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Strategy for Nature-Based Water-Oriented Livings Labs

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Table of acronyms

LL	Living Lab
WoLL	Water-oriented Living Lab
NBS	Nature-based Solution
NB-WoLL	Nature-based Water-oriented Living Lab

Executive Summary

This document is divided into two parts:

- Part I aims to provide an overview of the concept of Living Labs (LL) and the previous Interreg projects that have developed living labs in the water sector and contributed to the development of this document. It also includes an assessment of a data base of Water-oriented Living Labs (WoLL) developed by Water Europe, with the goal of understanding the main characteristics of existing living labs.
- Part II is the *Strategy for Nature-Based Water-oriented Living Labs* (NB-WoLL), which results from the inputs of previous projects as well as the learning obtained from the workshops developed under SOLLAGUA. The analysis performed in Part I set the tone to develop the strategy, so that it would be tailored to the main types of stakeholders that will implement nature-based water-oriented living labs

Part I therefore contains background information relevant to understand the principles that guided the development of the strategy but is not strictly needed for its implementation.

Part II will be published also as a stand-alone document (PDF), to be provided to the stakeholders that wish to implement a nature-based water-oriented living lab.

PART I

1 Introduction

Water scarcity remains an escalating global concern. As of 2022, nearly half of the world's population experienced severe water scarcity for at least part of the year, while one-quarter faced conditions of extreme water stress (United Nations, 2025). These statistics highlight the urgent need for sustainable and integrated water management strategies to ensure long-term water security and resilience.

Climate change, described by UN-Water (2025) as "primarily a water crisis", further exacerbates water scarcity. Altered precipitation patterns, increased evapotranspiration, and the growing frequency of extreme weather events are collectively reducing the reliability and availability of water resources. This poses significant challenges to meet the increasing demands of agricultural, industrial, domestic, and recreational sectors.

In response, the identification and implementation of alternative water sources have become increasingly important. Among these, the treatment and reuse of wastewater for non-potable applications has emerged as a viable and sustainable strategy, offering both resource recovery and demand reduction benefits within the water cycle.

Nature-Based Solutions (NBS) are defined as "living solutions inspired by, continuously supported by, and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner, while simultaneously delivering environmental, social, and economic benefits" (European Commission, 2015). By simulating natural hydrological and ecological processes, particularly through systems where vegetation plays a central role, NBS offer a multifunctional approach to water management. They have been increasingly recognized for their potential in addressing water-related challenges, notably in decentralized wastewater treatment and the recovery of alternative water sources.

1.1 Overview of the project SOLLAGUA

SOLLAGUA is a project co-funded by Interreg Sudoe, specifically designed to address these challenges by promoting NBS for water reuse in the Sudoe region. Adopting a bottom-up approach, the project focuses on identifying the specific needs of rural communities and developing tailored solutions to ensure sustainable water management.

The aim is to provide an alternative and more resilient water supply, while offering co-benefits such

as mitigation and adaptation to climate change. The project aims to revolutionize current practices, encouraging the adoption of green/innovative technologies in public tenders. These changes promote a circular economy based on the reuse of local wastewater, while providing a new source of water and an alternative to 'end of pipe' installations. This transition is suitable for rural areas that are generally less populated, with a more moderate economy than urban areas.

The project's key achievements include strengthening the capacity of nature-based solutions for the reuse of domestic wastewater and the establishment of three demonstration sites in Portugal, Spain, and France. These demonstration sites will be implemented through a new **Nature-Based Water-oriented Living Lab (NB-WoLL) strategy**. The development and deployment of this strategy constitute the central focus of the present document.

1.1.1 Objectives and scope

This document outlines a strategy for the implementation of living labs (LL) focused on promoting NBS for water reuse in rural areas. The strategy provides a flexible framework that can be applied to establish new NB-WoLL or to support the development of existing ones at any stage of maturity. It ensures that all activities and outcomes are aligned with the European Union's legal framework on water reuse, as well as with relevant national regulations.

The proposed strategy builds upon methodologies developed in other Interreg Sudoe projects, particularly TWIST and Tr@nsnet. The TWIST water-oriented living lab model will be specifically adapted to address the challenges of water reuse in rural contexts. In parallel, tools from the Tr@nsnet project will be used to strengthen governance structures and refine value propositions, both within the living labs and in the implementation of validated NBS through participatory co-creation processes.

1.2 Previous projects on water-oriented living labs

Interreg Sudoe (2014-2020) is a European Union funding program that promotes regional cooperation among the regions of Southwestern Europe. Its goal is to tackle common challenges such as climate change adaptation, social cohesion, and territorial balance through collaborative projects involving public and private entities from participating countries.

The Interreg Sudoe program funded TWIST project (2018-2021), which developed a model for organization and transnational/transregional collaboration to create, test, evaluate, and launch

innovative technologies and products in the water sector. A methodology for the creation, implementation and management of WoLL was created, which addressed the main components of a living lab, the process of creation, the incorporation of stakeholders, funding, management and a methodology for WoLL activities.

Under TWIST, the implementation of this methodology led to the creation of three living labs, each addressing a specific topic in the water sector:

- In Spain: the **Open Water Living Lab (OWL2)**, promoted by CENTA Foundation and located in its experimental facilities in Carrión de los Céspedes, Sevilla. OWL2 is focused on wastewater treatment and water reuse.
- In Portugal: the **Urban Lisbon Living Lab (UL3)**, promoted by the Instituto Superior Técnico (IST), Instituto Superior de Agronomia (ISA) and Águas do Tejo Atlântico, S.A. (AdTA), focused on wastewater treatment for reuse and resource recovery (water, nutrients and energy).
- In France: the **LaViso Living Lab**, which is promoted by the International Office of Water (OIEau), the Institute for Techniques of Separation and Filtration (IFTS) and the University of Limoges. LaViso is focused on wastewater treatment and the associated water infrastructure management.

