Water Europe

Technology & Innovation

# WATER-ORIENTED LIVING LABS

WOLL Water Oriented Living Lab

## DEFINITIONS, PRACTICES AND ASSESSMENT METHODS

## NOTEBOOK SERIES#1


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# ABSTRACT

Water Europe developed the first Atlas of EU Water-Oriented Living Labs between 2018 and the first half of 2019 following and applying the rationale of Water Europe Water Vision.

This Water-Oriented Living Lab Notebook series #1 document presents the results of a literature study aimed at collecting state-of-the-art knowledge on the definition, characterisation and assessment methods related to the concept of Living Labs.

The ultimate objective was to identify and select the best available Living Lab assessment method, with which to support Water Europe's strategy for the development of a network of Water-Oriented Living Labs (WOLLs), that support the implementation of Water Europe's Vision for the achievement of a Water-Smart Society. The present report reviews the EU approaches, definitions, evolution of Living Labs as well as Living Lab assessment and evaluation tools.

It also specifically examines a proposal for the assessment and mapping of WOLLs, based on the so-called Harmonization Cube method, which is considered to be the best available assessment tool, and has in fact been adopted as a best practice by the European Network of Living Labs (ENoLL) . The report proposes a tailoring of the Harmonization Cube method to the water sector, to allow for the coordinated assessment, analysis, synergic development, harmonization, and networking of local, municipal and regional WOLL initiatives.

The Water-Oriented Living Lab Notebook series #1 is followed by the Water-Oriented Living Lab Notebook series #2 document, which provides practical and provisional guidelines for the identification, assessment, and evolution of WOLLs. Its purpose is to serve as a manual for those parties who want to drive their research and development process towards a Water-Smart Society and embed their water-smart innovations in society, using the Living Labs concept.

# INTRODUCTION AND RATIONALE

A Living Lab is not only a network of infrastructures and services, but also a collaborative ecosystem that is established to sustain community-driven innovations in a multi-stakeholder context. It offers an effective research methodology for sensing, prototyping, validating and refining innovative solutions in multiple and evolving real-life contexts. The Living Lab concept is hence highly relevant to the innovation process leading towards a Water-Smart Society. It takes research and development out of laboratories and sets it in real-life contexts. This allows for a better understanding of what triggers innovation and helps identify those innovations that prove to be successful in different environmental, social and cultural contexts.

This first in a series of notebook documents on the subject of Water-Oriented Living Labs (WOLLs) presents the results of a literature review covering the definition and the evolution of Living Labs, and focusses in particular on the methods for their assessment and evaluation. Water-Oriented Living Labs are considered a key driver for the future research agenda in the water sector. This means that a harmonized approach would be beneficial and required in their set-up and practices, so that research results, innovations and good practices can be generated, compared and shared in a coordinated and concerted manner. Such a harmonized approach is expected to contribute to accelerating the innovation process aimed at tackling key societal challenges such as water scarcity, pollution and climate change impact, and ultimately at realising Water Europe's Vision of a Water-Smart Society.

This document is organized into six sections. The first deals with a brief European history of Living Labs; section two discusses its scientific roots and definitions; section three looks at Living Lab Characteristics in practice; section four at the characterisation of Water-Oriented Living Labs (WOLLs); section five considers mapping and assessment methods for Living Labs; section six then provides a recommendation on applying a specific assessment method for WOLLs and presents the conclusions and references.

*1) Water Europe 2016 "Towards a future proof model for a Water-Smart Society" https://watereurope.eu/wp-content/uploads/2020/04/WE-Water-Vision-english_online.pdf*
*2) https://enoll.org/*

# A BRIEF EUROPEAN HISTORY OF LIVING LABS

The European history of Living Labs traces its roots to the Scandinavian cooperative and participatory design movement of the 60s-70s, the European social experiments with IT in the 80s, and the Digital City projects of the 90s. During the 90s, the digital city concept took hold in Europe and elsewhere, referring to several digital initiatives undertaken by cities, especially related to digital representations of the city, digitally related economic development and urban regeneration initiatives and the provision of internet access for citizens. By the early 2000, consistent European Union (EU) policies lead to the Finnish Presidency launching the European Network of Living Labs (ENoLL) on the 20th of November 2006.

