

THE KEY CHALLENGE WATER OCCITANIE: SIX LIVING LABS NETWORK FOR THE ASSESSMENT OF THE RELEVANCE OF LOCAL WATER REUSE SOLUTIONS AND THEIR CONSEQUENCES

LE DÉFI MAJEUR CHEZ « WATER OCCITANIE » : UN RÉSEAU DE SIX LABORATOIRES VIVANTS POUR ÉVALUER LA PERTINENCE DES SOLUTIONS LOCALES DE RÉUTILISATION DE L'EAU ET LEURS CONSÉQUENCES

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ABSTRACT

The Water Occitanie (WOc) initiative is a strategic five-year action-research program designed to address the severe hydro-climatic challenges facing the Occitanie region, such as recurring droughts and declining groundwater levels. While France currently recycles less than 1% of its wastewater compared to 90% in countries like Israel, the WOc program seeks to investigate this gap by implementing a hybrid methodology that merges Living Labs and Science Shops and foster co-research. This approach unfolds through a structured process where inaugural forums identify local water priorities, steering committees refine research questions, and collaborative projects provide evidence-based solutions across six diverse territories. From decentralized wastewater treatment in Montpellier to biochar-based decontamination in the Clermontais, these projects tackle specific regional needs while ensuring that research remains grounded in social learning and stakeholder validation. After four years of operation, the program has highlighted the critical importance of flexible governance in balancing diverse interests, such as those between farmers and policymakers, and has underscored the necessity of addressing technical barriers through institutional cooperation. The positive impacts of the program are evident in the development of contextualized, low-cost tools and the integration of research into local water management strategies, effectively bridging the gap between scientific innovation and public policy. By empowering stakeholders to co-design solutions and testing reuse scenarios under various global change projections, the WOc initiative demonstrates how Water-Oriented Living Labs can build resilience against environmental pressure. Ultimately, the program establishes a scalable model for inclusive water governance, proving that long-term, transdisciplinary engagement is essential for successful climate adaptation. Future efforts will focus on institutionalizing these platforms to ensure that the knowledge generated is fully appropriated by water managers, industries, and citizens alike, thereby offering a sustainable and equitable blueprint for regions worldwide facing increasing water scarcity.

Keywords: Local water reuse solutions; Action-research program; Scalable model; Environmental pressure; Water scarcity.

RÉSUMÉ

L'initiative Water Occitanie (WOc) est un programme stratégique de recherche-action d'une durée de cinq ans, conçu pour répondre aux défis hydroclimatiques majeurs auxquels est confrontée la région d'Occitanie, tels que les sécheresses récurrentes et la baisse du niveau des nappes phréatiques. Alors que la France recycle actuellement moins de 1 % de ses eaux usées, contre 90 % dans des pays comme Israël, le programme WOc cherche à combler cet écart en mettant en œuvre une méthodologie hybride qui associe les « laboratoires vivants » (Living Labs) et les « ateliers scientifiques » (Science

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Shops) et favorise la recherche collaborative. Cette approche se déploie à travers un processus structuré où des forums inauguraux identifient les priorités locales en matière d'eau, des comités de pilotage affinent les questions de recherche et des projets collaboratifs fournissent des solutions fondées sur des données probantes dans six territoires divers. Du traitement décentralisé des eaux usées à Montpellier à la décontamination à base de biochar dans le Clermontois, ces projets répondent à des besoins régionaux spécifiques tout en veillant à ce que la recherche reste ancrée dans l'apprentissage social et la validation par les parties prenantes. Après quatre ans de fonctionnement, le programme a mis en évidence l'importance cruciale d'une gouvernance flexible pour concilier des intérêts divers, tels que ceux des agriculteurs et des décideurs politiques, et a souligné la nécessité de surmonter les obstacles techniques grâce à la coopération institutionnelle. Les retombées positives du programme sont manifestes dans le développement d'outils contextualisés et peu coûteux, ainsi que dans l'intégration de la recherche dans les stratégies locales de gestion de l'eau, comblant ainsi efficacement le fossé entre innovation scientifique et politique publique. En donnant aux parties prenantes les moyens de concevoir ensemble des solutions et de tester des scénarios de réutilisation dans le cadre de diverses projections de changement global, l'initiative WOC démontre comment les laboratoires vivants axés sur l'eau peuvent renforcer la résilience face aux pressions environnementales. En fin de compte, le programme établit un modèle évolutif de gouvernance inclusive de l'eau, prouvant qu'un engagement transdisciplinaire à long terme est essentiel à la réussite de l'adaptation au changement climatique. Les efforts futurs se concentreront sur l'institutionnalisation de ces plateformes afin de garantir que les connaissances générées soient pleinement appropriées par les gestionnaires de l'eau, les industries et les citoyens, offrant ainsi un modèle durable et équitable aux régions du monde entier confrontées à une pénurie d'eau croissante.

