MULTISOURCE

Best Practices for Financing and the Operation & Maintenance of Nature-Based Solutions for Water Treatment

Deliverable 3.1

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LIST OF ABBREVIATIONS

CAPEX	Capital investment
CAS	Conventional Activated Sludge
CLLD	Community Led Local Development
CSO	Combined sewer overflow
CW	Constructed wetland
CWIS	City-wide inclusive sanitation
EU	European Union
ERDF	European Regional Development Fund
FSTP	Fecal sludge treatment plant
NBS	Nature-based solutions
NBS^{WT}	Nature-based solutions for water treatment
O&M	Operation and maintenance
OPEX	Operating expenditure
R&D	Research and development
SDA	Slum Dwellers Association
SHG	Self-help group
SMEs	Small and Medium Enterprises
SuDS	Sustainable Drainage Systems
UIA	Urban Innovative Action
VFTW	Vertical Flow Treatment Wetland

EXECUTIVE SUMMARY

Cities globally struggle with the effects of climate change, from extreme weather events to compromised water resources. NBS with the primary purpose of water treatment (NBS^{WT}), such as bioretention and treatment raingardens, constructed wetlands, and green roofs and walls for water treatment, are gaining recognition for their ability to increase urban climate resilience, and their environmental, economic, and social benefits over grey infrastructures. More and more cities are applying NBS (Perrin, 2018). Yet, several barriers are hindering the mainstreaming and large-scale integration of NBS^{WT} into urban environments. The specific nature of NBS^{WT} in contrast to grey infrastructure is associated with uncertainties over stakeholder roles and responsibilities, returns of investment (Coles et al., 2019), and other aspects constituting business cases for urban water resources and wastewater management solutions. Financial barriers are one of the main challenges of mainstreaming NBS into urban built environments, in particular long-term financing and management of operation and maintenance (O&M). Long-term business models require new, collaborative governance models engaging multiple stakeholders at various stages of the NBS^{WT} lifecycle (Mayor et al., 2021).

This report has been produced within the Horizon 2020 MULTISOURCE project, Work Package 3 'Business models for enhanced natural treatment systems'. It is targeted at public and private entities interested in developing NBS^{WT} projects in cities and aims to condense the wide existing knowledge on NBS that applies to the specific subset of NBS^{WT}, to provide a comprehensive overview and guide for stakeholders, policymakers, investors, and researchers. It delves into the complexities surrounding the adoption and long-term O&M of NBS^{WT}, in terms of their financing, operation, and maintenance strategies. It provides proponents of NBS^{WT} projects with a set of existing reference best practices of financing and operating NBS^{WT}, demonstrating different business models for long-term continuation and provision of multiple ecosystem services. Business models are here understood as the connection between the stakeholders and how an organization implementing NBS creates, delivers, and captures value, in economic, social, cultural or other contexts (based on Osterwalder et al., 2010).

The report consolidates insights and best practices from literature, experts, and practitioners across the fields of NBS research and innovation, water and wastewater management, urban greening, and blue-green infrastructure. It provides an overview of identified best practices representing diverse types of NBS^{WT}, different financing and O&M arrangements, practices of stakeholder involvement in financing capital investment and O&M, managing the NBS^{WT} infrastructures, and conducting the O&M.

Chapter 2: Review of financing approaches and business models for NBS^{WT}

Unlocking the potential of NBS^{WT} in urban water management requires a nuanced understanding of diverse financing options. The success of NBS^{WT} hinges not only on securing adequate funding but also on aligning the financing mix with each project's unique characteristics. This report explores the spectrum of financing options, which span public funding, private investments, grants, and public-private partnerships. Stakeholders can tailor approaches to specific NBS initiatives, ensuring bankable business cases that guarantee project feasibility and long-term sustainability.

This chapter provides an overview of:

- Common approaches applicable to financing NBS^{WT} and the available types of funding sources (chapter 2.1),
- Value propositions of NBS^{WT} and different markets for the many ecosystem services that NBS^{WT} can provide (chapter 2.2),
- O&M needs and approaches to managing long-term O&M of NBS^{WT} (chapter 2.3),
- Considerations for equitable urban greening and examples for inclusive governance (chapter 2.4), policy links and drivers of NBS^{WT} projects that provide multiple ecosystem services in the long term (chapter 2.5), and
- A list of supplementary reports to provide guidance on aspects related to financing and business models for NBS^{WT} (chapter 2.6).

It delves into the complexities of financing business models for NBS^{WT} projects, exploring a variety of funding sources, from public sector budgets to private investments. While water infrastructures and NBS are traditionally funded by public budgets, innovative financing mechanisms are emerging. Small-scale NBS^{WT} projects, offering local urban water services, present specific financing challenges related to investment return clarity and coordinating funding between public and private financiers. Case studies, including treatment wetlands and Sustainable Drainage Systems (SuDS), illustrate the evolving landscape of NBS^{WT} financing, involving water utilities, private sector clients, and private building owners.

Public service infrastructure typically relies on tariffs, taxes, or transfers (3Ts). However, NBS^{WT}, generating additional co-benefits, opens avenues for collaborative financing beyond standard financial models. Projects providing societal co-benefits attract funding from public and philanthropic sources, offering blended finance opportunities that buffer risks for private financiers. Alternative funding solutions, including blended finance, green bonds, crowdfunding, and payment for ecosystem services schemes, diversify the financing landscape for NBS^{WT}. Considerations for the suitability and effectiveness of funding sources depend on project goals, ecosystem services, local contexts, and inclusiveness principles.

This report underscores the pivotal role of business cases in translating strategic plans into actionable NBS^{WT} projects. Central to these cases are value propositions, defining the unique benefits of NBS projects in economic and environmental terms. In the context of water treatment, effective value propositions articulate the positive impacts of NBS on water quality, flood resilience, ecosystem health, and community well-being. These propositions shape market opportunities, enhance project attractiveness to investors, align initiatives with broader goals, and establish a foundation for measuring success. Chapter 2.2 delves into the diverse value propositions of NBS for water management and wastewater treatment, encompassing environmental, economic, social, and direct user benefits.

Chapter 2.3 focuses on the specific and critical aspects of managing long-term O&M of NBS^{WT} projects. The unique nature of NBS^{WT} demands innovative partnerships for solving maintenance-related challenges. Proper O&M is crucial for success, efficiency, and prevention of negative impacts. While some NBS are more cost-effective in maintenance than conventional solutions, they often require specialized and trained staff. Maintenance efforts depend on the NBS type and local context. An illustrative set of O&M management solutions and examples are provided. Municipalities can either maintain NBS directly through funding or encourage other stakeholders, such as residents or businesses, to contribute. Case-specific maintenance and general urban green space maintenance require clear protocols and training. Engaging various stakeholders in design and maintenance fosters long-term support. Examples include community involvement, formal agreements, and creating new roles for maintenance, promoting shared responsibility and legitimacy.

Chapter 2.4 highlights the potentials and risks related to multi-actor engagement and inclusivity. Multi-actor engagement is essential for holistic, integrated NBS^{WT} solutions. Collaboration brings diverse perspectives, enhances adaptability, and ensures contextual relevance. Collaboration increases resource pooling, enhances project legitimacy, and results in more sustainable funding models for NBS projects. Engaging local communities in decision-making processes empowers them, fostering active participation, and increasing the likelihood of NBS acceptance and sustainability.

The existing trend of urban densification bears risks as private for-profit involvement in urban densification projects can limit public access to green spaces. Active monitoring and governance structures are necessary to safeguard public access in densified urban environments. The report highlights the risks associated with green gentrification, where green initiatives lead to increased property values and displacement. Equitable urban development strategies and community engagement are crucial to prevent negative impacts. Continuous engagement of stakeholders throughout NBS^{WT} project phases from co-definition and co-design to engaging end-users can strengthen community resilience and environmental sustainability.

Chapter 2.5 presents a selection of report that provide useful further information on aspects related to building long-term sustainable business models for NBS^{WT}.

Chapter 3: Best practice examples

This chapter presents 15 selected best practices, which comprise a diverse range of NBS^{WT} relevant to urban water and wastewater management classified in the following five categories:

- NBSWT for pollution and flood control, including sustainable drainage systems (SuDS) and systems for treatment of stormwater and combined sewer overflow (CSO)
- Constructed wetlands for wastewater treatment
- Building-integrated NBS for wastewater and greywater treatment, i.e., innovative systems particularly suitable for dense urban areas
- NBSWT for treatment of water reservoirs

Following the Nature-Based Solutions Business Model Canvas, they are characterized by their solutions, key activities and resources, value propositions (primary and additional values), main agents, key partners, and governance, key beneficiaries, cost structure and cost reduction, value capture and long-term financing arrangements, as well as some strengths and drawbacks. This overview provides insights into the organization of diverse NBS^{WT} projects in urban water management.

1 INTRODUCTION

Cities worldwide are struggling with the effects of climate change, such as extreme heat, droughts, floods, water pollution, and loss of ecosystem services to provide clean air, water, and soil. In an era marked by growing environmental challenges and the urgent need for climate-resilient and sustainable water management, nature-based solutions (NBS) have emerged as a promising approach to address water treatment needs while promoting ecological balance. NBS leverage the inherent capacity of natural ecosystems to enhance water quality, offering a cost-effective and environmentally friendly alternative to traditional water treatment methods. This report follows the definition of NBS provided by the European Commission, where NBS are "solutions inspired and supported by nature, designed to address societal challenges which are cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience" (European Commission, 2015).

Despite the growing awareness and interest of actors to invest in NBS for water treatment, their adoption in the mainstream water sector has been a relatively slow ongoing process. Barriers to the mainstreaming of NBS include path dependency, as well as regulatory, institutional, governance, and financing barriers (Mayor et al., 2021). NBS are not only an innovative approach in the water sector. They are also characterised by several critical differences from more common grey water infrastructures. Factors that bear implications for financing strategies include different long-term operation and maintenance (O&M) requirements, uncertain returns, decentralized implementation, and land ownership, as well as NBS projects affecting and depending on multiple urban stakeholders (e.g., several municipal departments, property owners, local inhabitants). To facilitate investment into NBS, it becomes essential for stakeholders, policymakers, and practitioners to navigate the complex landscape of financing, operation, and maintenance to ensure the long-term success of these solutions.