The experience gained with these three living labs is now being extended to SOLLAGUA to develop the *Strategy for Nature-Based Water-oriented Living Labs* and use this framework to strengthen stakeholder connections in rural areas to address water scarcity issues.

The Tr@nsnet project (2020-2023) was also funded under the Interreg Sudoe program, and developed a university living lab model for the ecological transition on campus. The results of Tr@nsnet will complement the development of the NB-WoLL strategy in SOLLAGUA.

The Tr@nsnet project proposed a university-centered living lab model to drive the ecological transition through collaborative innovation. Building on the 4-helix approach, linking academia, industry, public authorities, and civil society, the model integrates a coherent set of tools designed to strengthen living labs as platforms for sustainable transformation on university campuses and their surrounding territories. At the core of this model lies a suite of five complementary tools:

1. **Governance Model** to ensure clear stakeholder commitment.
2. **CoLabs or "Lab of Labs" Model** to structure LL as territorial networks centered on universities.
3. **Impact Methodology** to enhance the social, environmental, and market effects of validated

initiatives.

4. **Cross-ecosystem Methodology** to test innovations across different national contexts.
5. **Regulatory Sandbox** to address legal and policy barriers that limit innovation deployment.

Together, these tools form an integrated framework that combines governance, cooperation, impact assessment, cross-ecosystem validation, and regulatory experimentation. This system strengthens coordination among stakeholders, accelerates the transfer of innovative solutions, and bridges the gap between technological development, social needs, and policy adaptation. By doing so, it helps overcome common barriers such as fragmented governance, slow regulatory evolution, and the difficulty of scaling sustainable innovations. The model also reinforces universities' role as central actors in regional transformation, promoting replication, technological demonstrators, and cross-sectoral collaboration in support of sustainable development.

Through its methodological and organizational innovations, Tr@nsnet directly contributes to SOLLAGUA by enriching the NB-WoLL Strategy. Its tools and lessons provide a robust foundation for developing water-oriented living labs that integrate ecological, social, and economic dimensions. In this sense, Tr@nsnet's legacy underpins SOLLAGUA's mission to foster interconnected, sustainable innovation ecosystems across the Atlantic and Mediterranean regions.

2 Water-oriented living labs

2.1 Ecological transition and innovation

The ecological transition requires profound systemic changes across sectors and societies to address climate change, resource depletion and selective development. **Innovation** plays a central role in driving this transition by enabling the development and implementation of new technologies, practices, and governance models that support sustainability goals. Within this context, open innovation, characterized by collaborative processes that transcend traditional organizational boundaries, is increasingly recognized as a critical enabler of transformative change.

The European Green Deal, the EU's flagship strategy for achieving climate neutrality by 2050, underscores the need for inclusive, innovation-driven approaches to meet environmental, social, and economic objectives. It calls for new ways of producing, consuming, and governing that are not only technologically sound but also socially equitable and locally embedded. Open innovation frameworks, such as living labs, align strongly with this vision by fostering co-creation among diverse stakeholders, including public authorities, academia, industry, and civil society.

Living labs contribute to sustainability transitions by serving as real-world experimental spaces where systemic innovations can be co-designed, tested, and scaled in a participatory and context-sensitive manner. Their user-centered and place-based approach allows for the integration of local knowledge, stakeholder needs, and scientific expertise to develop solutions that are both effective and accepted by communities. By enabling iterative learning and adaptive governance, living labs help reduce the risks of innovation, accelerate adoption, and build social legitimacy around sustainability initiatives.

Moreover, living labs contribute to capacity-building and empower local actors to take ownership of the ecological transition. Their transdisciplinary nature allows for the alignment of environmental, economic, and social goals, making them valuable instruments for implementing the European Green Deal at regional and local levels. Through these contributions, living labs not only support innovation but also help shape the systemic transformations required for a sustainable future.

2.2 What are living labs?

The concept of living labs was pioneered by Professor William Mitchell at the Massachusetts Institute

of Technology (MIT), who initiated early research on everyday behaviors in controlled, home-like environments such as PlaceLab. This initial focus gradually expanded beyond domestic settings to encompass urban environments, where Mitchell's team explored the integration of emerging technologies, including electric vehicles, into city life. This transition marked a critical evolution from small-scale observational studies to large-scale urban experimentation, forming the conceptual basis for broader living lab frameworks (Leminin et al., 2019).

By the early 2000s, MIT's work had a significant influence on the development of living labs in Europe, particularly through collaborations with industry leaders like Nokia. This partnership led to the launch of NokiaSpacelab in Finland in 2001, which adopted a model of open innovation and real-world testing to drive technology co-creation. The European Union subsequently played a pivotal role in scaling these efforts, funding a range of cross-border living lab projects aimed at enhancing user-centered innovation (Leminin et al., 2019).

These developments culminated in the establishment of national networks and, eventually, the formation of the European Network of Living Labs (ENoLL) in 2006. Today, ENoLL includes 162 active members across 37 countries, operating in 12 sectors and 24 thematic areas, making it one of the most extensive collaborative platforms for innovation in real-life environments.

Nowadays, living labs can be described as innovation ecosystems that foster collaboration among multiple stakeholders to develop and test solutions in real-world settings. According to ENoLL they are characterized by (Schuurman et al., 2025):

1. **Active User Involvement**: End-users and stakeholders participate throughout the innovation process, ensuring solutions meet real needs.
2. **Multi-Stakeholder Participation**: Following the 4-helix model to create well-rounded, inclusive innovations.
3. **Orchestration**: Acting as facilitators, living labs coordinate stakeholders and manage the innovation process to align efforts with shared goals.
4. **Co-Creation:** Engaging all relevant actors in the design and development process, blending bottom-up (community-driven) and top-down (strategic) approaches.
5. **Real-Life Setting**: Operating in everyday environments rather than controlled labs, ensuring practical, applicable, and scalable solutions.
6. **Multi-Method Approach**: Using a diverse set of problem-driven methods tailored to specific challenges and stakeholders involved.