Mots-clés : Solutions locales de réutilisation de l'eau; Programme de recherche-action; Modèle évolutif; Pressions environnementales; Pénurie d'eau.

INTRODUCTION

With nearly 6 million inhabitants, the Occitanie region is particularly affected by climate change on its hydrology, mainly on the Pyrenean massif and the Mediterranean coast. Rainfall is expected to decrease and become more variable in time and space, while demand is expected to increase (Noto et al. 2023). Recent years have been marked by a succession of droughts and floods that have impacted the territory, and these climatic extremes are likely to increase, jeopardizing the security of the water supply for all uses and infrastructures, and the natural environments and the ecosystem services they provide. It requires new territorial arrangements to regulate the future uses of water and soil.

Local water management solutions seem to be adapted to meet the challenges of climate change and its local consequences. In this context, the reuse of water already mobilized for other uses before partial return to the natural environment can be relevant alternatives to guarantee access to water, for various uses such as, for example, agricultural irrigation, urban cooling, irrigation of green spaces and golf courses, groundwater recharge... Among these solutions, the reuse of treated wastewater is encouraged by some stakeholders in the sector and users and seems to respond to several challenges. In France, less than 1% of wastewater is recycled, while reuse is widely adopted in some countries, such as Israel (90%), Spain (14%) or even Italy (8%). It is also presented as a possible option in the case of Southern countries.

Based on this observation, the key challenge Water Occitanie (WOC), is an action research program, supported for 5 years by the Occitanie Region and which aims to assess the relevance of local water reuse solutions (Reuse) and the consequences that Reuse could have on the whole water cycle, based on experimental places in the regions: Living Labs.

The WOC Key Challenge is organized around three main objectives:

- Stimulate research and innovation on REUSE: Research projects within this challenge will (1) strengthen skills on understanding the integration of local water reuse solutions and effects on

the water cycle; (2) produce a large basin scale consequence assessment; (3) analyse the cumulative capacity to respond to the collective challenges of the large cycle;

- Structure academic research in Occitanie by federating transdisciplinary research to develop and/or strengthen research. The scientific community thus brought together consists of 41 research units, bringing together broad panels of expertise such as chemistry, process engineering, ecology, hydrogeology, humanities and social sciences or meteorology
- Create opportunities to further develop cooperation with socio-economic actors in the regional territory, through the «Living lab» scheme.

The WOC key challenge brings together research communities working on water in Occitanie, involving here academics from all disciplines and working on various objects. It mobilizes them on the evaluation of the relevance of water reuse solutions in a context of high quantitative and qualitative tension on water resources. In that context, six Living Labs have been set up to explore reusability issues of interest for local territories, through the co-construction of research questions.