In recent years many research projects have built up knowledge of funding and business models for NBS and several European Union (EU)-funded research and innovation projects have analysed cases of successful value capture of NBS for various purposes including urban water management and water treatment. This report aims to condense existing knowledge that applies to the specific subset of NBS with the primary purpose of water treatment (NBS^{WT}).

This handbook serves as a guide, bringing together insights and best practices from literature, experts, and practitioners across the fields of NBS research and innovation, water and wastewater management, urban greening, and blue-green infrastructure. Whether you are a water utility professional, government official, investor, or researcher, this handbook aims to support you with knowledge and reference cases to effectively implement, fund, and sustain NBS^{WT} projects.

Business model concept for NBS^{WT}

In this report, business models are understood as the connection between the stakeholders and how an organization implementing NBS creates, delivers, and captures value, in economic, social, cultural or other contexts, based on the definition provided by Osterwalder et al. (2010). The purpose of analysing business models is to shed light on the diversity of possible added values and ways to capture these values through sustainable and collaborative approaches that enable the long-term operation and value creation of NBS^{WT} for stakeholders and the wider society.

Collection of best practice examples

A literature review was conducted encompassing peer-reviewed publications, commercial technical reports, publications from past and ongoing EU projects and further desk research to gather publicly available information on existing solutions and their business model. A total of 57 NBS cases were collected in the first screening.

The selected NBS had to fulfill the following criteria:

- nature-based solutions for urban water treatment / management
- not entirely funded by a research program (or at least taken over by others)
- completed project / implementation
- ideally well-established with a long-term financing strategy

The sources relied on were Oppla, an open platform EU repository dedicated to NBS as well as a large number of Horizon 2020 projects, most notably the Green4Cities, Urbangreenup.eu, Naturvation.eu, GROWGREEN projects, among others. A table with key information was filled for each case which included provision for the urban water challenge addressed, other benefits, technical solution, scale, water source(s), types of financing entities, sources of financing, key actors, business model and other essential information, even though it was not always possible to find information in each of these categories. This was followed up with a deeper analysis and discussion of the apparent financing strategies and corresponding suitability for the report. The aim was to find projects with viable business models that did not rely solely on national or international funding and support citywide planning and long-term operations and maintenance.

A diverse set of NBS cases in terms of typology, actors involved, and financial scheme were selected for further investigation. Responsible persons related to those cases were contacted to gain more information for each case, specifically on the NBS system and their long-term business model, in direct conversations as well as an online survey. The design of the questionnaire included multiple choice, a rating scale, and open questions. The questions address the financial scheme, operation and maintenance, stakeholder involvement, business model, year of construction and other details pertinent to the cases. The subsequent sections of this report are based on the data collected through these questionnaires and literature review for each case.

2 REVIEW OF FINANCING APPROACHES AND BUSINESS MODELS FOR NBS^{WT}

Understanding the diverse range of financing options is crucial for developing effective strategies to support the integration of NBS^{WT} into urban water management. The successful implementation of NBS^{WT} relies on the availability of adequate funding mechanisms as much as on the alignment of the value capture approach, i.e., the financing mix, with the unique characteristics of each project. Different projects may require distinct financial models, encompassing public funding, private investments, grants, and public-private partnerships. By understanding and navigating this spectrum of financing options, stakeholders can tailor their approaches to the specific needs of each NBS initiative and develop bankable business cases, ensuring not only the feasibility of the projects but also their long-term sustainability.

A bankable business case is essential for attracting financial support from both public and private sectors. It provides a transparent and credible framework that outlines the project's objectives, benefits, risks, and expected returns on investment. Developing bankable business cases not only instills confidence in potential investors but also facilitates the allocation of financial resources towards NBS that contribute to resilient and sustainable urban water and wastewater systems, while also providing multiple ecosystem services as co-benefits, ultimately benefiting ecosystems and communities alike.

2.1 Existing practices and opportunities for financing of NBS^{WT}

This chapter aims to unravel the complexities surrounding the financing aspects of business models for NBS^{WT} projects by exploring the diverse array of funding sources available. Both common and emerging, innovative sources of financing water infrastructures and NBS are presented, from public funding mechanisms to private investment avenues, assessing their applicability to the characteristics of different types, scales, and implementation settings of NBS^{WT}.

Widely regarded as public goods, water infrastructures (Brears, 2023) and NBS in general are predominantly funded by public sector budgets (Sekulova et al., 2021). Small-scale NBS^{WT}, including constructed wetlands, green walls for greywater treatment, or raingardens with treatment capabilities, provide specific and local urban water services. NBS^{WT} may still have a certain "public good" nature, but the investment return can be specifically attributed to the individual units e.g. in terms of cost savings compared to grey solutions. This is a specific advantage of this type of NBS. However, despite these benefits, financing is challenged by lack of clarity with regards to investment return (Egusquiza et al., 2019) and challenges related to coordinating funding between public and private financiers as well as incorporating NBS benefits into valuation and accounting methods, particularly in the urban context (Toxopeus and Polzin, 2017).

In Europe, treatment wetlands have been widely applied at small scales to treat wastewater from households or tourist facilities located in remote areas without access to sewer systems and these NBS^{WT} for wastewater treatment are slowly gaining presence in urbanized areas as well. Similarly, NBS^{WT} for stormwater treatment and retention are increasingly being adopted in built environments as a recognized cost-efficient and sustainable solution to reduce flooding risk and alleviate damages. For the purpose of wastewater treatment in urbanized or settlement contexts, the clients are usually water utilities, who pay for the installation and O&M, and continue to manage the NBS^{WT}. The case of Sustainable Drainage Systems (SuDS) is reportedly more complex, as the allocation of mandates (responsibilities) and asset ownership and related asset value accounting systems do not correspond to the surface area requirements of NBS^{WT}, in contrast to a wastewater treatment plant.

In addition, NBS^{WT} have been installed for private sector clients, such as building owners and industry stakeholder that are compelled to provide for wastewater treatment plants in order for them to permit the discharge the wastewater generated in their operations. The collected cases also include private building owners (e.g. a single building owner, a hotel, a cooperative that owns a building complex) who were motivated to adopt sustainable water management approaches, including water reuse for irrigation, and co-financed the installation of innovative NBS^{WT} (vertECO®) despite the ability to connect to a sewage network, the absence of prescriptive legal requirement to treat/reuse water on-site, and even in the face of legal barriers.

Multiple co-benefits create opportunities for collaborative financing

Usually, public service infrastructure are financed over the long-term from one of three main sources, the "3 Ts": tariffs, taxes or transfers (Browder et al., 2019), as shown in figure 1 below. A sufficient flow from the 3Ts is necessary to cover capital investments, O&M costs, as well as debt services. Capital investments include investments to maintain and modernize aging infrastructure.

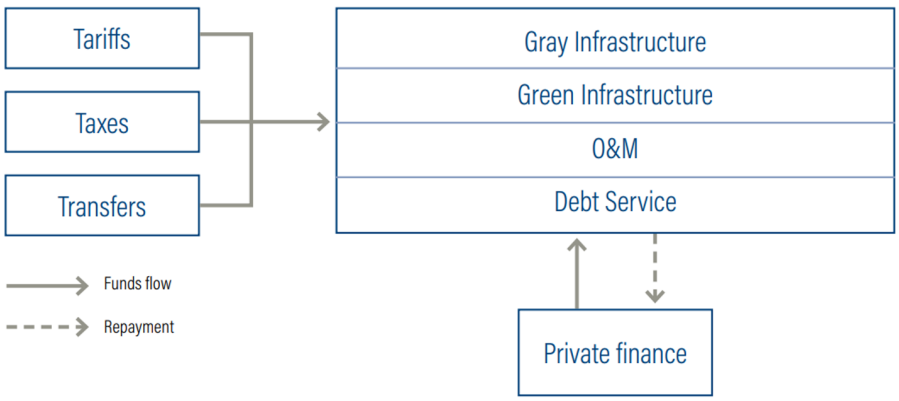

Figure 1: General Infrastructure Finance Model, by Browder et al. 2019

Due to the ability of green infrastructure to provide additional co-benefits outside the purview of public service providers, such projects open financing opportunities outside the standard financial model previously described, and can be marketed to governments, the private sector, or development agencies,

and thereby also alleviate potential finance challenges. This opens financing opportunities from other public sources interested in the potential societal co-benefits (Browder et al., 2019), i.e. innovative pooling from budgets of multiple public authorities and agencies.

Public and philanthropic sources can make investments more attractive to private financiers by providing opportunities for blended finance, through concessional development capital, thereby buffering risks associated with investments in NBS (Coles et al., 2019), as well as environmental bonds, development agencies, and other service providers (Browder et al., 2019).

Considerations for the suitability and effectiveness of funding sources in meeting the needs of NBS^{WT}

While the great majority of NBS is still funded through public budgets, from local to central governments, alternative funding solutions have started to gain traction (Trinomics and IUCN 2019). Possible alternative sources of funding for urban water and green infrastructure, in addition to public funding and private investment, include blended finance, green bonds, crowdfunding or payment for ecosystem services schemes, international aid, and the investment of non-financial resources such as time and existing assets (built environment, urban public or private spaces).

For example, NBS projects can draw on climate finance if the project size is large enough to constitute an investment product, or to directly capture and/or abate carbon emissions at an amount large enough to be applicable for carbon offset credits on the carbon market (e.g., forestry and grassland conservation (Wilk et al., 2020)). Meanwhile, an individual treatment wetland for a specific local function will be suitable for financing from a municipal or water utility budget. NBS for water resources management and disaster risk reduction (DRR) are prominently funded by public institutions and, in the private sector, by water utilities (Mayor et al., 2019).

When NBS create value in the form of marketable products, such as food production, this can be privately appropriated through standard business models and therefore more readily privately financed, in contrast to NBS with public good outcomes such as climate change mitigation or urban regeneration and air quality (Toxopeus and Polzin, 2017).

Choosing the appropriate revenue financing model involves considering the specific goals of the NBS project (e.g., ranging from natural resources restoration to an urban enhanced natural treatment unit), the specific ecosystem services it can provide, the local institutional and regulatory context, and scales of implementation, as well as sustainability principles of inclusiveness, transparency, accountability, and flexibility. Combining multiple revenue streams through a diversified financing approach can furthermore enhance the sustainability of NBS initiatives.