Since then, Living Lab initiatives and communities have had a significant impact on European research and innovation policy, migrating from more linear research and innovation approaches to open and collaborative innovation concepts. Not only did these developments influence the research agendas and programmes of the European Union (e.g. EU R&D Framework programmes, Horizon 2020 and Horizon Europe), they also inspired research, development and innovation at regional level, within Cohesion Policy and Territorial Cooperation Programmes, particularly through the Smart Specialisation Strategies defined for all EU Regions and Member States.

Living Lab initiatives in Europe often start from the needs and aspirations of local and regional stakeholders. They provide valuable input to European policies and programmes, including Horizon 2020 and Horizon Europe, Smart Specialisation, the Urban Agenda, Cohesion Policy, and so forth. This is particularly apparent in developing policy and practice around the concept of 'smart cities' where strategic initiatives supported by the 7th Framework Programme for Research and Innovation/ICT Future Internet Experiment Facility and Experimentally driven Research (coordination and support actions) and the CIP ICT-PSP (open innovation, user experience and Living Labs theme / Smart City and open innovation/smart city portfolio) supported and contributed to the development of multiple cross-border experiments with Living Labs mainly in the urban context.

Specific calls for proposals in different sections of the European Research and Innovation programmes directly recommend Living Labs as innovation and experimentation instruments in areas related to smart cities, urban innovation, mobility and international cooperation. Living Labs are promoted to combine vertical domains of research (health, smart cities, climate, water, education etc.) with horizontal and territorial aspects (digitalisation, multi-stakeholder governance etc.) to strengthen the emerging European Open Innovation ecosystem. The aim is that Living Labs enable the more effective resolution of societal challenges, acceleration of innovation, internationalisation of industries (e.g. SMEs) and the creation of a pan-European experimentation environment supporting the realisation of the European (Digital) Single Market.

In this context, Water Europe launched the initiative to map and promote a network(s) of Water-Oriented Living Labs as a means for sharing and collaboration to foster common methodologies and tools across Europe that support, stimulate, and accelerate co-creative innovation processes, relying on users' involvement, with the final aim to tackle urgent societal challenges resulting amongst others from climate change, and contribute to EU Policies such as the Green Deal through a Water-Smart Society.

# SCIENTIFIC ROOTS AND DEFINITIONS OF LIVING LABS

The scientific roots of the Living Lab concept lie in different innovation theories such as user-driven design theories firstly developed by Von Hippel (1988), the appropriation of technologies theory elaborated by Silverstone (1993) and theories that considers the usefulness of experiments with user involvement in design processes (e.g. Frissen & van Lieshout, 2006). Recently new developments such as Open Innovation and Open Business Model approaches (Chesbrough 2003, 2006), and the rise of social media, have opened new research and innovation avenues and the spontaneous emergence and exchange of innovations enabled by online platforms (Pallot et al., 2010; Kiemen & Ballon,2012). Nowadays, Living Labs are considered an important concept to foster innovation and user-engaged co-creation, as expressed by the president of the European Network of Living Labs (ENoLL) in 2016.

Living Labs have an important role to play in improving trust in society as "with the engagement of different stakeholders in the conversation -citizens, scientists, companies, public authorities and policy makers- we can create more trust which is key for the creation of bold innovative solutions" **Tuija Hirvikoski, ENOLL President**

Researchers share the view that Living Labs are grounded in real-life environments with a strong focus on the key role of users (Leminen & Westerlund 2016). Nonetheless, according to Dutilleul, Birrer, and Mensink (2010), the term "Living Lab" has diverse meanings (Dutilleul et al. 2010) e.g.:

- Innovation system consisting of organized and structured multi-disciplinary networks fostering interaction and collaboration in vivo monitoring of a 'living' social setting generally involving experimentation of a technology.
- Approach for involving users in the product development process.
- Organizations facilitating the network, maintaining and developing its technological infrastructure and offering relevant services.