The 4-helix model is a foundational framework in living labs that brings together four key stakeholder groups – academia, industry, public authorities and civil society – to collaboratively drive innovation in real-world settings. Its strength lies in promoting co-creation, knowledge exchange, and context-sensitive solutions by involving actors with complementary perspectives and capabilities. The four stakeholder groups have the following roles:

1. **Public authorities:** (e.g. regulators, licensing bodies and local and regional administrations) - create enabling policies, provide funding, ensure regulatory compliance and supports scalability
2. **Academia:** supports research, from early Technology Readiness Levels (TRL) to later stages of product development, ensuring the scientific accuracy of the processes being developed. It can also provide research insights, develop methodologies and evaluate impacts to support evidence-based decision-making.
3. **Industry**: private companies developing their products and services, which aim to boost their activities through capitalizing synergies between the different stakeholders needs. They bring investment, identify market opportunities and ensure feasibility and scalability.
4. **Civil society:** Identifies local needs, tests solutions in daily life, promotes social innovation, builds community support

Although the living lab concept usually refers to an organization that innovates according to the 4-helix model, it can also be applied to lower-level applications. A three-level application can be associated with living labs that helps structure their activities and clarify their role in innovation ecosystems:

- **Macro level (living lab organization):** This represents the overarching LL ecosystem, a stable, long-term collaboration among stakeholders (e.g., public-private partnerships). It fosters open innovation and knowledge exchange across organizations.
- **Meso level (living lab projects):** Encompasses specific innovation projects within the LL organization, aiming to develop solutions and generate new knowledge.
- **Micro level (living lab activities and methods):** Focuses on hands-on research, real-life experimentation, and active user involvement through diverse methodologies such as workshops, experiments, and focus groups.

2.3 Living lab methodology: open innovation process

The living lab methodology is based on an open innovation process, where multiple stakeholders (civil society, academia, public authorities, and industry) collaborate to co-create, test, and refine innovative solutions in real-life contexts. This approach shifts innovation from closed, laboratory-based environments to open, user-centered ecosystems that promote continuous learning, adaptation, and scaling. The process unfolds in three interconnected phases: exploration, experimentation, and evaluation.

Exploration

This first phase focuses on understanding the context, identifying challenges, and engaging key actors. It involves mapping needs and opportunities, gathering insights from end-users and stakeholders, and defining a shared vision for innovation. The outcome is a well-defined problem statement and a collaborative framework that ensures all voices contribute to shaping the innovation agenda. Exploration sets the foundation for co-creation by aligning objectives and resources.

Experimentation

In this phase, ideas and solutions are co-designed, prototyped, and tested within real-life environments such as campuses, communities, or territories. The experimentation process is iterative, allowing continuous feedback and adjustment from users and partners. Living labs act as open platforms where technologies, services, and practices are validated under real conditions, promoting collective learning and ensuring that solutions are both technically feasible and socially accepted.

Evaluation

The final phase assesses the outcomes and impacts of the tested solutions. Evaluation goes beyond technical performance to include environmental, social, and economic dimensions, ensuring that innovations contribute to sustainability and systemic transformation. It also examines the scalability and replicability of the solutions, identifying lessons learned and improvements for future iterations. This phase closes the feedback loop, providing evidence for policy recommendations, new research directions, and wider market uptake.

Overall, the open innovation process in living labs is dynamic and cyclical. Insights from the evaluation phase often feed back into new rounds of exploration and experimentation, fostering continuous

innovation and long-term stakeholder engagement toward the ecological and societal transitions.

2.4 Atlas of the EU Water-oriented Living Labs

The *Atlas of the EU Water-oriented Living Labs* is an initiative by Water Europe aimed at mapping and consolidating WoLL across the European Union. The atlas was analyzed to gain a clearer understanding of our target audience, enabling the development of a strategy that supports the establishment and consolidation of WoLL. After analysis of the 84 living labs described in the atlas, the information was condensed into a matrix and classified them based on the following key characteristics:

- **Maturity Levels** – Categorized into four stages:
  - Level 1: Preparation – Stakeholder engagement, vision building, and initial community formation.
  - Level 2: Limited Experimentation – Prototype development, early testing, and user feedback integration.
  - Level 3: Extensive Field Experimentation – Full-scale implementation, validation, and tool integration.
  - Level 4: User-Led Co-Creation – Sustainable business models, long-term collaboration, and service provision.
- **Geographical Scope** – Varying from cross-territory and regional levels to city-based and rural initiatives.
- **Networked Value Creation** – Ecosystem-based mission-driven labs focused on co-creation versus project-based labs primarily engaged in testing and validation.
- **Market Position & Initiative Drivers** – who drives the initiative? Solution Providers-Driven (private sector-driven), Public Authority-Driven (policy and governance-driven), Public-Private Partnership-Driven (collaborative innovation), and Citizens-Driven (grassroots-driven problem-solving).
- **Organizational Coordinators & Stakeholders** – Categorized into academia, industry, public authorities and civil society.

Findings revealed that most of the WoLL are subregional and city-scale, reinforcing their role in addressing localized water challenges (Figure 1). In terms of maturity, most of the living labs were at Level 3, focusing on extensive field experimentation, with an overall average maturity level of 2.4 (Figure 2).