All the mechanisms listed in the following table are applicable to NBS^{WT}. “Short-term” refers to the financing of capital investment for installation and “long-term” covers O&M as well. More details on most of the listed financial instruments as well as additional case studies can be found in (Baroni, Nicholls, Whiteoak, 2019).

Table 1: Types of financing sources applicable to NBS^{WT}

Type of instrument	Definition/purpose	Applicability/requirements	Short-term or long-term	Examples
Public budgets	Allocated funds and financial resources that government entities earmark for planning, implementing, and maintaining water infrastructure, green infrastructure, and restoration of natural ecosystems	Primary purpose and/co-benefits must correspond to public budget mandates	Long-term	• Reed bed filter (constructed wetland) for the treatment of combined sewer overflow (CSO) commissioned by the Metropolis of Lyon, France (Department of water service) and the catchment water agency (Agence de l'eau), and operated by the Metropolis of Lyon
Public-private partnerships (PPPs)	Collaborative arrangements between public and private entities to fund, develop, and maintain NBS: PPPs can be defined as "long-term contracts between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility" (UN-Habitat, 2017). PPPs have been used for a range of infrastructure services (government entities 'delegate' service provision to a private entity) and can also be developed for the delivery and/or maintenance of GI. In general, PPPs can take various forms, including operation and maintenance contracts, leases, concessions, etc. (UN-Habitat, 2017)	Suitable for projects that deliver benefits towards public policy goals and cost reduction or attractive return to a private entity	Long-term	• Constructed wetland for tertiary treatment at the municipal wastewater treatment plant of Lamni, Finland: City of Hämeenlinna (concessional loans, equity) and local wastewater treatment company HS-Vesi (O&M)
Innovative pooling of public budgets	NBS^{WT} not only generate benefits within the water sector, but also others, e.g. public health, education, police, climate change adaptation, roads and public transit. Therefore, funding from different government budgets could be acquired.	Multipurpose NBS^{WT}	Long-term	• Municipal authorities for urban greening or environment, urban roads, and sewers pool budgets to implement stormwater bioretention and treatment systems
Green debt and concessional financing	Sustainability-linked loans or green bonds, concessional financing, crowdfinancing, co-financing instruments at EU or international levels, specialised banks. Concessional financing (soft loans) are financial resources provided at more favorable terms than standard market conditions. These terms may include lower interest rates, longer repayment periods, or more flexible terms. Concessional financing is designed to facilitate projects in regions or sectors that may face challenges in accessing commercial loans.	Alignment with green finance standards and contribution to environmental (societal) impact, large scale (district), robust risk mitigation strategies, demonstration of long-term sustainability in the project design, meaningful engagement with local communities and stakeholders	Short-term	• Green corridors for urban heat mitigation in Athens, Greece, financed by the Natural Capital Financing Facility (NCFF) • Bank of and for the Dutch public sector (Bank Nederlandse Gemeenten) providing financing to local authorities (water authorities, municipalities, provinces) a.o. with tailored financing solutions where clients can design their own repayment schedule

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Type of instrument	Definition/purpose	Applicability/requirements	Short-term or long-term	Examples
Green bonds, Environmental Impact Bonds (EIB) and Social Impact Bonds (SIB)	Outcome-based contract, where upfront private investment funds the NBS and is then repaid by public bodies upon achievement of pre-specified outcomes; Green bonds: Issuing bonds to raise funds specifically for environmentally friendly projects, including NBS. Private funders of NBS include commercial investors. Green, blue and climate bonds can collectively be referred to as "green bonds".	An entity, typically a government, municipality, corporation, or financial institution, issues the green bond to raise funds for projects.	Long-term	• Governments or organizations issuing green bonds to finance projects related to reforestation, green infrastructure, or habitat restoration. • Washington DC Water Environmental Impact Bond, one of the first pay-for-success, or pay-for-performance applications: The investors of Washington DC's Stormwater Bond are paid interest rates according to the performance of the green infrastructure (Browder et al., 2019).
Finance by development partners	Provision of financial resources and support by international development organizations, donor agencies, and other entities that collaborate with countries or regions	Country ownership, predefined results, programmatic nature, capacity building components	Short-term, capacity building for long-term	• Community-based restoration project to restore canopy cover and provide natural protection against flooding and landslides in Freetown, Sierra Leone, financed by the World Bank (Global Facility for Disaster Reduction and Recovery, GFDRR)
Crowdfunding and philanthropic donations (voluntary beneficiary contributions)	Receiving charitable donations from individuals (citizen community), organizations, or philanthropic foundations to fund NBS initiatives, can be facilitated by public or private actors	Local tangible impacts that address passionate supporters	Short-term or long-term with recurring payments/ subscriptions	• MyParkScotland initiative: Anyone can financially support new grassroots greening projects and citizens are supported to start NBS crowdfunding projects. • Donations to support the creation of urban green spaces, community gardens, or habitat restoration projects.
Grants	Grants are financial contributions provided to support projects or initiatives without the expectation of repayment. They are essentially gifts or subsidies given to individuals, organizations, or governments to carry out specific activities or achieve predefined goals.	Grants may be allocated to fund various aspects of a project, including the planning, implementation, and maintenance, typically provided to support initiatives that contribute to societal benefits, including research and innovation.	Short-term	Securing grants for wetland restoration, afforestation projects, or sustainable urban development, for example: • European Structural and Investment Funds • Program for the Environments and Climate Action (LIFE) • Horizon 2020 • Development aid and cooperation • Global Environment Facility (GEF) • Green Climate Fund (GCF)

Type of instrument	Definition/purpose	Applicability/requirements	Short-term or long-term	Examples
Property developer contributions or charges	Payments by landowners or beneficiaries to capture the land value gain from a public project (e.g. via higher rent)	Assessment of land value gains for property owners	Short-term	• In the UK, Section 106 (S106) agreements and the Community Infrastructure Levy (CIL) allow local authorities to charge developers a fee for new infrastructure works (including green spaces) (Drayson and Newey, 2014).
Private real estate development	Private funders include private companies that install NBS, such as homeowners or building owners and companies required or interested to treat their wastewater. Facility managers are responsible for maintenance.	Regulations (e.g., maximum permissible stormwater discharge per area) and marketing benefits and higher rent or real estate sale (due to greening, innovation, and sustainability) incentivize private investment in NBS in real estate development	Long-term	• Green Living Concept Novi Sad: The implementation of NBS was driven by the construction company Erker Inzenjering. The company aims to integrate greening into the living spaces they develop (Wilk et al., 2020).
Eco-tourism revenue	Generating income through sustainable tourism activities linked to NBS	"Special" characteristics that can attract visitors must be generated, such as biodiversity, demonstration of innovation, hospitality to generate revenue	Long-term	• Guided tours, bird watching, or eco-friendly accommodations within or near natural reserves.

Insights from collected best practices of financing urban NBS^{WT}

The results of the collection of best practices of financing urban NBS^{WT} are presented in Table 2 below, differentiating funding sources by (i) Financing of initial capital investment for installation (CAPEX), and (ii) Financing of O&M (Operational expenditure, OPEX). The collection of cases confirmed that public budgets predominantly fund the installation of NBSWT, with O&M costs carried also by public funding in most cases, though with greater presence of private funding sources.

Table 2: Sources of financing for innovative NBS^{WT} among surveyed case studies

Primary purpose of NBS^{WT}	Financing of initial capital investment for installation	Financing of O&M
Raw wastewater treatment (including reuse cases)	• Public grants (Horizon 2020) • Private equity (client, e.g. household, company, school)	• Local partners who were partners in the Horizon 2020 project within which the NBS was installed, as well as other local partners • Clients / users: household, company, school
Greywater treatment (including reuse cases)	• Public grants (Horizon 2020) • Private equity and loan	• Small research grants • Residents / users • Business where the NBS is installed (hotel)
Pre-treated wastewater treatment	• Public budget (loans, guarantees, equity)	• Wastewater utility (charges wastewater tariffs from residents)
Stormwater treatment (CSO treatment wetlands and treatment raingardens, including reuse cases)	• Public grant (Municipal / metropolitan budget, European Regional Development Fund (ERDF) through urban Innovative Action, research grants) • Public subsidies (from municipal, metropolitan city or regional budget) • Public loans, guarantees, equity (municipality, metropolitan city, regional authorities, water utility funding authority) • Water utility (public or private; charges tariffs from population served) • Private (housing corporations)	• Public grant (Horizon 2020, ERDF) • Municipal / metropolitan budget • Private financing (Business Improvement District, housing corporations, water / wastewater utility)
Urban reservoir restoration	• Public grants (Community Led Local Development (CLLD))	• CLLD grant • Local municipality
Productive urban landscape	• Public grants	• Local municipality

The following financing related experiences were shared most often among practitioners involved in the selected best practice cases:

- A path dependency is perceived, with resistance to adopt new technologies. Solutions are often still considered unsuitable as being not “very technologically advanced”, which reduces success in tenders. More reference examples are needed to win.

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- Local authorities do not prioritise the added value of NBS, but rather cost efficiency and preventing discomfort for citizens.
- Where technology providers sell technologies to brokers, who further sell them to users, innovative approaches and the argument of co-benefits do not hold. Brokers mainly consider the investment cost and "known" solutions. The non-financial benefits of the investment do not benefit the broker or investor, but the user. The broker / investor is therefore less inclined to include circular ideas into the budget, while users are not involved in the decision-making process, making it impossible for them to gain such co-benefits, and very difficult to achieve at a later stage.
- More technical guidance is needed for design and maintenance of NBS across a variety of applications.
- Successful technology demonstrations can motivate others to adopt these technologies. For example, a school treats its wastewater using an aerated hybrid wetland (Phytoparking®), the local authority may create an aerated hybrid wetland for the neighbouring houses as well, which are currently not connected to the sewage system either.
- Replicability and continuation after end of funded projects tends to be uncertain, but they are simple if the technology's functionality is proven to the funding body.

Cases that demonstrate funding models and attractive risk profile are needed in different countries to showcase the possibilities and de-risk technologies for respective governments, local authorities, and public utilities.