Starting from the ICT sector, the first one in which the Living Labs concept arose, some scholars defined Living Labs as a human-centric research and development approach whereby innovations [on ICT] are co-created, tested, and evaluated in open, collaborative, multi-contextual real-world settings (Bergvall-Kareborn et al. 2009). Living Labs do not only focus on involving users in the development processes, the approach also strives to facilitate the interactions among other relevant stakeholders, including academia and research organizations, SMEs, business industry, civic sector, ICT professionals, and public partners (Chen & Chou 2010). Shifting to the users' co-creation and appropriation of innovation elements, scholars also considered the community setting (which could be both online and offline) and involving business stakeholders (Ballon & Schuurman, 2015). The aspect of the user-focused definition gives relevance to the experimentation environment in which technology is given shape in real-life contexts and (end) users are considered 'co-producers' (Ballon et al., 2005).

Researchers defined two main archetypes of Living Labs: the ones supporting context research and co-creation, and the ones functioning as testbeds (Følstad 2008). Furthermore, Living Labs are often described as a research methodology, for example, for sensing, prototyping, validating, and refining complex solutions in multiple and evolving real-life contexts (Eriksson et al., 2005). According to Mulder (Mulder et al. 2008) six aspects represent the essential characterization of a Living Lab. These aspects are:

1. User involvement
2. Service creation
3. Infrastructure
4. Governance
5. Innovation outcomes
6. Methods & tools

*3) The European Network of Living Labs (ENoLL) is the international, non-profit, independent association of benchmarked Living Labs.*

Dell'Era & Londoni (2014) assert that a Living Labs design research methodology aims at co-creating innovation through the involvement of aware users in a real-life setting. This indicates the evolution from user-centered design, in which the user is considered the main subject, to participatory design, in which the user is seen as a partner in the innovation making, based on two primary elements: 1) a real-life test and experimentation environment and 2) the users who are aware that they are co-involved in the innovation process. The accent on participation is even more relevant for those scholars considering Living Labs as ecosystems, platforms, and methodologies for organizing user participation in the innovation process (Bergvall-Kåreborn et al., 2009). Living Labs as collaborative platforms facilitate the creation, prototyping, validation, and testing of new technologies, products, services and systems (Westerlund and Leminem 2011); but also, the interaction among users, private and public organizations, and research institutions, offering the opportunity to co-create new products or services in physical or virtual settings that replicate realistic use situations (Bergvall-Kåreborn et al., 2009; Leminen et al., 2012).

Living Labs apply mixed methods, tools, and principles in the interaction between humans and technology, drawn from well-known and established disciplines (e.g., design, science, ICT, etc.) and set in a real environment and on local/societal scale (Fulgencio et al. 2012). In these spaces, the innovation arena integrates in real-life environments cultivating the user-led insights "whereby the lab is able to surface tacit, experiential and domain-based knowledge such that it can be further codified and communicated" (Almirall & Wareham, 2011). This integration concept entails a direct integration of customers and other stakeholders to reduce new product development risks. Under this concept, additional characterization can be identified, such as the systemic innovation approach, which involves direct participation of all stakeholders in a product, service, or application development process. In this case the Living Lab is seen as a R&D methodology to generate innovations which are collaboratively validated in multi-contextual, empirical real-world environments, and the involved individuals can play the role of, at the same time, producers, and consumers. Both users and enterprises have access to direct customers' feedback, promising a more reliable market evaluation and resulting in significant reduction of technology and business risks and, in combination with scientific evaluation methods, attractiveness to SMEs, micro-organizations, and start-ups.