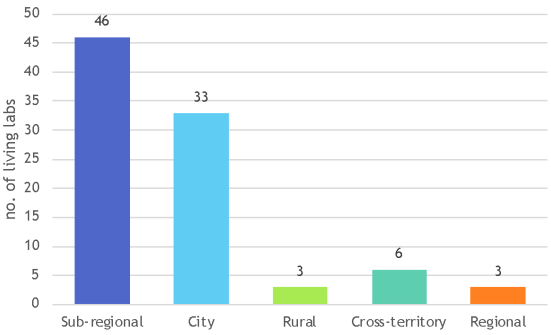

Figure 1. Geographical scale of the WoLL analysed.

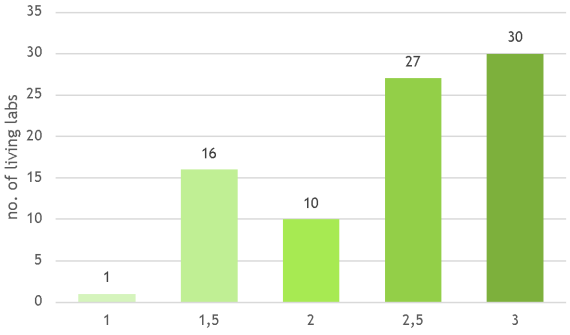

Figure 2. Maturity level of the WoLL analysed.

A dominant trend in governance emerged, as public-private partnerships (PPP) were the leading initiative drivers, accounting for 65 out of 84 WoLL (Figure 3). This highlights the importance of collaboration between public and private sectors in advancing water-related innovation. PPP-driven living labs are initiated by public and/or private organizations, either as short-term project-based efforts or long-term transformative initiatives, to co-develop new products, services, and solutions by leveraging their combined networks, portfolios, and assets. These labs focus on enhancing operational development through the exchange and generation of knowledge, with information collected for immediate or future use.

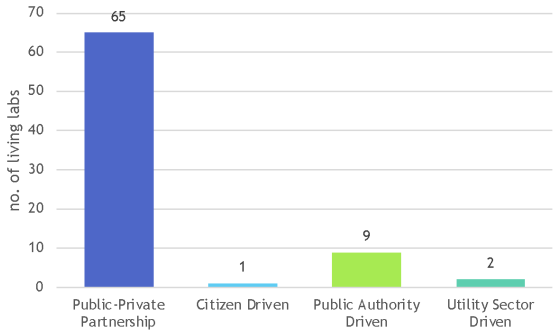

Figure 3. Market positioning of the WoLL analysed.

It is worth noting that, while all WoLL were mission-oriented, aiming to generate broad-scale impact, some started as individual project-based initiatives, focusing on specific innovations and test-bed applications.

The most common combination of stakeholder involvement is a collaboration between academia, public authorities, and industry, with 41 WoLL following this model. Furthermore, 11 living labs embraced the full 4-helix approach, integrating academia, industry, public authorities and civil society.

Civil society is the least commonly involved stakeholders, highlighting persistent barriers to their inclusion, despite their crucial role in user-centered innovation (Figure 4).

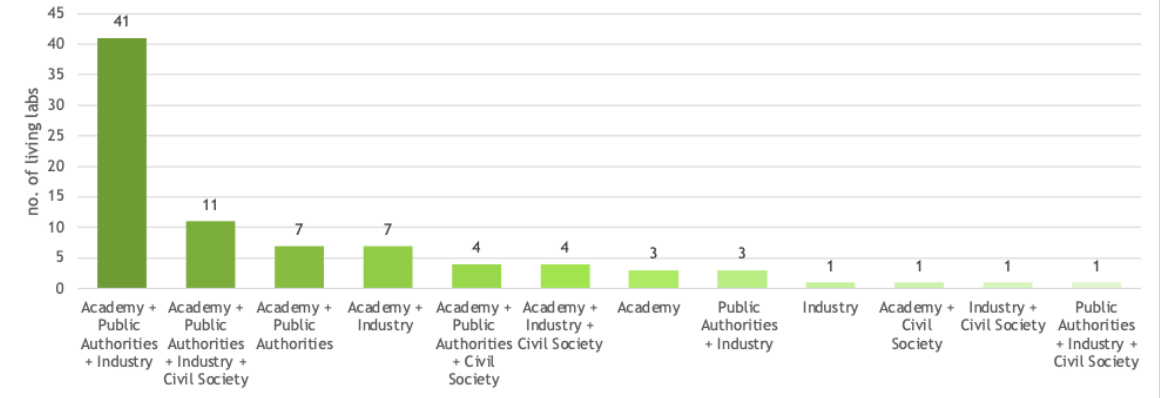

Figure 4. Stakeholder involvement in the WoLL analysed.

Academia is the most frequent coordinator, leading 41 WoLL followed by public authorities (15), industry (10), and civil society (5). Very few living labs had more than one coordinator (Figure 5). While it is expected that academia often initiates projects, given its close alignment with research funding mechanisms, it is essential to ensure knowledge and responsibility transfer to promote the long-term sustainability and functionality of these initiatives.

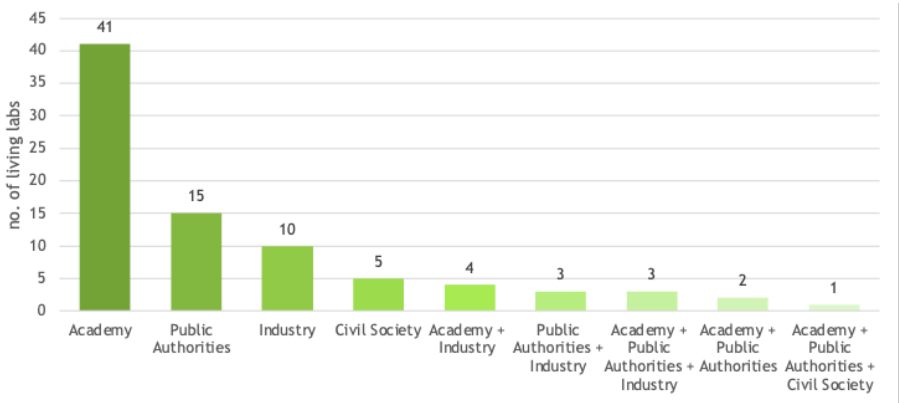

Figure 5. Organizational coordinator involvement in the WoLL analysed.