2.2 Crafting Compelling Value Propositions of NBS^{WT}

Business cases bridge the gap between strategic planning and investment for NBS^{WT}, facilitating the transformation of plans into actionable projects. Value propositions serve as the cornerstone of business cases. They articulate the unique benefits and advantages that NBS projects bring to the table, both economically and environmentally. In the context of water treatment, effective value propositions identify and communicate the positive impact of NBS on water quality, flood resilience, ecosystem health, and community well-being. Value propositions define the market opportunities for the NBS^{WT}, such as the environmental services market, stormwater markets, credit systems.

A compelling value proposition enhances the attractiveness of NBS^{WT} projects to potential investors, help align NBS^{WT} initiatives with broader strategic goals, such as climate resilience, engage stakeholders, and set the foundation for measuring the success of NBS^{WT} projects.

NBS^{WT} can provide a host of co-benefits in addition to their primary purposes (wastewater or stormwater treatment). In the following section, value propositions of NBS are described along environmental, economic, social, and direct user propositions (McQuaid, 2019).

- *How will the NBS address key **environmental challenges** at community, city or regional level?* For example, NBS for water management could support water supply for green areas, and/or reduce local and regional flooding.
- *How will the NBS address important **social challenges** at community, city or regional level?* For example, NBS for water treatment could increase the health of citizens by reducing water pollution in receiving waters.

- *How will the NBS help address priority **economic challenges** at community, city or regional level?* For example, NBS for water treatment could create new green jobs related to maintenance, produce service water for other enterprises, and reduce costs on conventional wastewater treatment units.

- In addition, there might be **additional direct or indirect value propositions** arising from the NBS or any direct end-user benefit which has not been considered, e.g. if crops are planted, this may lead to a value for urban agriculture or direct end-user value from picking fruit for consumption.

- **Potential trade-offs** might exist between the different value propositions. *Does the environmental value proposition generate any negative potential impacts on the social or economic value propositions?* For example, large-scale NBS for water ecosystem restoration may lead to land use conflicts (negative social value). *Does the social value proposition generate any negative potential impacts on the environmental or economic value propositions? Does the economic value proposition generate any negative potential impacts on the social or environmental or value propositions?*

The primary purposes of the NBS^{WT} within the scope of the MULTISOURCE project are either stormwater retention and treatment or wastewater treatment. In the following, these two groups of value propositions are described in more detail:

a) Value propositions of NBS for water management

Water Management activities reduce risks associated with water-related disasters and climate change and enhance water availability for the irrigation of green areas or for the use in buildings. They include retention of rainwater, stormwater, and surface water, buffer discharge of the water into receiving waters or into the stormwater drainage system, as well as filtered infiltration into groundwater.

i) Environmental value proposition

How will the NBS address key environmental challenges at community, city or regional value? NBS for water management equalize heavy rainfall and reduce local and regional flooding (e.g., Stavros Niarchos Cultural Centre in Athens, Reed Bed Park in Bézannes' Joint Development Zone), while increasing groundwater supply (e.g., Tolka Valley park wetlands & greenway in Dublin). They will prevent sewer systems from overflow. The retained water is used for irrigation of green areas, such as roofs, building facades and parks (e.g., Biodivercity in Malmö, Infiltration trench and rain garden in Malaga). Installing green infrastructure can contribute to enhanced microclimatic conditions in terms of humidification and cooling of surrounding air (reducing urban heat islands), reduced air pollution, increased biodiversity on species level as well as on ecosystem level and increased carbon sequestration. NBS provide a mechanism to adapt to and mitigate climate and land use impacts (Diringer et al., 2020).

ii) Social value proposition

How will the NBS address important social challenges at community, city or regional level? NBS for water management can increase the health and safety of citizens through abatement of traffic noise, pacification, creation of inviting destinations and fostering psychological wellness due to the stress-relieving impact of plants on humans (e.g., City Forest in Sofia, Office 22 in Barcelona). NBS additionally add an aesthetic benefit through green urban infrastructure (e.g., Green Roofs B.R.O.T in Vienna, Treebox-Rain-Garden in London).

iii) Economic value proposition

How will the NBS help address priority economic challenges at community, city or regional level? NBS for water management can decrease costs compared to other solutions for water management and could create new "green" jobs related to distribution, implementation, and maintenance. By reducing flood-related catastrophes (e.g. flood victims, destruction of important infrastructure, such as buildings, roads). They have the potential to foster resilience averting major disasters. Economic growth and positive

association of a certain location can also be stimulated through NBS (e.g., De Ceuvel in Amsterdam, Green Waterfront in Vancouver).

iv) Additional value propositions

Sustainable urbanisation areas with NBS for water management can further be used for educational purposes and even farming (e.g., Parc Marianne Ecodistrict in Montpellier).

v) Trade-offs between different value propositions

Area used for NBS could also be area for living or business. Economically seen, NBS are a long-term investment, which can pay off through the mitigation of catastrophes for humans and the connected environmental damage. The primary challenge for corporations is that there is no standardized method to identify, estimate and monitor the benefits that NBS can provide, making it hard to build the case for investments in these solutions (Brill et al., 2021).

b) Value propositions of NBS for wastewater treatment

NBS for wastewater treatment are improving water quality in combination with the creation of green areas, e.g. through natural and constructed wetlands, or riparian buffer strips.

i) Environmental value proposition

How will the NBS address key environmental challenges at community, city or regional value? NBS for water treatment will increase the health of ecosystems and inhabiting species by reducing water pollution in receiving waters. They can contribute to ecosystem restoration and further support ecosystem functions (i.e. Natural wastewater treatment in Valladolid). When integrated into buildings, the treated water can be reused in the building, thereby reducing water consumption of the building and relieving pressure from natural ecosystems (i.e. Rain garden in Izmir and Valladolid). With the help of NBS in wastewater treatment, nutrients can be recovered for reuse, reducing the need for energy-intensive production or fossil mining of mineral fertilizers, and supporting a circular economy (i.e. Libellule Zone through ZHART Project in Saint-Just).

ii) Social value proposition

How will the NBS address important social challenges at community, city or regional level? NBS for wastewater treatment are robust, cost-efficient solutions that are particularly widespread in settlements with no connection to sewer systems. Therefore, NBS might be able to provide wastewater treatment and thereby enhanced sanitation and human health benefits where wastewater is otherwise discharged without treatment, or where improved sanitation is otherwise not available.

iii) Economic value proposition

How will the NBS help address priority economic challenges at community, city or regional level? NBS for water treatment will create new green jobs related to maintenance, produce service water for other enterprises, reduce costs on lacking/insufficient wastewater treatment units, support the bioeconomy in general. Treated water can be reused, thereby reducing costs for water supply. With the help of NBS in wastewater treatment, nutrients can be recovered for reuse, reducing costs for energy-intensive production or fossil mining of mineral fertilizers.

iv) Additional value proposition

See a) iv) as well as reduced soil sealing compared to conventional wastewater treatment plants.

v) Trade-offs between different value propositions

NBS for water treatment may lead to concerns about public health safety (negative social value).

2.3 Long-term financing for operation & maintenance (O&M)

Who is in charge of maintenance? Who is in charge of routine checks? Who communicates maintenance needs and failures, and how, to whom? All of these questions form part of the business models for NBS^{WT} and are often yet to be solved as these are innovative solutions that often require innovative partnerships.

Appropriate O&M of the NBS^{WT} are essential for their success and long-term functioning, to secure treatment efficiency and prevent negative impacts (Cross et al., 2021). Due to their nature, NBS^{WT} are handled differently than other technologies and need specified protocols for implementation and maintenance (Kabisch et al., 2016). Even if these procedures could be perceived as a barrier because of their novelty, it should be highlighted that some NBS are even more cost-effective in terms of maintenance than conventional solutions. They can have lower O&M requirements during their lifetime than "grey" technologies. For example, French Vertical Flow Treatment Wetlands (VFTWs) require just a weekly inspection while a Conventional Activated Sludge (CAS) System needs daily supervision. Also to retrofit and upgrade an NBS can require less work than for a CAS treatment plant (Cross et al., 2021), and the less effort it takes to maintain the NBS, the more preferred they are (Somarakis et al., 2019).

However, the maintenance of NBS often requires specialized and trained staff (Wilk et al., 2020). This could mean to train workers to monitor and carry out regular checks (Cross et al., 2021). Specialized staff trainings were also needed for about half of the implemented technologies in the case studies presented in this work, though this does not seem to be linked to the assessed level of effort (low, medium, high), but for the kind of work that must be done. Otherwise O&M works are often conducted by gardeners or specialized Small and Medium Enterprises (SMEs) (Wilk et al., 2020). There is a need for more technical guidance on design and O&M of NBS across a variety of applications.

Naturally, the O&M effort depends on the type of NBS implemented and on local contexts. The table below presents several selected urban NBS for wastewater treatment and their operation and maintenance effort (extracted from „Nature-based solutions for wastewater treatment" by Cross et al. (2021)).

For a lot of cities, it is difficult to secure long-term O&M of NBS due to scarce financial resources and capacity (Wilk et al., 2020). When implemented, NBS often face the challenge of having a designated budget for the O&M works throughout their lifetime.

Particularly in the case of research and innovation, NBS^{WT} project funding (grants) is secured for CAPEX and short-term O&M, while solutions lack to cover O&M after the project ends (Kabisch et al., 2016). If long-term responsibilities for the O&M of the NBS are not carried out in the design and development phase it is more difficult to accomplish later (Wilk et al., 2020). Sufficient guidance protocols and technical support in terms of instructions for implementation and O&M for the NBS are often missing (Somarakis et al., 2019).