METHOD

Origin: Living Labs and science shops

To meet the rising demand for more grounded and participatory research, we chose to build on two existing approaches meant to include further non academics in emergence and diffusion of new knowledge, so that knowledge is better attuned with stakeholders' expectations and realities of the place. As presented more extensively in Barreteau et al. (2026), we first ground our approach on Living Labs. These are co-research arrangements designed to explore grounded solutions to local problems, involving a diversity of types of stakeholders. While defined by dedicated networks, such as ENoLL⁴, Living Labs are a dynamic concept with diverse interpretations. They function as methodologies, networks, arenas, governance approaches (Hossain et al., 2019; Steen, Van Bueren, 2017). The flexibility of this concept enables its adaptability to the local contingencies brought by participants, which is essential for their "cultural safety" (Scher et al., 2023). Most references to Living Labs start now from ENoLL and are further shaped into several subcategories such as Urban Living Labs (Nesti, 2018; Steen, Van Bueren, 2017). According to the domain of investigation, such as environmental problems, Living Labs are associated with a specific place, encompassing not only the physical environment but also past experiences, norms, and values (Hadfield et al., 2024). This pair (thematic issue, place) is constitutive of the Living Lab and a marker of its identity (Batalla-Bejerano et al., 2023). We stucked to this proposition as water scarcity management in general and water reuse specifically are completely embedded in a place, where existing resources, infrastructures and water uses shape the emergence of new questions to enable a more efficient use and management of water. Recent evolution with Living Labs, and especially Nature-based Living Labs, include extension towards policy innovation and also the availability of spaces for the co-production of knowledge with a research purpose, tagged as "knowledge innovation" (Bhatta et al., 2024). Despite these evolutions towards more inclusivity and a broader view on innovation dimensions, Living Labs remain biased towards testing solutions that have been framed externally.

Science Shops have developed separately to enable access to academic facilities to civil society organisations in order to "provide independent, participatory research support in response to concerns experienced by civil society" (Gnaiger, Martin, 2001, p. 6). They act as brokers between academics and Civil Society Organisations (CSOs), driven by CSO demands on academics (Savoia et al., 2017). They handle any issue of interest to CSOs on which academics connected to the Science Shop might bring expertise. The localisation of Science Shops in universities helps to develop the connections between CSOs and academics who are affiliated to this place. In a review of Science Shops' success and failures,

⁴ Living Labs are user-centered, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings (<https://enoll.org/living-labs/#living-labs>)

Gresle *et al.* (2021) point out a mismatch with the local political agenda, partly due to the focus on CSOs as main or only type of non-academic stakeholders.

In the follow up of this paper, we describe an experience that is trying to hybridise the Science Shop with Living Labs, to cover all the steps of a co-research process with a focus on water issues, and include the broadest diversity of stakeholders as described with the quadruple helix model: policy making, academics, private businesses and CSOs (Zingraff-Hamed *et al.*, 2020). We still call these Living Labs, considering that Science Shops reinforce Living Labs in covering the whole co-research process.

In these Living Labs, we paid attention to an early involvement of local public policy making bodies concerned by the topical scope to ensure consistency with on-going policy processes, selecting one of them as co-leader of the Living Lab. We expanded then partnerships beyond this main partner, to include stakeholders concerned by water in the area from all the types of the quadruple helix. For each Living Lab, we devised a governance scheme, with a hybrid steering committee of about a dozen members, with 50% of academics, depending on the selected issues, and 50% coming from all the non-academic categories, selected with a few close collaborators directly concerned by water governance (e.g. river basin organisations) along two dimensions: availability and concern. Figure 1 below synthesises the co-research process. The knowledge development priority is targeted through providing the financial means for Master students' six-months internships, as in Science Shops, to investigate research questions elaborated by the Living Lab.