Based on these findings, the strategy will be designed to support NB-WoLL at varying stages of maturity, including those that are yet to be launched. Emphasizing diverse coordination beyond academia, the strategy will be written in clear, accessible language to ensure that it can be understood and implemented by a wide range of stakeholders.

The strategy will focus on strengthening stakeholder engagement methods, promoting inclusive and participatory approaches that ensure farmers, local authorities, researchers, and community organizations are equally involved in co-creation, decision-making, and evaluation. Special attention will be given to capacity building and communication tools that empower local actors to take ownership of NBS initiatives for wastewater treatment and reuse.

Furthermore, the strategy will propose mechanisms to transform short-term pilot projects into long-term, self-sustaining initiatives, integrating financial, institutional, and social sustainability measures. This includes fostering partnerships with public and private entities, identifying funding opportunities, and embedding NB-WoLL activities within existing regional and agricultural policies.

Ultimately, the strategy aims to create a lasting framework for collaboration, knowledge exchange, and innovation in water reuse, ensuring that NB-WoLL become resilient platforms for continuous learning and real-world impact.

PART II

3 Strategy for nature-based water-oriented living labs

3.1 Governance model

A governance model is a framework that outlines an organization's general leadership accountabilities and describes how leaders and members interact with other parties.

The governance model of a Nature-Based Water-oriented Living Lab (NB-WoLL) is designed to facilitate open, collaborative, and iterative innovation among diverse stakeholders. It provides a structured yet adaptable framework that ensures all participants contribute meaningfully toward the co-creation and implementation of a NB-WoLL for sustainable water reuse solutions.

3.1.1 Living lab coordinator(s)

The initial set-up of a living lab is typically led by a coordinator or a small group of coordinators. While academic institutions have taken the lead in most Water-oriented Living Labs (WoLL) in Europe (see Chapter 2.4), any actor within the 4-helix model (academia, industry, public authorities and civil society) can assume this role.

A living lab often begins with a small group of motivated individuals or organizations who identify a shared problem or opportunity. As the lab grows and more stakeholders become involved, coordination may shift to those more directly connected to the specific issue or context. This flexible approach allows the living lab to remain relevant, dynamic, and responsive to evolving needs.

The coordinator should be someone genuinely committed to the lab's focus and actively engaged in bringing stakeholders together. Strong communication and facilitation skills are essential to building trust, encouraging collaboration, and ensuring broad and meaningful participation throughout the process.

3.1.2 Defining the mission

Once the coordination team is in place, the next essential step in establishing a living lab is to define its mission. For a nature-based water-oriented living lab, the overarching mission is the co-creation,

implementation, and validation of Nature-Based Solutions (NBS) for water reuse in real-life settings. This is guided by a fit-for-purpose approach tailored to address water scarcity challenges, particularly in rural and peri-urban contexts.

This mission is achieved through the development of practical, scalable models for circular water use across various sectors, with NBS serving as the key enabler to connect water sources with appropriate uses. A fundamental part of this process is identifying local water needs, both in terms of quantity and quality, and adjusting the treatment and reuse strategies accordingly. Water should be treated to match its intended use, optimizing resource efficiency and ensuring environmental and public health protection.

Within each NB-WoLL a more specific mission can be defined, to adjust the living lab goals and objectives to the context and geographical location where its activities are developed. The main benefits of this approach include:

- Enhanced water resilience and sustainability
- Protection and restoration of ecosystems
- Improved climate adaptation capacity
- Stakeholder empowerment through inclusive and participatory processes
- Efficient water reuse based on tailored treatment aligned with actual demand

3.1.3 Stakeholders' identification

The success of the NB-WoLL depends on the active involvement of a diverse set of stakeholders, each bringing unique expertise, needs, and perspectives. Key stakeholders typically include:

- Local authorities and water utilities (infrastructure owners and regulators)
- Farmers and rural community members (end-users and beneficiaries)
- Research institutions and technical experts (knowledge providers)
- Non-governmental organizations (facilitators of social inclusion and advocacy)
- Private sector actors (technology providers, SMEs)

Understanding who your stakeholders are and how to effectively engage them is crucial for the success of any research project. The stakeholder identification can be developed using a three-step approach, adapted from *Biodiversa's Stakeholder Engagement Handbook* (2023).

STAGE 1: Identify all potential stakeholders and stakeholder groups

The initial phase focuses on mapping all actors connected to or affected by water reuse for agriculture, including those capable of influencing its implementation. An inclusive approach is essential, recognizing both the potential contributions of stakeholders and the incentives that may drive their participation.

Stakeholder identification may draw on several complementary methods:

- Collaboration with agricultural organizations and municipalities active in related initiatives;
- Consultation with experts and professional networks;
- Review of secondary data sources such as government statistics, historical records, and media reports;
- The use of participatory mechanisms such as self-selection, snowball sampling (when one stakeholder identifies others), and existing institutional lists or advisory forums.