Table 3: Selected NBS for water treatment (possible in urban environment) and their related operation and maintenance efforts (based on Cross et al. 2021)

Type of NBS^{WT}	Types of influent wastewater	Operation and maintenance (O&M) work
Anaerobic ponds	Raw, primary treated	**Daily** ● Flow data recordings, cleaning of screening units and grit chambers, flow control to the treatment units, monitoring of field parameters **Weekly** ● Checking of the pumping system, checking of pipe blocking, weirs, and valves **Extraordinary**

		● Sludge accumulation, removal, drying and disposal, grass trimming, sampling of influent and effluent, and delivery of samples for laboratory analyses **Troubleshooting** ● Odour: due to organic overloading, excess sulphate (≥400 mg/L) in the influent, and operation and maintenance failure ● Efficiency: removal efficiency reduction due to sludge overaccumulation (≥1⁄3×V, where V is the AP volume)
Vertical-flow treatment wetlands	Greywater, primary treated	**Regular** ● Nitrification can be checked by measuring effluent ammonia nitrogen using a test kit on a monthly basis, minimum ● Measurements should be recorded in a 'maintenance book' together with all maintenance work done and operational problems that occur **Annual tasks** ● Sludge removal from primary treatment to prevent sludge drift to the vertical-flow (VF) beds. The emptying interval depends on the volume of the tank, but sludge must be removed at least once a year ● The intermittent loading can be checked by measuring the height difference in the loading tank before and after a loading event ● To prevent freezing of wastewater in the distribution pipes, it is essential that after a loading no water stays in the pipes. This needs to be checked once a year ● Wetland plants should be cut every 2–3 years. If cut before the cold season, the plant material should be left on the filter surface to provide an insulation layer **Extraordinary** ● During the first year, weeds should be removed until a mature cover of wetland vegetation is established **Troubleshooting** ● After a few years, the rubber part of some siphons can get porous, which allows wastewater to seep continuously and thus only one part of the VF filter is loaded
French vertical-flow treatment wetlands	Raw	**Regular** ● Twice a week: checking the batch feeding systems for proper operation and filter alternation ● Regular cleaning of coarse screening ● Once a month: weed control ● Once a year: checking the organic deposit height and harvesting the reeds ● Plant maintenance frequency in tropical climates can be higher **Extraordinary** ● First growing season: weed harvesting ● Removal of deposit layer at least every 10–15 years **Troubleshooting** ● First stage clogging: if continuous hydraulic overloads arrive on the filters
Floating treatment wetlands	greywater, primary treated	**Monthly** ● Check anchoring and positioning of the mats ● Weed control **Yearly** ● Depending on treatment goal and chosen plant

		species, harvesting might be necessary ● Mat structure and growth media need to be checked **Extraordinary: troubleshooting** ● Tracer tests for short circuiting and dead zones in case of insufficient treatment
Living walls (green walls) for greywater treatment	greywater	Regular ● Control efficiency of primary treatment and removal of settled solids, oils, and grease ● Planting and harvesting depend on plant species ● Control of the feeding system ● Inspection of the distribution system ● Control outflow of planter box for blockage (clogging or roots) Extraordinary ● Removal of plants with high root density (clogging issue) ● Flushing of irrigation/feeding system when clogged Troubleshooting ● Blockage of the outflow due to roots Pump/compressor maintenance is also needed, and occasionally pipe cleaning.
Rooftop treatment wetlands or constructed wetroof	greywater, primary treated	**Regular** ● Continuous: grass mowing by robot (e.g. with an electric mower left on the roof) ● Once a year: check technical equipment and elements (switchboard, pumps, pressure pipes, valves, etc.) **Extraordinary** ● If a septic tank is used, it should be emptied once every couple of years (depending on the primary treatment size and the wastewater quality)
Hydroponic system	secondary treated, river diluted	Level of maintenance depends on the type of crops, selected media, type of water flow and size of the system. **Daily** ● Plant check ● System supervision 24/7 (SMS alarms, on-call service) ● Integrated pest management ● Continuous system water monitoring **Weekly** ● Technical check ● Adjusting nutrient solutions ● Cleaning the system (pumps and technical installations) **Monthly** ● Cleaning of some system parts ● Replacement of plant cultures **Yearly** ● System cleaning (pipes) Extraordinary: troubleshooting ● Check the pumps, aeration, oxygen, blockages, water flows for any issues
Aquaponic system	secondary treated, river diluted	**Daily** ● Supervise fish and plants ● System supervision 24/7 ● Fish feeding ● Integrated pest management

		● Continuous system water monitoring **Weekly** ● Technical check ● Cleaning the system (pumps, sediments, and technical installations) **Monthly** ● Cleaning of system parts ● Replacement of plant cultures **Yearly** ● System cleaning (pipes) Extraordinary: troubleshooting ● Check the pumps, aeration, oxygen, blockages, and water flows for any issues ● As soon as there is a malfunction, action must be taken immediately to reduce the risk of harm to the fish
In-stream restoration	secondary treated, river diluted	**Regular** ● Planting trees, grass and other plant species in the riparian zone **Extraordinary** ● Artificially created meanders **Troubleshooting** ● Manual removal of sediments

The table provided offers insights into the O&M tasks required for various NBS^{WT}, underscoring the critical role of comprehensive knowledge and maintenance plans in ensuring optimal performance. For NBS providers, documenting both the implementation and ongoing maintenance is essential, as it serves as the foundation for developing guidance protocols and offering essential technical support. This knowledge-sharing process not only establishes clear guidance for effective execution but also serves as a key catalyst in promoting implementation (Somarakis et al., 2019).

Solutions and examples of O&M management

For operation and maintenance of NBS a municipality has the following options (Baroni, Nicholls, Whiteoak, 2019):

1) **Maintain directly**: The municipality pays for the intervention through funds or by obtaining loans and revenues to finance the project.
2) **Encourage other stakeholders**: residents, utilities, business etc. to contribute to the maintenance of existing public NBS. The local authorities offer incentives to other actors or otherwise encourage private financing.

Distributing responsibilities to other actors like citizens, private housing companies or school administrations can allow for more case-specific maintenance, while including NBS^{WT} in the scope of general maintenance of urban green spaces requires clear protocols and perhaps trainings of municipal maintenance staff.

The CLEVER Cities project's deliverable on "Governance business and finance models" presents several ways to encourage other stakeholders to take over maintenance tasks (Wilk et al., 2020):

- Build a sense of ownership for the co-implemented solutions on behalf of the engaged local residents and end-users (e.g., co-design processes)
- Link in with existing priorities and interests of stakeholders (e.g., green school projects)
- Formalize co-maintenance responsibilities in agreements (e.g., with neighborhood committees, local associations, companies etc.)
- Establish a new professional role with pertinent responsibilities to maintain NBS (e.g., community gardener in residence offering workshops and drop-in sessions for residents)

Another example for other stakeholder support is the Montreale park in Potenza city. The maintenance is conducted by a self-organized citizen group called 'Hoes armed citizens'. The park is perceived as an essential space for their recreation and urban life. The citizens' initiative was committed to preserve and improve the quality of this urban green space when, in the wake of austerity measures, the city was unable to maintain this park (Frantzeskaki, 2019).

Collaborative governance starting at the design of NBS^{WT} can gain allies for long-term O&M in decentralized settings. The following chapter explores the benefits and considerations for multi-actor engagement and inclusivity for the benefit of more sustainable NBS^{WT} projects.

2.4 Multi-actor engagement and inclusivity

Relevance of collaborative business models

Collaborative business models involving multiple actors are particularly relevant in urban context for the inclusiveness, sustainability, and the development of more effective business models for NBS^{WT}. NBS^{WT} often requires addressing complex and interconnected challenges. Multi-actor engagement involves bringing together diverse perspectives, experiences, expertise and unique knowledge of the local context and cultural nuances in planning and implementation, for:

- More holistic, integrated solutions that balance relevant interests and needs,
- Enhance awareness of risks and adaptability to changing conditions,
- Ensure that the NBS^{WT} initiatives are contextually relevant, and
- A broader pool of resources, including financial support.

According to the Governance Analysis conducted by the CLEVER Cities projects, particularly in urban implementation settings, multi-sector, polycentric and adaptive governance models can provide these success factors and suitability for dynamic local planning, joint learning, and adaptation (Wilk et al., 2020). These actors can include local communities, government agencies, businesses, non-profit organizations, and researchers.

Resource mobilization becomes more effective when stakeholders from various sectors collaborate. Besides pooling of resources, the active engagement of various stakeholders enhances the legitimacy of NBS^{WT} projects. The shared responsibility and legitimacy can lead to the development of more sustainable and resilient funding models for NBS projects.

Further, engaging local communities in decision-making processes empowers them to actively participate in shaping the outcomes and evolution of NBS^{WT} projects. Involved communities are more likely to embrace and sustain NBS interventions. Water infrastructure managers and cities can leverage the "social muscle" for co-management of decentralized NBS^{WT} in particular, securing allies to support long-term maintenance and management after pilot funding ends (Wilk et al., 2020). This can be supported by formalizing citizen participation in institutions, i.e. by creating a citizen organisation and facilitating their participation in decision-making and solution-finding. Financing can also act as a catalyst for promoting collaborative governance (Wilk et al., 2020), for example through minimum requirements in public procurement or even collaborative approaches to drafting public bids involving other actors.

NBS^{WT} approaches are determined by specific natural and cultural contexts, and their implementation is a matter of societal choice. When successful, they are not only addressing specific problems through efficient management of ecosystems, but also ensuring that cultural and societal values, norms, and practices are reflected in the process. This can enhance their capacity to self-sustain over time (Cohen-Shacham et al., 2016). There are good practices of successful NBS approaches from around the world which are managed and accepted by local communities, including successful governance practices.

Risks of private for-profit involvement and an environmental justice approach for the equitable access to NBS and their benefits

The importance of green spaces in urban development and planning is known, and measures taken to increase them in relation to the built environment have improved the quality of lives of many people. However, their distribution tends to favour affluent areas, leading to growing socio-spatial inequalities. To address urban water challenges with NBS, it is crucial to recognize the complex socio-environmental dynamics and prioritize solutions that consider and mitigate social impacts. As such, within the last decades, socio-spatial inequalities within urban environments have been growing (Haase, 2017).

Green gentrification refers to the phenomenon where the implementation of sustainable and environmentally friendly initiatives leads to an increase in property values, often resulting in the displacement of existing, often lower-income, residents. To avoid green gentrification, it is crucial to adopt equitable and inclusive urban development strategies. This includes engaging in community-based planning and decision-making processes, ensuring that the benefits of green initiatives are accessible to all residents. Affordable housing policies and mechanisms to protect vulnerable communities from rising property costs should be implemented. Additionally, fostering partnerships between local governments, community organizations, and developers can help create strategies that prioritize social equity, affordability, and environmental sustainability, preventing the negative impacts associated with green gentrification and promoting a more inclusive and resilient urban environment.

The strong momentum for urban greening and NBS overall raises the need to ensure that this development is equitable in delivering expected benefits. Applying environmental justice approaches to the planning and implementation of NBS^{WT} projects helps to avoid exacerbating inequities in urban development and nature-enabled dispossession, and to instead build equitable nature-based justice that provides ecosystem services and societal benefits to the most ecologically and vulnerable local population (Anguelovski and Corbera, 2023).

