stage – and earlier, in the *design & engineering* and the *construction* stages – can foster specialised and targeted service contracts that are aligned across the multiple benefits and functions of the NbS^{WT}.

Finally, training and building of capacity of the local staff, the street level bureaucrats, the community members and citizens who are to maintain and develop the natural environment involved in the NbS^{WT} is critical on an ongoing basis. This training and capacity building can equally be supplied by experts, local knowledge and peer instruction. Sustained attention to this can ensure proper maintenance and prevent degradation of NbS functionality over time.

Conclusion

Nature-based solutions for water treatment (NbS^{WT}) represent a transformative approach to addressing urban water management challenges while delivering a multitude of co-benefits, including enhanced biodiversity, climate resilience, and improved social well-being. Despite their evident advantages, the widespread implementation of NbS^{WT} continues to face barriers, including fragmented responsibilities, sectoral budgetary constraints, and the complexity of aligning diverse stakeholder motivations. This deliverable provides practical guidelines to bridge the gap between the recognition of NbS^{WT} benefits and their realisation at scale.

The structured six-stage project lifecycle framework—spanning project development, planning, design and engineering, construction, and operation and maintenance—offers a comprehensive roadmap for successful NbS^{WT} implementation. Each stage is detailed with actionable insights, from engaging stakeholders and assessing feasibility to establishing long-term maintenance strategies and governance structures. Additionally, the deliverable addresses the critical role of financial and operational models, presenting diverse collaborative approaches and tailored business models that enable the alignment of stakeholder interests and the sustainable funding of multifunctional projects.

The practical recommendations provided in this guide draw on transdisciplinary methodologies, including literature reviews, co-creation workshops, and case studies across European cities. The insights highlight the importance of co-design processes, clear role distributions, and adaptive management to overcome implementation barriers and optimise the multifunctionality of NbS^{WT}.

By consolidating lessons learned and best practices, this report equips project proponents, municipal planners, and private sector partners with the tools and knowledge to navigate the complexities of NbS^{WT} development. The integration of NbS^{WT} into urban infrastructure holds the potential to significantly enhance cities' resilience to climate change, improve water quality, and contribute to creating more liveable urban environments. With continued collaboration, innovation, and investment, NbS^{WT} can become a cornerstone of sustainable urban development, benefiting communities and ecosystems alike.

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The overall goal of MULTISOURCE is to, together with local, national, and international stakeholders, demonstrate a variety of about Enhanced Natural Treatment Solutions (ENTS) treating a wide range of urban waters and to develop innovative tools, methods, and business models that support citywide planning and long-term operations and maintenance of nature-based solutions for water treatment, storage, and reuse in urban areas worldwide. The project includes seven pilots treating a wide range of urban waters. Two individual municipalities (Girona, Spain; Oslo, Norway), two metropolitan municipalities (Lyon, France; Milan, Italy), and international partners in Brazil, Vietnam, and the USA will contribute to each of the main project activities: ENTS pilots, risk assessment, business models, technology selection, and the MULTISOURCE Planning Platform. The use of urban archetypes in the Planning Platform will enable users to quickly classify regions (in both developed or developing countries) suitable for the application of nature-based solutions for water treatment (NBSWT) and compare scenarios both with and without NBSWT.

MULTISOURCE
enhanced natural treatment solutions

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