Organizing the collected information in a structured table facilitates classification by sector, expertise, or level of influence, enabling a clearer understanding of how each group contributes to and benefits from the initiative. The mapping process should be iterative, revisited throughout the project to capture emerging actors and shifting priorities. Including diverse perspectives, including those expressing reservations or opposition, supports transparency and helps anticipate potential sources of conflict while strengthening the legitimacy of the engagement process.

STAGE 2: Assess and prioritize the stakeholders

Following identification, the subsequent phase involves analyzing stakeholders to determine suitable modes and intensities of engagement. Stakeholders can be categorized according to their level of interest and influence in water reuse for agriculture. This categorization supports the design of tailored engagement strategies, ranging from close collaboration and active involvement to periodic consultation or simple information sharing.

Engagement should remain differentiated and adaptive, recognizing that not all stakeholders require the same degree or timing of participation. The relevance and influence of specific actors may vary across research stages or project activities. For example, the timing of water reuse experiments must align with the crop calendar, meaning that farmers are uniquely positioned to determine when field trials can take place. Their decisions are guided by planting, irrigation, and harvesting schedules, as well as soil and climatic conditions that influence the feasibility and impact of water reuse applications.

Through strategic prioritization, attention is directed toward those stakeholders whose knowledge, resources, or position are most critical to achieving project objectives or who may be most affected by its outcomes. This analytical approach ensures that engagement efforts are both efficient and aligned with the evolving dynamics of the initiative.

STAGE 3: Develop an understanding of your stakeholders

Building meaningful engagement around water reuse for agriculture requires moving beyond identification and prioritization toward a deeper understanding of stakeholders, their motivations, relationships, and perspectives. This stage aims to develop a nuanced stakeholder profile that informs collaboration and communication throughout the project.

- Gather insights: A comprehensive understanding of stakeholders involves examining their networks and interactions, their level of knowledge regarding water reuse practices, attitudes toward research and innovation, and their willingness and capacity to engage. Mapping connections among key actors, such as farmers, water authorities, research institutions, and community organizations, helps to identify synergies, collaboration opportunities, and potential areas of conflict. This diagnostic process should also include an assessment of how each stakeholder group perceives and values NBS, distinguishing advocates, neutral participants, and potential skeptics.

- Identify key actors: Within each stakeholder group, it is important to identify one or more individuals who demonstrate both strong interest in the project and a solid understanding of NBS. These individuals can serve as reference actors or liaison figures, helping to guide activities, facilitate communication within their networks, and sustain engagement over time. Their involvement ensures that stakeholder perspectives are effectively represented and that knowledge exchange flows smoothly between the project team and the broader community.

- **Communication strategies:** Effective engagement depends on communication approaches tailored to the needs, capacities, and expectations of each stakeholder group. Technical actors, such as researchers and engineers, may benefit from targeted policy briefs, data-driven discussions, or thematic workshops, whereas farmers and local practitioners may respond more positively to participatory field demonstrations, storytelling, and peer-to-peer exchanges. Adapting language, format, and frequency of communication fosters trust, transparency, and shared ownership of project outcomes.

Through these combined efforts, gathering insights, identifying key actors, and developing targeted communication strategies, stakeholder understanding becomes a strategic foundation for successful co-creation and long-term collaboration in sustainable water reuse for agriculture.

3.1.4 Co-creation and decision making

Decision-making within the NB-WoLL on water reuse for agriculture follows a participatory and consensus-based model grounded in transparency, inclusivity, and shared responsibility. While the consultation process invites broad stakeholder input, final decisions are taken by designated representatives or committees to ensure coherence and accountability.

The governance structure is designed to balance scientific, technical, and practical perspectives, recognizing that certain operational aspects, particularly those linked to agricultural production, depend on context-specific knowledge. Key elements of the governance model include:

- **A steering committee** composed of representatives from each stakeholder group to define strategic direction and ensure alignment with project objectives.
- **Co-creation workshops** for collective deliberation on pilot design, monitoring protocols, and performance indicators related to water reuse efficiency, crop productivity, and environmental safety.
- **A neutral facilitator or coordinator** to mediate discussions, promote balanced participation, and sustain engagement among stakeholders with differing priorities.

Decisions are reached primarily through consensus, supported by open dialogue and evidence-based discussion. When consensus cannot be achieved, alternative mechanisms such as majority voting or expert arbitration are used to resolve outstanding issues while maintaining fairness and continuity.

3.1.5 Communication and dissemination strategy

For a NB-Woll to be effective, inclusive, and engaging, it must be built on a strong foundation of clear communication, defined roles, and public visibility. This ensures smooth internal operations and fosters trust and participation from external stakeholders.

Internally, clear and consistent communication between the research coordinator, the leader of the promoting group, and all partners is essential. Analyzing TWIST's *E 2.1.1 Report on the common methodology for creation, implementation and management of three experimental Living Labs* (2020), the following practices are recommended:

- Establishing email groups or mailing lists for different teams
- Defining communication protocols for regular updates and decision-making
- Holding periodic meetings, including both strategic (steering) and technical meetings for coordination and problem-solving
- Using collaborative platforms (e.g. shared drives, project management tools) for document sharing and task tracking

Externally, the NB-WoLL must develop a recognizable identity and public presence to promote transparency, attract interest, and enable wider engagement. Important elements include:

- A name and visual identity, including a logo, that reflect the mission and values of the NB-WoLL;
- A dedicated webpage or microsite, where stakeholders and the public can access information about the NB-WoLL's goals, activities, members, and outcomes;
- Communication materials such as brochures, infographics, and videos to explain the concept and progress of the NB-WoLL;
- Annual or periodic reports that document activities, findings, and impacts, and are disseminated to the stakeholder community and the broader public.