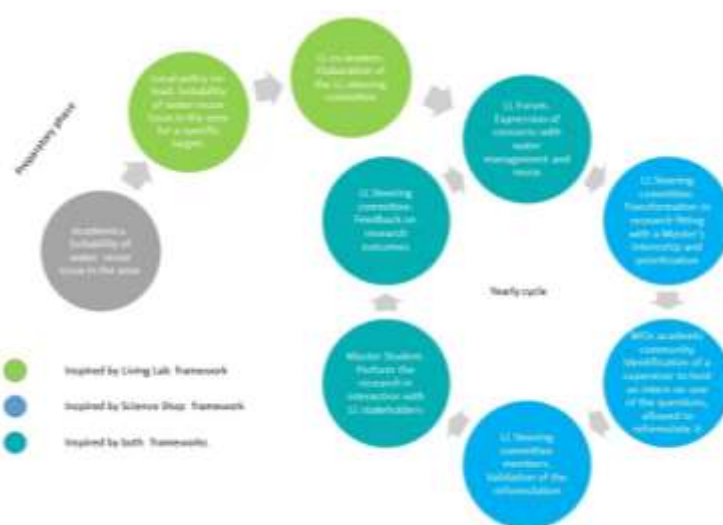


Figure 1 - Process model of research questions elaboration and selection within WOC Living Labs (LL = Living Lab) (from Barreteau *et al.* 2026)

Evaluation in itinere of this network of Living Labs

As recommended in the litterature for participatory research, we developped a reflexive analysis of this co-research arrangement (Hazard *et al.* 2020 ; Scher *et al.* 2023). For this purpose, we first had a self assessment within the WOC steering committee using a grid provided by the consortium Water4All to qualify Water oriented Living Labs⁵. However this grid was more oriented towards mainstream Living Labs, regarding possibility and effectiveness of innovation and its dissemination. The originality of our focus on joint elaboration of research question that came from the hybridisation with Science shops was rather weakly considered on that grid.

⁵ <https://www.water4all-partnership.eu/joint-activities/water-oriented-living-labs>

We then hired a Master intern for six months in 2025 after 3 years of Living Labs progress. The intern conducted semi-structured interviews with participants from the six Living Labs and the four blades of the quadruple helix as reported in table 1 below. She then analysed them regarding the added value perceived by the respondents and their expectations for change. The value created within a Living Lab can be cognitive, social or economic. When the objective of the Living Lab is to create an innovation, the value can be directly observed as a product or prototype created on the platform and thus takes on an economic dimension. However, when the objective is the production of knowledge and the networking of stakeholders from different disciplines and origins, the value created—social and cognitive—is more abstract as it depends on the contexts (Bhatta et al., 2024). To identify value in all its forms, Leclercq et al. (2016) introduced value co-creation, which implies that the value created in participatory research must be reciprocal amongst all stakeholders.

Table 1: profiles of interviewees for reflexive assessment of the Living Labs (Pace, 2025)

Living Lab	Public Body	Academics	CSOs	Businesses	Total
Toulouse	1	3	0	1	5
Montpellier	2	1	1	1	5
Claira	1	3	0	0	4
Adour Amont	1	0	1	1	3
Armagnac	1	0	0	1	2
Clermontais	2	1	0	0	3
Total	8	8	2	4	22

RESULTS

A network of Living Labs

We designed then a network of six Living Labs as a pair of thematic issues and places. We chose the places first, selecting them according to diversity of context within Occitanie Region and existence of a preliminary thinking about water reuse among local stakeholders. Identification of the topical frame came second, through a first narrowing down of reuse issue with each Living Lab steering committee. Figure 2 locates them on a map, while main topical issues are in table 2 below (column 2).