According to ENoLL, Living Labs are defined as "user-centred, open innovation ecosystems based on a systematic user co-creation approach in public-private-people partnerships, integrating research and innovation processes in real-life communities and settings" **(ENOLL, 2013).**

# LIVING LABS CHARACTERISTICS IN PRACTICE

For the purpose of assessing, evaluating and evolving Living Labs, it is important to not only consider academic defnitions of Living Labs, but also how they operate in practice in order to define the common principles that should typically be respected when deploying a Living Lab in real life contexts. It is important to consider that test-facilities and innovation eco-systems have been established in different configurations and with different objectives e.g.: 1) as temporary set-ups, meaning that their goal is to carry out a single innovation project; or 2) as (semi-) permanent set-ups, when they are topic or domain related and are active beyond single projects duration. Both are functional and contribute to the realisation of relevant research and innovation. In the light of our goal to foster a longer term vision and research roadmap towards a Water-Smart Society, the authors recommend to promote (semi) permanent set-ups for the definition of Water-Oriented Living Labs (WOLLs).

Living Labs can be physical or virtual spaces. According to this, their number of members or engaged stakeholders can vary, ranging from few to several thousands, especially in Living Labs established as virtual communities or platforms. They are bringing innovation enthusiasts together, involving different actors in one ecosystem: business and public institutions (CoreLab 2008), and innovation-focused researchers, all interested in the development of innovation and progress. As such they can be chacterised by the type of collaborations and type of stakeholders involved e.g. public–private–people partnerships (Edwards-Schachter et al. 2012; Veeckman et al. 2013), quadruple/quintuple helix, as a model of open innovation (Cossetta and Palumbo 2014; Baccarne et al. 2016; Keijzer-Broers et al. 2015) and as eco-systems that foster cross-sectoral collaboration (Gatta et al. 2017; Nesti 2017).

Typically Living Labs have and provide access to state-of-the-art technologies - often competing ones - delivered through different business models. Different actors join Living Labs for different reasons. Large and global firms, and public organizations usually join for funding and governance reasons, but also to implement strategies of renewals (Kviselius et al. 2008), mitigation of dependency and lock-in (Eriksson et al 2005), standardization of regional technological infrastructures (Eriksson et al. 2005), and harmonization of approaches, methods and tools (Mulder, Velthausz & Kriens, 2008), which are necessary to intensify knowledge sharing and mutual learning and foster inter-regional collaborations (Santoro et al. 2009).

Living Labs normally provide services to its members or stakeholders, which can be classified under:

- Co-Creation: facilitating co-creation of products, services, application generally following 4 phases: product ideas, product concept, product development and product launch.
- Integration: an efficient, transparent, and smooth integration of products/service accomplished by Living Lab providers in a user environment to obtain customers' feedback and trust.
- Data preparation: standardized data preparation to reduce data complexity, increase value for or the user (customer) and the developer, and foster comparability of results (including coming from different Living Labs in a network).

Living Labs and the services they provide are often set-up to deliver a clear public value e.g.:

1. Administrative: to improve administrative processes (Alford & O'Flynn 2009).
2. For citizens: improve the relationship between public administrations and citizens (Bryson et al. 2014); e.g. a) citizen-centricity: creation of knowledge on citizens' needs by bringing them within the organization. New connection forms, built on partnerships, balancing out the distance between government and citizens, and driving higher trust levels as a public value. b) higher citizen satisfaction; lower numbers of complaints or dissatisfaction with the government.
3. Societal: improve transparency, accountability, and responsibility for the sake of the larger society. Disruptive public sector innovation democratization of public sector innovation (Jørgensen & Bozeman 2007; Stoker 2006).
4. Economic: improve how public administrations deliver services, save costs, and generally become more efficient and effective. More effective and efficient new product/process development and solving wicked societal problems (O'Flynn 2007).

*4) EC Factsheet "Water Scarcity and Drought in the European Union"*
*5) Joint Research Centre (JRC). (2020). Climate change and Europe's water resources*

Hence, Living Labs mostly function in the capacity or with the potential to deliver ecosystem services, for which there is societal and market demand. They also encompass the results derived from these ecosystems: people benefit from their results and services (i.e., nutrition, access to clean air and water, health, safety, etc.) which have an impact (usually positive) on human wellbeing, a key target of socio-economic system management.

All in all, we can summarise a number of common principles for fostering well-functioning Living Lab ecosystems, and the authors recommend to take into consideration all when assessing (Water-Oriented) Living Labs e.g.