Additionally, involving partner institutions that can contribute communication and outreach services (e.g., media agencies, universities, or civic organisations) can strengthen dissemination efforts and help the NB-WoLL reach new audiences. By building a clear and visible identity, supported by strong communication infrastructure, the NB-WoLL becomes more accessible, trustworthy, and inclusive, fostering sustained stakeholder engagement and public support.

3.2 Operational structure of the NB-WoLL

3.2.1 NB-WoLL's infrastructures

Understanding available infrastructures is crucial for project planning and execution. We can categorize these into essential infrastructures and potential infrastructures, as described on TWIST's *E 2.1.1* report (2020).

Essential infrastructures form the physical and functional foundation of the NB-WoLL. These include permanent or temporary experimentation facilities, such as testing fields for water reuse trials, as well as event and collaboration spaces for workshops, meetings, and training sessions. Equally important are digital networks and connectivity systems, including broadband internet, local area networks,

servers, and communication platforms, that enable efficient data exchange and coordination among participants.

Potential infrastructures vary according to each NB-WoLL's thematic focus and specific projects. These may include software tools for data analysis, modeling, and simulation; project management and online collaboration systems; and specialized hardware such as Internet of Things (IoT) devices, sensors for water quality and soil monitoring, and remote-sensing technologies for evaluating crop responses to water reuse. A detailed mapping of existing infrastructures helps identify potential gaps, limitations, or constraints that could affect experimentation and long-term operations.

Effective infrastructure management requires a clear utilization plan defining roles, responsibilities, and procedures. Each key infrastructure should have an assigned manager, access rules, usage scheduling procedures, and technical support protocols. Usage should be logged to ensure accountability, and issues should be reported through a transparent process.

Financial and operational protocols must also be clearly defined. Larger or shared infrastructures may require formal collaboration agreements specifying cost-sharing, maintenance responsibilities, and access conditions, while smaller resources can rely on informal arrangements based on mutual trust. A clear cost model should outline how acquisition, maintenance, upgrades, and consumable costs are distributed among partners or covered by NB-WoLL funds. Transparency in these arrangements ensures that resources are used efficiently, sustainably, and equitably.

Complementary to the NB-WoLL, the identification of existing NBS within the region is essential. These sites can serve as demonstrators for testing and showcasing different NBS technologies related to water reuse. Linking these demonstrators to the NB-WoLL strengthens regional collaboration, supports comparative assessment, and enhances knowledge transfer across projects and territories.

3.2.2 Available tools for NB-WoLL

As part of its strategy to promote sustainable water reuse in agriculture, SOLLAGUA has developed a set of practical tools to support the implementation and operation of the NB-WoLL. These tools provide structured guidance for selecting, evaluating, and managing wastewater treatment and reuse solutions adapted to local contexts. By integrating technical, environmental, and economic perspectives, they assist stakeholders in making informed decisions about the most suitable treatment schemes, ensuring that water reuse practices are efficient, cost-effective, and environmentally sound.

Portfolio of different treatment schemes for water reuse

SOLLAGUA's deliverable *D1.1.1: Portfolio of different treatment schemes for water reuse* serves as a State of the Art (SoA) review of current technologies for wastewater reclamation. The portfolio includes detailed factsheets of 17 different technologies, exploring their key features, performance metrics, operational requirements, and potential applications. It examines how green and grey approaches can be combined to enhance treatment efficiency and meet quality standards.

These fact sheets are intended to aid in the decision-making process, offering concise yet informative guidance on the most relevant and innovative wastewater treatment solutions.

Decision Tree

SOLLAGUA's deliverable *D1.2.1: Decision Tree* aims to help identify and select the most appropriate wastewater treatment trains for agricultural irrigation reuse. This document provides an overview of treatment systems or treatment trains suitable for wastewater reuse in different communities. It considers:

- National regulatory frameworks;
- Key design and operational parameters of each treatment type;
- Effectiveness in removing contaminants and pathogens;
- Typical characteristics of different wastewater types;
- Real-world application histories of each treatment option.

Its goal is to help communities, operators, and stakeholders make informed decisions about sustainable wastewater reuse for agriculture, in compliance with local standards and in support of water resilience and environmental protection.

Lifecycle and cost/benefit analysis

SOLLAGUA's deliverable *D1.4: Lifecycle and cost/benefit analysis* presents the results of the cost-benefit analysis (CBA) and the life cycle assessment (LCA) of four green and three grey treatment solutions for water reuse in rural areas. These seven treatment chains were identified as the main water treatment solutions chains through the Decision Tree.

This analysis supports informed decision-making by helping to determine the most suitable treatment solutions for water reuse across varied rural scenarios.

3.2.3 Financial sustainability

Financial sustainability is essential for NB-WoLL to maintain long-term operations and expand their impact. Although the primary objective of NB-WoLL is to create social and environmental value, stable funding is required to ensure that these benefits are sustained over time. Many existing initiatives remain temporary due to the absence of viable financial models and continued dependence on public subsidies, which may not guarantee future stability (TWIST, 2020).

To achieve long-term viability, NB-WoLL can adopt a combination of funding models, typically grouped into four main categories (Gualandi & Romme, 2019):

- **Pay per Service (PPS):** Direct payment for specific services provided by the NB-WoLL within projects or collaborative initiatives.
  Source: Primarily private, occasionally public if linked to social or environmental outcomes.
  Scope: Project-level funding based on the delivery of defined services.
- **Subsidies (SUB):** Long-term funding from strategic partners recognizing the NB-WoLL's contribution to public and private value creation.
  Source: Mainly public (e.g., municipalities, regional authorities, research institutions).
  Scope: Supports broad, shared objectives beyond individual projects.
- **Out of Network Funds (ONF):** Grants and competitive funds obtained from European, national, or regional programs aligned with public policy priorities.
  Source: Predominantly public institutions.
  Scope: Project-based, typically linked to the generation of public or environmental value.
- **Cross-Financing (CRF):** Revenue generated from the NB-WoLL's physical assets or complementary activities, such as renting equipment, laboratory space, or offering training services.
  Source: Largely private and external.
  Scope: Not directly related to the core activities of the NB-WoLL but supportive of its financial stability.