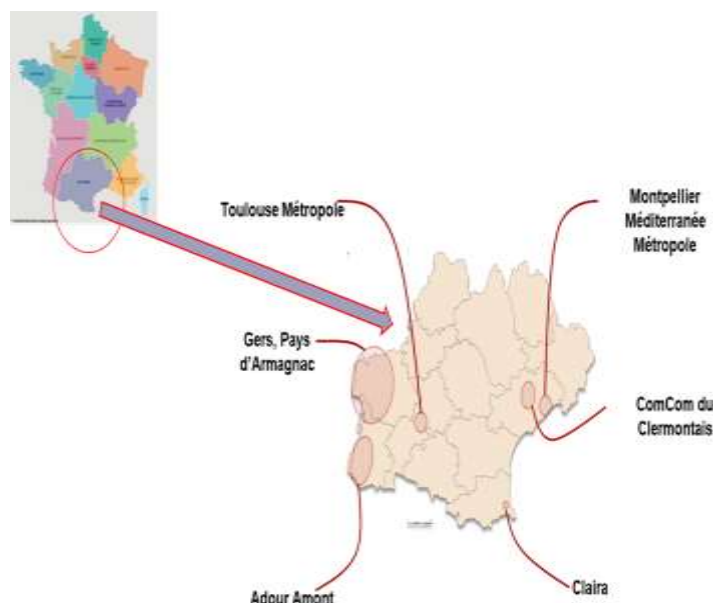


Figure 2 - Situation of the Living Labs in Occitanie

Outputs Sample among 6 Living Labs from diverse places and topical issue

The Living Labs span urban, rural, and coastal areas, each tackling specific reuse challenges and results describe in the table 2.

Table 2 – Samples of projects and Living Labs results along the 6 living Labs

Place	Thematic issue	Project	Project results	Living Labs Results
Montpellier Méditerranée Métropole:	Sustain peri-urban agriculture without increasing water pressure.	Preexisting ReWa project for distributed wastewater reuse among small waste water treatment plants involving 3M and academics from Montpellier		Optimizing urban water reuse within the city: the block scale is identified as the most effective approach for enhancing technical feasibility, resource sharing, and stakeholder coordination.
Toulouse Métropole:	Reuse urban water to secure water availability during hot periods.	BioROC - Biofilm management in nature-based irrigation systems.	Treatment Performances are improved with worms bioaugmentation , increase of micropollutants removal is also observed ;	Water storage : Assessment of biofilm-related risks in stored non-conventional water reveals complex microbial communities not captured by standard regulatory analysis.
Claira (Pyrénées-Orientales):	Aquifer recharge with water Reuse to prevent from seawater intrusion	CompAqui : Advanced treatment for aquifer recharge And pre-existing on-going study of feasibility on groundwater recharge with treated wastewater, done by a consultancy for the Municipality	Managed soils infiltration as an alternative to intensified advanced oxydation for Micropollutants and pathogens removal .	Evaluating agricultural water reuse in a drought-prone area: Success hinges on an integrated territorial approach that balances technical feasibility with hydrological, socio-economic, and institutional realities.
Clermontais	Mitigate water stress in pesticide-contaminated wine-growing areas.	EauCharb'Oc - Biochar for decontaminating agricultural drainage water. TERR'REUSE - Hydrological/economic impacts of reuse scenarios.	Viability of such system is demonstrated regarding biochar aging	Swimming pool water recycling possible thanks to treatment in certain usages.
Gers-Armagnac	Reduce dependence on Pyrenean water transfers for agriculture.	TERR'REUSE - Hydrological/economic impacts of reuse scenarios. BREW : water reuse interest in a mico brewery network	Simulation game elaboration for support discussions about reuse implementation at the territory scale	Rain water collected from roofs needs treatment before cattle drinking water disposal.
Adour Amont	Holistic assessment of urban water reuse for agriculture.	Pre-existing study of opportunity of treated waste water reuse for agriculture done by a consultancy for basin institution in partnership with farmers' representatives		Water reuse implementation is slowed down by several factors among which the commercialization of the produces is preponderant

DISCUSSION

Originality of outputs

Outputs have been obtained thanks to internships, that have addressed the issue of water management, including successful practices with several typologies of territory, urban / agricultural / peri-urban. Whether it is rainwater or water leaving WWTP, storage is a crucial and potentially harmful step for water quality, as important as the management of water treatment processes (from conventional activated sludge to biospirated planted filter). Relevance arises from an economic perspective, with costs that are often prohibitive if to be paid only by final users, and also from a geographical point of view, with the need for uses to be located near sites where reuse water is made available in the territory. Political choices for territorial development are therefore crucial. These internships and the studies carried out made it possible to address three spatial scales from the infrastructure collecting and/or treating water to the whole basin through the social ecological system where infrastructures are set, by promoting participatory science methodologies, and studies of the interactions between actors and impact at the territorial and watershed levels.