There is an inherent conflict for space between urban densification and urban greening. Densification is recognized as a sustainable land-use goal, yet its implementation faces challenges such as fragmented landownership, high land values, and navigating diverse interests in cities. Increased density often results in a reduction of public green spaces and potential overuse of existing ones. The involvement of private actors, including developers and real-estate investors, in densification processes adds another layer of complexity (Verheij et al., 2023). The powerful role of private for-profit actors in densification projects often results in green spaces being restricted to exclusive spaces, so-called “club goods”, where public access is restricted to a limited group (Verheij et al., 2023). The club good theory provides a lens to assess spatial planning and development projects, and in turn enable the alignment of NBS governance structures to support NBS with an open and public character. Verheij et al. (2023) underscore the importance of active monitoring post-planning to address potential conflicts and safeguard public access to green spaces in densified urban environments.

Understanding NBS within the socio-environmental nexus and phases of stakeholder engagement

When aiming to develop NBS, it is important to understand that the socio-environmental nexus is complex and that the impacts of NBS on the social environment need to be included when considering solutions to urban water challenges. According to Ferreira et al. (2020), a major challenge in this respect is the need to develop capacity-building tools to increase knowledge and awareness of NBS business models across stakeholder groups, both in public sector agencies and with external stakeholders. Our review NBS cases, revealed that local authority and EU are the main funders and shareholders of NBS investments, followed by hybrid (public and private) financing of NBS. Private investment in NBS is still low, amongst other things, due to a lower level of awareness of NBS in the private sector compared with the public sector. These findings are supported also from other research works (Ferreira et al., 2020).

Figure 2 below illustrates the role of NBS and participatory processes at the interface of the social system and the natural ecosystem.

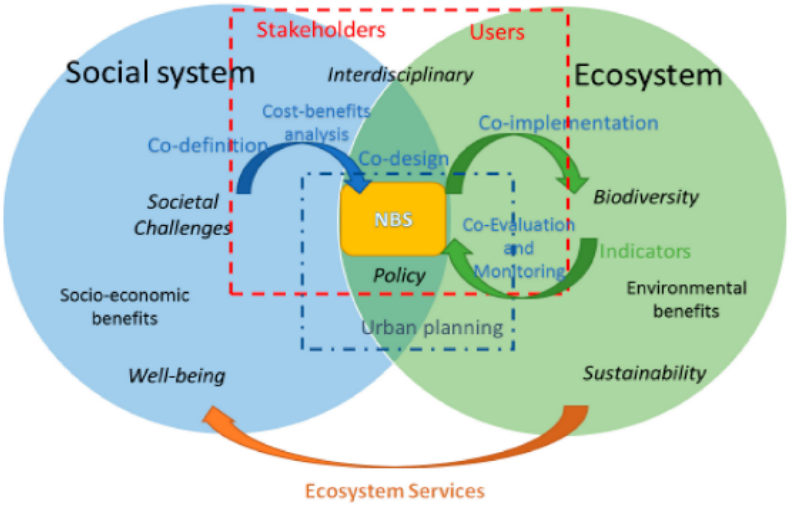

Figure 1: Conceptual understanding of NBS and involvement of stakeholders from co-definition, co-design to end-use of the NBS). Source: Ferreira et al. (2020)

The involvement of stakeholders in NBS^{WT} projects extends through various crucial stages, from co-definition and co-design to engaging end-users. In the co-definition phase, stakeholders collaborate to define the goals, objectives, and parameters of the NBS project, ensuring diverse perspectives are considered. The co-design process involves active participation from stakeholders in shaping the physical and functional aspects of the NBS, fostering a sense of ownership and alignment with community needs. As the project progresses, continuous engagement with end-users becomes paramount, ensuring their input is integrated for effective implementation and long-term success. This inclusive approach not only enhances the overall quality and relevance of NBS but also establishes a collaborative framework that strengthens community resilience and environmental sustainability.

Examples of inclusive governance in NBS projects applicable to enhance the social impact and inclusiveness of NBS^{WT}

For example, the city of Milan collaborated with private actors, including companies and citizens, in drafting a public bid to subsidize the construction of green roofs and green walls for both public and private entities. The initiative addressed identified barriers, such as additional costs and limited access to technical expertise. An innovative procedure was developed, involving the co-financing of 10 pilot projects, a preliminary feasibility check, and funded technical support for co-design and implementation of green roofs or walls. Additionally, selected applicants commit to a co-design process with building occupants, creating a 10-year maintenance plan, and supporting monitoring activities (Wilk et al., 2020).

In Hamburg, various locations along a green corridor are slated for enhancement with green features, involving diverse stakeholders depending on the specific intervention. These stakeholders will be strategically distributed spatially within the corridor. For instance, the initial area will undergo co-designing involving refugees and neighbors of refugee accommodations. The culturally adept individuals from the workshop 'Made in Suderelbe' will contribute to co-designing specific elements, such as the guiding system for Neugraben Fischbek. For the green roof and facades, and rainwater management, a range of actor groups from both the private and public sectors are participating, including a real estate company, Hamburg Wasser, the Ministry of Environment and Energy, and various departments of the district council. (Wilk et al., 2020)

City-wide inclusive sanitation (CWIS) programme (Odisha, India): The state government launched the programme in several cities in Odisha as one of the schemes to provide sustainable, inclusive, and equitable sanitation facilities to urban households and communities. The programme supports the capacity of women's self-help groups and the Slum Dwellers Association (SDA) to work at grassroots governance as service delivery partners. The sanitation infrastructure provided includes a decentralised greywater management system that incorporates constructed wetlands and lane level trench structures. The system is operated as part of the community partnership (Vathanan, 2023).

Sea Heroes Community Garden (The Hague, Netherlands): The local community collected 2500 signatures to build a 1700 m^2 green space and community gardens, which are now visited regularly by up to 300 citizens improving social cohesion. The project was financed by foundation Stichting De Versteking, different private funds, a bank, the municipality of the Hague, a healthcare facility, and citizens themselves (NATURVATION, 2017).

Vitoria-Gastez (Spain): The project used the Harava tool to support the inclusion of inhabitants of the city in question into shaping NBS and develop an urban management plan for the city. This was done through questionnaires covering a range of issues and such form of consultation (300 participants) provided about 2487 spatial elements in the city (van Ham and Klimmek, 2017).

Golden Hill Community Garden (Bristol, UK): This NBS, built in 2011 and opened in 2012, not only brought a community garden, accessible to wheelchair users, but reduces flood risks, increases biodiversity, has energy efficient buildings but also increased social inclusion and interaction. A project coordinator was contracted, but many volunteers were involved in the project – community Garden volunteers, allotment volunteers, but also Bristol Trust for Community Volunteers, which assisted in the design and creation of the garden.

Buurttuin Oost Indisch Groen (Amsterdam, Netherlands): This project was a citizen initiative on the edge of the Flevopark in Amsterdam. Its aim was to make an Indian neighbourhood of the city more sustainable and healthier, but also fun, through the engagement of the community. The community garden is the central NBS, which supports sustainable food production as crops are grown using organic agriculture and permaculture techniques. A community kitchen and an educational meeting place, which provides opportunities for citizens to realise their own sustainable and green solutions were built. The design, implementation, and maintenance of the garden, as well as all other activities related to Buurttuin Oost Indisch Groen, were organised by the local population. The initiative also organises educational tours and workshops, which were aimed at teaching children and adults about nature, healthy living, and sustainability. (Armstrong A., 2020)

2.5 Supplementary reports

Several reports already provide useful information for public and private actors seeking to implement NBS^{WT} projects. The following table presents a selection of these reports, particularly guides to building business cases for NBS, identifying suitable financing sources and solutions, and evaluating NBS investment cases.

Table 4: List of supplementary reports related to business models and financing for NBS^{WT}

Title and reference	Content	Target audience	Reference
Governance, business, and finance models	• Examines governance models, business models, and financing sources and solutions in relation to the project's NBS	Public officials including policy makers, city planners	(Wilk et al., 2020)

	• Provides 6 steps for cities to develop feasible NBS projects that provide long-term value		
Nature-Based Solutions Business Model Canvas Guidebook	• Introduces the Nature-Based Solutions Business Model Canvas tool adapted from Osterwalder's Business Model Canvas, guides city authorities to apply it to their case	Cities	(McQuaid, 2019)
Analysis of the business case for the application of the nature-based solutions	Provides a framework for NBS project proponents to: • Analyse potential co-benefits, stakeholder linkages, and economic efficiencies of NBS investment cases, and to • Develop a business case including ways to capture value and leverage investment	City planners and NBS researchers looking for NBS investors and financing	(Coles et al., 2019)
NBS Market Potential through Synergies at International Level: business plan case studies and scope for international mainstreaming	• Demonstrates how the benefits of NBS can be translated to a business case format • Aimed at actors interested in investing in, evaluating, designing and implementing NBS projects	Public officials including policy makers, city planners	(Coles and Tyllianakis, 2019)
Nature-Based Solutions Handbook	• Provides knowledge on NBS from project development to financing and policymaking, including lessons-learnt	All stakeholders who use NBS (specialized sectors for research, business, and policy)	(Somarakis et al., 2019)
Handbook for the implementation of Nature-based Solutions for Water Security: Guidelines for designing an implementation and financing arrangement	• Operational guide for the preparation of bankable NBS projects for public and private investors • Focused on NBS for water security	Public and private investors	(Altamirano et al., 2021)
International Good practices in financing and funding nature restoration	• Examples of successful mobilisation of funds for implementation • Examples of funding instruments and facilities	Public officials including policy makers, city planners	(Mayor et al., 2019)
Business Models and Financing Strategies	• Examples of business models for NBS • Potential financing strategies	City planners and policy makers	(Maciulyte, 2020)
NBS Value Model	• Associates NBS with selected beneficiaries, their individual benefits, and financing options	Project managers and decision makers in the field of NBS	(Mok et al., 2019)
Incorporating Multiple Benefits into Water Projects: A Guide for Water Managers	• Framework for water managers to compare water technologies and management options, to identify opportunities to share project costs among beneficiaries and public representatives, and discover design improvements	Water managers	(Diringer et al., 2020)
Integrating Green and Gray: Creating Next Generation Infrastructure	• Guidance on how to integrate green into conventional grey infrastructures, thereby reduce costs and provide more resilient services • Includes examples of how to integrate green and grey infrastructures in project appraisals and investments	Infrastructure service providers, public officials	(Browder et al., 2019)

3. BEST PRACTICE EXAMPLES

3.1 Reporting framework

The best practices span different types of NBS^{WT} relevant to urban water and wastewater management classified in the following five categories:

- NBS^{WT} for pollution and flood control, including sustainable drainage systems (SuDS) and systems for treatment of stormwater and combined sewer overflow (CSO)
- NBS^{WT} for treatment of water reservoirs
- Constructed wetlands for wastewater treatment
- Building-integrated NBS for wastewater and greywater treatment, i.e., innovative systems particularly suitable for dense urban areas

They are described following the Nature-Based Solutions Business Model Canvas (McQuaid, 2019), an adaptation from the general Business Model Canvas tool (Osterwalder et al., 2010) to cater to the specific requirements of business cases for NBS and the urban context.