A balanced mix of these funding mechanisms strengthens the NB-WoLL's resilience, allowing it to operate beyond project cycles and continue fostering innovation in water reuse and sustainable management.

3.2.4 Catalog of services

An NB-WoLL can provide a wide range of services to external stakeholders, generating added value and contributing to its long-term sustainability. These services are particularly relevant to local authorities, farmers, cooperatives, schools, NGOs, companies, and other organizations that can engage in wastewater treatment and reuse through NBS in rural and peri-urban areas.

- Co-creation of water reuse solutions: The NB-WoLL facilitates participatory diagnosis of local water challenges, followed by the design, testing, and validation of NBS such as constructed wetlands, vegetated buffer strips, and agroforestry systems adapted for wastewater treatment and irrigation reuse. Activities may include pilot implementation, adaptive management, and monitoring of treatment performance under real operating conditions.

- Capacity building and training: The NB-WoLL serves as a platform for technical training on the operation and maintenance of NBS for wastewater treatment and reuse. It can host workshops for local technicians and water managers, provide on-site demonstrations of decentralized reuse systems and low-tech treatment technologies, and offer instruction in monitoring methods and data collection.

- Awareness and sustainability education: Through public engagement, the NB-WoLL promotes awareness of safe water reuse and NBS practices. This may include community campaigns, educational programs for schools and youth, and the development of informational materials, such as videos, brochures, and signage, illustrating how local NBS operate. Citizen science initiatives can also be encouraged to involve residents in water quality monitoring and stewardship.

- Advisory and support services: The NB-WoLL can provide expert guidance on national and EU regulatory frameworks for water reuse, support stakeholders in identifying funding opportunities and project development pathways, and offer tailored consultancy for the design and adaptation of NBS to specific agricultural or peri-urban contexts.

These services can be offered locally or regionally and adapted to the needs of both public and private clients. By linking innovation, capacity building, and practical implementation, the NB-WoLL strengthens collaboration among stakeholders while ensuring the economic viability and long-term impact of nature-based wastewater treatment and reuse systems.

3.2.5 NB-WoLL monitoring and evaluating over time

As reported by TWIST (2020), monitoring and evaluation (M&E) are essential to ensure that the NB-WoLL remains aligned with its objectives and adapts effectively when needed. Systematic observation of ongoing activities allows early identification of challenges, continuous improvement, and verification of real impact.

A monitoring and evaluation plan, though not mandatory, provides a structured framework for tracking the performance of the NB-WoLL and its pilot projects. It helps align daily operations with strategic goals and enables timely adjustments when outcomes diverge from expectations.

The first step in developing an M&E plan is to define clear objectives, both for the NB-WoLL as a whole and for each project focused on wastewater treatment and reuse through NBS. These objectives are then translated into measurable indicators, typically grouped into three categories:

- **Process indicators:** track implementation activities, such as the number of stakeholder meetings or pilot installations.
- **Outcome indicators:** measure medium-term progress, such as the adoption of NBS or new collaborations established.
- **Impact indicators:** assess long-term results, including improved water reuse efficiency, policy uptake, or replication of successful models.

Indicators should be well-defined, reliable, and practical, ensuring that data collection is accurate, accessible, and cost-effective. Regular evaluation reports summarize progress, compare results with initial objectives and baselines, identify gaps or delays, and provide recommendations for decision-making. These reports also communicate achievements transparently to stakeholders, funders, and the wider community.

Through consistent monitoring and evaluation, the NB-WoLL remains focused, accountable, and capable of demonstrating the tangible value of NBS for wastewater treatment and reuse, both in the short term and over the long run.

4 Concluding remarks

This strategy outlines a comprehensive framework for establishing and operating nature-based water-oriented living labs for water reuse in agriculture. It highlights the essential elements needed to support collaborative innovation in the sectors involved and provides a structured approach to defining governance models, identifying and involving stakeholders, fostering co-creation, and setting up the operational and infrastructural foundations necessary for NB-WoLL to function effectively.

The strategy is intended to serve as a reference point for those aiming to initiate or strengthen NB-WoLL in diverse contexts. It recognizes the importance of clarity in roles, alignment of missions, inclusive decision-making processes, and transparent communication as key factors in ensuring the relevance and coherence of WoLL initiatives.

Building on this strategic framework, a dedicated **action plan** will be developed as the next step. This action plan will serve as a practical template, or a **road-map**, for implementing NB-WoLL on the ground. It will translate strategic concepts into actionable steps, offering concrete guidance on how to apply the outlined principles in real-world settings.

Interreg Sudoe

Co-funded by the European Union

SOLLAGUA

PROJECT INFORMATION

Project title

Nature-based solutions (NBS) and living labs for rural water reuse.

Start - end date

01/01/2024 - 31/12/2026 (36 months)

Programme

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Project type

Priority 1: Preserving natural capital and strengthening climate adaptation in the SUDOE area.
Specific objective 2.5: Promoting access to water and sustainable water management.

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€1,389,232.10

Coordinator

Université de Toulouse

Project review

SOLLAGUA, funded by the Interreg SUDOE Programme, is a three-year project that aims to promote nature-based solutions (NBS) for water reuse across the SUDOE region, which faces major challenges linked to water scarcity due to its semi-arid climate, the impacts of climate change and a growing population. The initiative seeks to address these shared challenges by implementing sustainable water-management strategies in three rural communities in France, Portugal, and Spain.

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