Sustainability of LL network⁶

The Living Lab members interviewed described a transdisciplinary collaboration that worked well. Participants feel that they were being listened to and that the governance is balanced. They also did appreciate the multidisciplinary approach to research, with internships covering aspects that are sometimes highly technical and others more social. The stakeholders involved felt that they were better informed about water reuse and could then form an informed opinion on the topic. Academics assessed the outcomes of the steering committees meetings as essential advances in research on water reuse. Working with local stakeholders helped them to identify practical issues and limitations associated with these alternative solutions, which researchers do not always encounter in their research (Pace 2025).

Regarding value creation, interviews could identify several limits related to the format chosen in setting the Living Labs format in WOC and its constraints. First, regarding temporality, WOC choice to work through Master thesis constrained to work on questions that could be handled in 6 months, while the 5 years span of WOC limited the time horizon of involvement and the cumulative dynamics that could appear across years. The difference in temporalities between research and other operation domains came also out as a constraint as they did not always match. Disparity in language registers came then second, as it impairs communication between various participants coming from different blades of the helix. Together with the 5 years duration of WOC it limited the full appropriation of research outcomes by non academics despite their fitness to local concerns. Communication issue came also with the format of outputs of internships (report and presentation in steering committee) that did not meet the way to grasp information for non academics stakeholders. Finally the overarching framing on water reuse, although broad and timely regarding local agendas, has been a limit as many participants were keen on considering it as an alternative and a complementary resource within a basket of solutions.

The value created within Living Labs is not limited to innovation and scientific research. Pace (2025) could distinguish between two types of value : direct and indirect. These values are co-created through the transdisciplinary collaboration established by the programme, which implies that value is created reciprocally among all stakeholders (Leclercq, 2016), and that everyone benefits from and shares it. This sharing takes place within the Living Lab, which, according to Fasshauer (2022), represents a 'platform for engagement in the service of social innovation, designed to foster interactions between diverse stakeholders to co-produce an innovative offering'. She could synthetise in the following diagram in figure 3 the different pathways to value creation. It turns out from this analysis that event though participants acknowledge that they learned on water reuse through their involvement in the Living Lab journey, their main added value was indirect and social, on relation across the four helix blades. They pointed out the opportunity to meet and discuss sensible issues with other stakeholders in secured and

⁶ This section is mostly extracted, translated and synthetised from the unpublished Master thesis of Clementine Pace (2025)

exploratory frame they could not do otherwise. This was their main reason to come back to steering committees.



Figure 3 : the different pathways to value creation, according to Pace(2025)

CONCLUSION

Bridging Innovation and Governance: The Future of WOC's Living Labs

In the context of global changes, **WOC's Living Labs** network has emerged as a scalable model for inclusive water management. By transforming research into a collaborative, real-world endeavor, these labs demonstrate that effective water stewardship is not merely a technical challenge, but a social one—one that thrives when stakeholders are actively involved in designing context-specific, sustainable solutions.

A Model for Collaborative Success

The strength of the Living Lab approach lies in its ability to bridge the gap between academic research and practical application. By fostering environments where scientists, policymakers, and local communities co-create interventions, WOC ensures that solutions are culturally resonant, technically sound, and environmentally robust. This model proves that when stakeholders are treated as partners rather than beneficiaries, the resulting initiatives are far more resilient to the complexities of local water cycles and socio-economic dynamics.

Scaling for Long-term Impact

As these initiatives move from pilot phases to broader implementation, the focus must shift toward **institutionalization**. To achieve long-term change, Living Labs must be integrated into the fabric of permanent water governance, evolving from temporary research projects into enduring platforms for policy dialogue and collaborative action.

A Global Blueprint

As water stress continues to intensify across the globe, the lessons learned from WOC's initiatives are increasingly relevant beyond their original scope. The WOC approach is firmly rooted in the pillars of **participation, innovation, and equity**. By prioritizing these values, WOC offers a replicable blueprint for regions worldwide that are struggling to balance the competing demands of climate change, urbanization, and sustainable development. Ultimately, the future of water security depends on our ability to replicate this spirit of inclusive innovation, ensuring that every region has the tools and the collaborative framework necessary to manage its most precious resource.

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