The framework aims to characterise the following features of the selected best practices:

- **Key data and NBS/technical solution**
- **Key activities and resources** from planning, technical design, installation, to routine and specialised O&M
- **Value proposition**, including values captured in the business model as well as those that could be offered additionally to public, private, and/or citizen community actors:
  - Primary value: Main problem or purpose addressed by the NBS^{WT} project (primary value)
  - Additional values, or co-benefits
- **Main agent(s), key partners, and governance**: Actors involved and their roles in the phases of the NBS^{WT} projects from initiation to long-term O&M
- **Key beneficiaries:** Direct beneficiaries of primary value and co-benefits (equivalent to "customers" in the general Business Model Canvas), including those paying for the NBS^{WT} and thus for the service, as well as those not paying in the given case but may be willing to pay for generated value when aware and understanding their value (see Mayor et al., 2019)
- **Cost structure and cost reduction**
- **Value capture and long-term sources of financing:** Types and sources of funding and revenue streams
- **Main strengths and drawbacks** of each business model

3.2 NBS^{WT} for pollution and flood control

Table 5: Reed planted filter for treatment of rainwater and/or combined sewer overflow (CSO)

Key data	NBS/technical solution	Key activities and resources
Location: Marcy l'Etoile, Lyon, France **Design scale:** Municipality **Constructed:** February 2012 **Status:** Operational	Reed planted filter for rainwater treatment and/or sewer system. The system can treat combined water during wet seasons or heavy rainfalls. The design criteria is 1 year return period, which is 1160 m^3). After the water is treated and the maximum storage volume is achieved, the outflow of the filter goes towards the Yseron creek. This flow rate is 500L/s. The surface of the filter on its bottom is 526 m^2. The filter removes 90% of BOD and TSS, 65% of COD and 60% of NK.	• R&D, installation • Monitoring, O&M, specialized staff trainings
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: CSO treatment **Additional values:**	• Public sector: The Metropolis of Lyon (Control and operation department of water service) and Agence de l'eau pay for O&M	• The Metropolis of Lyon and the River Syndicate

	• Research organisations: INRAE in charge of technical work incl. O&M • Enterprises: INSAVALOR, SINT, and EPURNATURE • Engineering consulting: The industry located upstream	• Citizens and people living next to the river • Users/visitors of the river
Cost structure and cost reduction	Value capture and long-term sources of financing	Main strengths and drawbacks
Cost for design and installation: € 774,000	**Capital investment**: Public grant for research **Funding of O&M**: Metropolis of Lyon	**Strengths:** • High level of public acceptance

Table 6: Gorla Maggiore Water Park

Key data	NBS/technical solution	Key activities and resources
Location: Gorla Maggiore, Milan, Italy **Design scale:** Meso-scale: regional, metropolitan and urban level (project area 30000m^2 **Constructed:** 2008 **Status:** Operational	The water park consists of several constructed wetlands (CW) and SuDS situated along the Olona riverbank. It includes (i) a section for pollutant removal equipped with a grid, sedimentation tank, and four vertical sub-surface flow constructed wetlands; (ii) a versatile area featuring a surface flow constructed wetland or pond serving various functions; and (iii) a recreational park featuring revitalized riparian trees, expanses of green open space, and pathways for walking and cycling.	• Planning and installation (landscape architecture and educational design, engineering, construction) • Maintenance of green spaces and furniture • Monitoring and maintenance of NBS^{WT}
Value proposition	Main agents, key partners and governance	Key beneficiaries
Primary value: Flood protection (bioretention), pollution control (bioremediation, CSO treatment) **Additional values:** Recreational green space, biodiversity conservation, public engagement and education, health and wellbeing	• 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)	• Public sector institution (e.g. school or hospital) • NGOs, civil Society • Citizens or community groups • Youth and children
Cost structure and cost reduction	Value capture and long-term sources of financing	Main strengths and drawbacks
Cost for design and installation: € 500,000 - €2,000,000 **Cost reduction:** Reduced financial cost for urban management	**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	**Strengths:** • Multi-purpose NBS^{WT} • Citizen co-management

Table 7: Amsterdam Blue Green Roofs

Key data	NBS/technical solution	Key activities and resources
Location: Amsterdam, Netherlands **Design scale:** Buildings, neighborhoods **Constructed:** 2018 **Status:** Operational	10,000 m² of blue-green rooftops with smart sensors and valves and a crate system for enhanced water retention and storage	• Planning and installation • Maintenance of the roofs, plants, smart valves, etc. (high O&M efforts and specialized staff needed)
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary values: Water storage during peak events, urban heat island reduction, biodiversity increase	• Initiating organisation: City of Amsterdam • Hogeschool van Amsterdam and Vrije Universiteit - higher education and research, • Waternet - public water company, • MetroPolder Company, Consolidated - SMEs, • Stadgenoot, De Key, and De Alliantie - social housing companies • Rooftop Revolution – foundation • 1500 residents involved in co-creation	• Residents of Amsterdam
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: €6,000,000	**Capital investment**: Co-financed by the European Regional Development Fund (ERDF) via de Urban Innovative Actions initiative (UIA) – paid for 80% of costs. 20% of the investment were paid by all the partners. **Funding of O&M:** 5-year grant project, then housing corporations are responsible for their roofs	**Strengths:** • Multi-stakeholder collaboration among public, private, research, and community actors • 1500 residents involved in a co-creation approach • High public acceptance **Drawbacks:** • Replication without subsidy was considered uncertain

Table 8: Oasis schoolyards project

Key data	NBS/technical solution	Key activities and resources
Location: Paris, France **Design scale:** City, schoolyards amenities/ 25 schoolyards in Paris per year **Constructed:** 2018 **Status:** Operational	Rainwater recovery systems (by evapotranspiration), trees, school gardens (incl. vegetable gardens), green walls and roofs, fountains and others cooling techniques.	• Planning and installation • Maintenance of green spaces and furniture: City of Paris
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Improved stormwater management **Additional values:** Cool islands, associated health benefits, increased social cohesion in neighborhood	• City of Paris, architects and hydrologists NGOS, Students, educational community • A new governance and participative management of local public facilities is being developed (status 2021)	• School communities, and widely Parisians
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: not provided	**Capital investment**: Public allocated budget (City of Paris, French Rainwater Agency) and public grant (ERDF) **Funding of O&M**: City of Paris	**Drawbacks:** • Generally well accepted, but experienced some resistance due to novelty

Table 9: Grey into green ("Szare na Zielone") programme

Key data	NBS/technical solution	Key activities and resources
Location: Wroclaw, Poland **Design scale:** City **Constructed:** Since 2017, over 100 schools participated in the programme	Transforming grey, concrete areas near schools and kindergartens into green areas, friendly to the pupils. Among others: Removal of concrete, greenery (scientifically, carefully chosen species), rainforests, flower and vegetable gardens, natural green walls, composters, rainwater storage barrels and roofs for irrigation. (additional information taken from the website of Green Wroclaw (Zielony)/municipality of Wroclaw	• Planning and installation • Maintenance of green spaces: cooperation with schools (school facility managers), no specialization needed
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Stormwater management **Additional values:** Education, awareness for healthy food (human health benefits), recreational green space, biodiversity conservation, rainwater use for irrigation	• Wroclaw Municipality (Sustainable Development Department, Education Department), teachers, children, landscape architect	• School communities • Inhabitants of Wroclaw
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: around € 25,000 for each school garden **Cost for maintenance**: € 120,000 per year	**Capital investment**: Public allocated budget **Funding of O&M**: Schools	**Strengths:** • Additional use for educational purpose and participation of schools in watering the garden

Table 10: Tooley Street Vertical Rain Garden

Key data	NBS/technical solution	Key activities and resources
Location: London, UK **Design scale:** Building **Constructed:** 2016 **Status:** Operational	Green wall, modified to receive rainwater from downpipe, 10m long and 3 m high.	• Planning, engineering, and installation • O&M: Some landscaping (low efforts)
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Retention of rainwater/ flood attenuation **Additional values:** Provide habitat, foster biodiversity	• Led by Team London Bridge (Business Improvement District) • Conceived by Green Infrastructure Consultancy Ltd • Installed by Treebox • Funded by Drain London project (Greater London Authority) • O&M conducted by local public utility • Local residents and local authority consulted at design/planning stage • The local community has plans for further development of the location (gathering spot, outdoor activities; even swimming in some years to come - water quality to be verified)	• Local residents and visitors
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: App. 20,000 £	**Capital investment**: Public (Grant, within the framework of the sustainable urban drainage program "Drain London")	**Strengths:**

Cost reduction: Prevention of flood damages to the local urban environment	**Funding of O&M**: Local municipality	• Local public utility operates and maintains the decentralized and innovative NBS^{WT} unit • Savings due to the lack of need for a water and power supply, serves as a passive structure with no energy demand • Support and activation of the local community