- Openness: to promote cross-fertilization, different levels of openness and collaboration between different stakeholders within the innovation ecosystem.
- Distributed: distributed knowledge base and a transparent distribution of values to enable sharing of learnings and good practices.
- Influence: involvement of competent partners and domain experts to enable state of the art and meaningfull development and deployment of innovation paths.
- Continuity: to foster continued trust building and context-unique knowledge that evolves over time, within a sustainable Living Lab ecosystem.
- Realism: allowing for testing and evaluation of innovations in users' real-world environments.
- Value: promoting economic value of innovation outcomes and activities and 'value in-use' concept, to ensure adequate drivers to "bring innovations to market".
- Sustainability: economic viability of a Living Lab over a longer period of time to enable continuity in engaging community stakeholders, build trust and leverage on progressing insights and learnings in a real-life or representative setting.
- Empowerment of users: to foster motivation and creative ideation capabilities of user communities.
- Spontaneity: to stimulate spontaneous interaction, reaction and ideation as a basis for serendipity and innovation co-creation between solution providers, researchers, users and public "authorities".

These common principles of Living Labs in practice complement and make explicit the academic definitions of Living Labs described in the previous paragraphs. We recommend they are adequately integrated in (future) methods for mapping, assessing, evaluating and evolving (Water-Oriented) Living Labs, in the light of our goal to develop a network of well functioning WOLLs that jointly contribute to the realization of the innovations necessary for a Water-Smart Society.

# CHARACTERISING WATER-ORIENTED LIVING LABS

Whereas the previous sections of this report focus mainly on the characterisation of Living Labs in general, our ultimate purpose is to look into opportunities to assess, evaluate and evolve Water-Oriented Living Labs, with the aim to contribute to Water Europe's Vision of a Water-Smart Society.

It is hence relevant to define the concept of a Water-Oriented Living Lab from this perspective, taking on board the results of our literature search as described above.

When considering the specific features and characteristics of the water sector, as well as the goal to foster the longer term vision of a Water-Smart Society, Water-Oriented Living Labs have been defined by Water Europe as follows:

**Water-Oriented, real-life demonstration and implementation instrument that brings together public and private institutions, government, civil society, and academia to jointly build structured grounds to develop, validate, and scale-up innovations that embrace new technologies, governance, business models, and advancing innovative policies to achieve a Water-Smart Society.**

Taking a closer look at the characteristics of Living Labs as described in the paragraphs above, and based on scientific literature, more specifically Mulder's (Mulder et al. 2008) six aspects (or foundational elements) that represent the essential characterization of a Living Lab (User involvement, Service creation, Infrastructure, Governance, Innovation outcomes, Methods & tools), we can chacterise a Water-Oriented Living Lab more in detail as follows:

**USER INVOLVEMENT**
Objective: involve users of water (e.g. urban/citizens, industry and/or agriculture) as well as users of innovations that enable a "Water-Smart Society" (e.g. same as above + utilities, and related service providers such as waste water management companies etc.), giving them the opportunity to influence the solution that will affect their life later on.

**SERVICE CREATION**
Objective: facilitating and supporting the development of new ideas, services and solutions that contribute to a sustainable and Water-Smart Society, and offering representative (semi) real-life environments of water production, distribution and (re) use, for co-design and validation.

**INFRASTRUCTURE**
Objective: providing the physical or virtual environment, to integrate, try-out, validate and measure the performance of water innovations. This may include an experimental set-up (e.g. in labs, or demo-sites) or (preferably) real-life test environments including (external) infrastructures for water production, distribution and (re)use (e.g. at utilities, urban areas, (agro) industrial sites).

**GOVERNANCE**
Objective: engage the quadruple helix from the water sector in a (inter) regional context e.g. involving public (water managing) authorities (including utilities), water users (e.g. cities/citizens, industries and/or agriculture), water research organizations and technology developers, which jointly agree on managing and maintaining the WOLL.