3.3 Constructed wetlands for wastewater treatment

Table 11: Post-treatment wetland of Lamni wastewater treatment plant

Key data	NBS/technical solution	Key activities and resources
Location: Lamni, southern Finland **Design scale:** Region (former municipality) **Constructed:** 1960's **Status:** In operation except the months from May to September (growing algae biomass in CW)	Constructed wetland for the post-treatment (after conventional wastewater facility) of domestic wastewater of 4000 inhabitants.	• Planning and installation/construction • O&M: monitoring, rare troubleshooting/repairs
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Decrease the nutrient and pathogen load of the treated wastewater to the receiving lake	• Local wastewater treatment company (HS-Vesi) – O&M • Lammi Biological Station of the University of Helsinki (research institute) • City of Hämeenlinna (municipality)	• Users of the adjacent lake (beach residents, swimmers, boaters, fishermen, farmers, tourism companies etc.)
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
	Owned by the local wastewater treatment company (HS-Vesi) and financed by charging a wastewater fee from residents	

Table 12: City-wide inclusive sanitation (CWIS) with decentralized greywater management, constructed wetlands, and lane level trench structures

Key data	NBS/technical solution	Key activities and resources
Location: Odisha state, India **Design scale:** State-level program, city-level projects **Status:** Operational	The state government of Odisha is working to achieve sanitation delivery to cover the entire city area in all its cities, including formal and informal settlements, by securing tenure and implementing urban planning. Each city's CWIS strategy covers tap water supply, fecal sludge and septage management, greywater management (constructed wetlands and lane level trench structures, low-tech), decentralized solid waste management (nature-based, low-tech fecal sludge treatment plant (FSTP)), the delivery of cluster and individual household toilets, and resource recovery.	• Planning and construction of infrastructure • Establishment of multi-level governance and service provision system, incl. capacity building • Operation of low-tech, nature-based fecal sludge management system: community-led
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Increased access to improved WASH services	• Initiation: state government of Odisha • City-level implementation: cities • Engages women's self-help groups (SHG) and the Slum Dwellers Association (SDA) to	• Inhabitants, in particular marginalized communities

Additional values: Resource recovery ("waste to wealth" model), pollution control/enhanced water quality of rivers, human health, social cohesion and empowerment, recreational area at FSTP site	enable them to work as service delivery partners	
Cost structure and cost reduction	Value capture and long-term sources of financing	Main strengths and drawbacks
Cost reduction: Both CAPEX and OPEX reduced compared to previous solid waste management system	**Capital investment**: State and municipal governments **Funding of O&M**: Municipal governments, municipal corporations, waste to wealth model	**Strengths:** • Engages civil society organisations in the full water and wastewater chain • Supporting the inclusion of women, transgender people, the urban poor, waste pickers and manual cleaners, and covers all sectors contributing to the delivery of sanitation services, including those managing water, solid and liquid waste, and storm water • Low-tech and scalable waste to wealth model

3.4 Building-integrated NBS for wastewater and greywater treatment in dense urban areas

Table 13: vertECO® FELS 2 Zürich with on-site greywater treatment and reuse

Key data	NBS/technical solution	Key activities and resources
Location: Zürich, Switzerland **Design scale:** Multi-party residential building (12 apartments) **Constructed:** 2021 **Status:** Operational	Outdoor greywater treatment system (vertECO® aerated horizontal sub-surface constructed wetland) in multi-party resident building.	• Planning 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
Value proposition	Main agents, key partners and governance	Key beneficiaries
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	• Initiator: Real estate developer and architect • Local house technician: routine O&M • Service providers (alchemia-nova): specialized periodic maintenance and troubleshooting • ETH Zürich: periodical water quality control • Amt für Abfall, Wasser • Energie und Luft Zürich	• Residents • Architects • Service providers • ETH Zürich • City of Zürich
Cost structure and cost reduction	Value capture and long-term sources of financing	Main strengths and drawbacks
Cost for design and installation: € 20,000	**Capital investment**: Private equity (real estate developer) and loans **Funding of O&M**: Apartment owners **Revenue:** Sale and rent	**Drawbacks:** • Private demonstration project, high initial costs in startup phase and low profit but highly replicable

Table 14: Cambium vertECO® with on-site wastewater treatment and reuse

Key data	NBS/technical solution	Key activities and resources
Location: Fehring, Austria **Design scale:** Apartment building (50 persons) **Constructed:** 2022 **Status:** Operational	Indoor constructed wetland (vertECO® system in greenhouse heated with compost heating system), treatment of the liquid fraction of the household wastewater, reuse of fertigation water for irrigation of agriculture nursery	• Co-design with local inhabitants • Engineering and installation • Routine O&M (checks of functioning, plants, water quality) • Specialized maintenance and troubleshooting • Annual deconstruction and set-up of compost heater (Biomeiler) • Water quality monitoring
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Decentralized water cycle (water reuse), nutrient recovery **Additional values:** Demonstration of innovative, sustainable system, educational value	• Co-creation processes with building owners and inhabitants • Municipal authority: permit • Development/planning: alchemia-nova • Suppliers: e.g., plant suppliers, metal framing, substrate etc. • Implementation: plumber, electrician, construction company • O&M: alchemia-nova with support of inhabitants	• Inhabitants • Municipality
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation of WW treatment system: € 50,000 **Cost reduction:** irrigation and water and fertilizer savings	**Capital investment**: Horizon 2020 grant, co-financing (25%) by building owner association **Funding of O&M**: Building owner association	**Strengths:** • Citizen co-management • High level of acceptance due to intensive co-design and co-creation

Table 15: Phytoair, Kristus Koning

Key data	NBS/technical solution	Key activities and resources
Location: Brecht, Belgium **Design scale:** Parking lot, treatment of wastewater from 48 PE **Constructed:** 2020 **Status:** Operational	Aerated hybrid wetland of 40m² on which permeable paving with grass troughs has been placed. Placement of the pumping station and the septic tank under the parking lot. The 40m² of permeable paving refer to 4 of the total 18 parking spaces.	• Planning and installation • Routine O&M: Regular mowing of grass • Periodic specialized maintenance: Changing membranes of blowers, periodic check of pumps, drainage pipe, and septic tank, flushing of irrigation pipes
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Decentralized (on-site) wastewater treatment, not connected to the sewer system **Additional values:** Multifunctional use of space, innovative value, green (vegetated) parking lot	• Rietland (design, construction, maintenance) • Cofrax (construction) • School Kristus Koning (client), local • Local authorities (permits)	• School Kristus Koning, as a client
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: € 35,000	**Capital investment**: Semi-public and private school with equity (Kristus Koning is a public-private school. It is partly financed by the	**Strengths:** • Zero land opportunity costs, as surface area is used multifunctionally as

O&M costs: electricity € 230, maintenance € 350 **Cost reduction:** Zero land opportunity costs	government, the diocese and donations from sympathizers, former students.) **Funding of O&M**: School	parking lot and wastewater treatment plant

3.5 NBS^{WT} for treatment of water reservoirs

Table 16: Pond Kamešnica

Key data	NBS/technical solution	Key activities and resources
Location: Kamešnica, Slovenia **Design scale:** Local pond **Constructed:** 2021 **Status:** Operational	The local pond was affected by eutrophication and unsuitable for any activities. Several NBS measures were implemented to improve the water quality, avoid future eutrophication occurrence. These include a wetland, floating green islands, green embankment.	• Planning, landscape design and engineering • Local community involvement • Construction • Maintenance of green spaces: some landscaping activities
Value proposition	**Main agents, key partners and governance**	**Key beneficiaries**
Primary value: Habitat for biodiversity, recreational space **Additional values:** Potential source of irrigation water	• Local municipality for maintenance (local public utility) • CLLD community for initiation • Limnos (SME) for design • Local contractor for earthworks and a social enterprise for elaboration and installation of islands and embankments • Local community was involved, incl. fishermen	• Local inhabitants, farmers (if they choose to use water for irrigation), local fishing community
Cost structure and cost reduction	**Value capture and long-term sources of financing**	**Main strengths and drawbacks**
Cost for design and installation: appr. € 22,000 **Maintenance cost:** < € 1,000 per year	**Capital investment**: Public grant (CLLD) **Funding of O&M**: Local municipality	**Strengths:** • Robust, low-maintenance system

4. CONCLUSION

In the pursuit of developing NBS^{WT} in urban areas, both cities and private actors face the challenge of navigating a complex landscape marked by the multifaceted impacts of climate change. Recognizing the potential long-term benefits, this report integrates insights from existing good practices, offering a guide for stakeholders. Reviewing the business model components of successful cases provides an understanding of the potential multiple sources of funding that could be acquired to develop NBS^{WT}, the ways in which stakeholders can be engaged, and how O&M could be organized in the long term.

The multifaceted nature of NBS^{WT}, addressing water resources management and wastewater treatment, contributes to wider environmental, social, and economic values. Despite uncertainties related to stakeholder roles and responsibilities in financing and O&M, the report underscores the opportunities that arise from these multiple values to form collaborative business cases, attracting investment from diverse funding sources and across sectors.

The main challenge pertains to the lack of designated budget for the O&M of NBS^{WT}. Further, often specific knowledge and skills are required for the proper O&M, which must be inferred to entities in charge, and transferred upon changes of responsible actors or staff. In some cases, the municipality or NBS^{WT} owner manages O&M directly. In other cases, users, and beneficiaries, such as residents, utilities, or businesses, have been engaged to conduct O&M tasks.

Various financing mechanisms, rooted in both private sector interest and public actors' motivations, exist to support the implementation and O&M of NBS^{WT} projects. Innovative solutions such as multi-sector partnerships based on multifunctional urban blue-green infrastructures, Business Improvement Districts (BID), endowments, public-private partnerships institutionalizing community organizations in their governance structure, and community asset transfer offer approaches to ensure continuous financing for O&M costs.

The report emphasizes the importance of stakeholder engagement as a cornerstone for gaining financing sources, decentralizing financing, and building NBS^{WT} for the long term. It recognizes the critical role of community driven NBS^{WT} projects to build a sense of ownership and responsibility, and to ensure public acceptance of NBS^{WT}. It also highlights the necessity of inclusivity to generate social co-benefits and eliminate potential trade-offs. By examining and presenting selected NBS^{WT} cases, the report aims to equip professionals, policymakers, investors, and researchers with actionable insights to effectively implement, fund, and sustain NBS^{WT} projects, fostering resilient and sustainable urban water management practices.

PARTNERS INVOLVED IN THE WORK

alchemia-nova led the development of this deliverable, conducted a survey of literature and collected good practices. Forum FER collected successful cases managed by local communities and their acceptance of NBS. Several consortium partners (ICRA, IRIDRA, GLYON, and RIETLAND) contributed information about selected NBS^{WT} projects.

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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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