**INNOVATION OUTCOME**
Objective: facilitate predominantly innovations that contribute to a sustainable and Water-Smart Society ("mission focus"). These outcomes can be knowledge, new products and services and/or IPR. Outcomes can be in the form of finished end-user applications but also in the form of prototypes or mere knowledge about usage patterns.

**METHODS AND TOOLS**
Objective: provide and continuously update specific (interoperable) methods and tools to acquire relevant large scale user data related to the targeted innovation outcomes within the water sector.

These objectives related to the foundational elements hence need to play an crucial role in assessing, evaluating and evolving Water-Oriented Living Labs, applying state of the art methods and tools.

# LIVING LABS ECOSYSTEM MAPPING, ASSESSMENT, AND EVALUATION

The mapping, assessment and evaluation of innovation ecosystems is a relevant activity to enhance understanding of their value and functioning in the light of a common or societal objective. It allows to better plan and evolve services of innovation eco-systems at local, regional, national, EU and international level; mapping, assessing, and analysing, furthermore, supports decision makers to properly identify priority areas and relevant policy measures as well as public investments to promote research and innovations through such innovation eco-systems. It is a systematic process which consists of:

1. Mapping and characterisation-identifying innovation eco-systems, their location, spatial size/geographic scope, and characterisation (focus, objectives, stakeholders and governance)
2. Assessment of ecosystem condition- analysing the set-up and status of the ecosystem and "health" of the ecosystem functions
3. Evaluation of ecosystem service delivery- assessing the connection between ecosystem condition, the quality and health of functions, the way they affect the ecosystem capacity to deliver ecosystem services to meet its objectives

As indicated above Living Labs can be considered as innovation ecosystems. Mapping, assessing and evaluation, allows for monitoring the evolution of their organization and their maturity levels, which opens-up the opportunity. Criteria used by the European Network of Living Labs (ENoLL) to assess their suitability to become members refer to the organizational set-up, openness, resources, user involvement and real-life facilities and value creation potential of the initiative (Dutilleul et al. 2010), and are very much in line with the common principles for fostering well-functioning Living Lab ecosystems as indocated above. Asssessment is usually based on the evaluation of the actual results of Living Labs against expectations, but also exploring the satisfaction levels of participating actors. Living Lab assessments can be run applying both qualitative and quantitative tools, though the latter are far less common:

- Qualitative Evaluation Tools: participatory action research, workshops, email surveys, phone surveys and semi-structured questionnaires (mostly inductive content analysis).
- Quantitative Evaluation Tools: assessing Living Lab-introduced technologies and its impact; mostly combined with qualitative methods (i.e. mixed methods of data collection).

Our literature search resulted in the identification of several approaches and methods to assess and evaluate the impact and success of (elements of) Living Labs. We summarized them in the following table.

*Table 1: Overview of (possible) Living Lab assessment methods.*

| Approach | Details | References |
|---|---|---|
| Living Lab Analysis Model (LLAM) | Based on the concept of engineering analysis which includes three module units i.e., principle, process, and signposts. Principles and processes are considered as two factors for constructing an analysis model. Interoperability "cube" for harmonizing Living Lab data.<br>• Principle: a set of elements which represent necessary working items for designing a Living Lab.<br>• Process: an aggregation of interdependent stages transforming and manipulating elements into products. A key point we would like to emphasize here is, applicable actions will be generated as long as the working items are prioritized, confirmed, and classified into a stage.<br>• Signposts. a strategic checking item for progress review and control. A signpost is a composition of watched conditions following one or more associated actions. | Chen and Chou 2010 |
| Logit Model | Measuring the effectiveness of involving users in digital innovation process. Usefulness and value of LL project, initial objectives and achieved effects, effects on investments, revenues, and employment because of LL project results. | Ballon et al. 2018 |
| Reference Model | Similar to the Logit model; applied for user-driven innovation assessment, highly structured. | Guzmán et al. 2008 |
| Alcotra & Harmonization Cube method | To evaluate the interactive value production coming from the LL. Columns of the cube describe the organizational, contextual, and technological issues; Rows represent the maturity level of LLs, as: setup, sustainability, and scalability Encouraged by ENoLL. | Mulder et al. 2008 |

| Approach | Details | References |
|---|---|---|
| Digital Co-Creation Index (DCCI) | Newly developed digital co-creation monitoring technique providing a systematic understanding of the basic factors shaping the co-creative processes in LLs. Emphasis on interplay between places, technology. | Maciuliene & Skaržauskiene 2020 |
| PACE (Project Assets, Core competencies and Exploitable items) | Evaluation toolkit more elaborated than but similar to the DCCI. | Vontas & Protogeros 2009 |
| Four-capital method | Human (productive potential of individuals), financial (funding), environmental (natural resources), and manufactured (infrastructure) of sustainable development evaluation framework recommended to assess the long-term viability of Living Labs in Kenya, describing how sustainable development can be realized. | Ekins et al. 2008<br>Ondiek and Moturi 2019 |
| Conceptual framework | Mixing user-centred strategy and participatory strategy, user-centred strategy, observing user's behaviours, capturing users' insights, and receiving users' feedback. 2 Constructs applied:<br>1. capability of achieving the project objectives in terms of expected lead time, budget, and quality.<br>2. capability of delivering a solution able to reach the market, i.e., to move from the research and experimentation stage to the innovation stage. | Dell'Era 2019 |
| Sustainable Livelihood model | Characteristics of LLs v. LLs' effects & outcomes. 3 pillars: Innovation Outcome, Living Lab Environment, Living Lab Approach. | Parkinson & Ramirez 2007 |
| Maturity grid-based assessment tool | Guidance tool to evaluate the maturity degree of an innovation laboratory or to adapt an existing LL project. | Osorio et al. 2019 |
| Business Model Canvas (BMC) | Parameters divided under LL environments (technical infrastructure, ecosystem approach, level of openness—property rights and partnerships, community, real-world context, lifespan, and scale) and LL approach (evaluation, context research, co-creation and user role). | Osterwalder & Pigneur 2010<br>Veeckman et al. 2013 |
| Process Reference Model (PRM) for LLs | 5 categories: Innovation initiatives management, Organizational management, technical development, Monitoring and evaluation and Deployment and operation. | Guzmán et al. 2013 |
| 5 key principles | Value, sustainability, influence, realism, and openness. Focus on value creation for partners & users, which influences long-term viability of LL membership & activities. | Stahlbrost 2012 |
| 5 questions | 1. Is the product/service development and design process sufficiently on schedule (working plan and budgets)?<br>2. Are learning results from users (user feedback) sufficiently integrated into the design process?<br>3. Do the designing actors remain sufficiently aligned with each other, with a common vision and common interests?<br>4. What is the satisfaction of the participant actors with the results and processes so far?<br>5. Is the Living Lab sufficiently open to attract partners in a broader network enabling support in upscaling and implementation? | Van Geenhuizen 2018 |

This review shows there are several available methods to assess and evaluate (elements of) Living Labs. The literature review also shows there are limited studies demonstrating a robust set of approaches, metrics, analysis methods or an overarching framework for the evaluation across different Living Lab contexts. Many methods are case-specific and not widely applicable cross-context, except for the Harmonization Cube (LLAM) model which combines academic learnings and definitions i.e. the six aspects (e.g. foundational elements) that represent the essential characterization of a Living Lab (Mulder et al. 2008), and as well as many of the common principles for fostering well-functioning Living Lab ecosystems as defined by this paper. It furthermore standardises ("harmonizes") them for a comprehensive assessment of Living Labs on all its aspects. Using such a "harmonizing" approach allows for comparative and concerted maping, assessing and evaluation of Living Labs. Having been adopted by ENoLL as its key taxonomy for classifying Living Labs from all sectors, it also promises potential for benchmarking and comparison with a network of Living Labs throughout Europe (even from other sectors), allowing for sharing best practices and learning from eachother in the development of Living Labs towards higher levels of maturity. We therefore, recommend using the LLAM method as a baseline to further develop a tailored assessment approach for Water-Oriented Living Labs.

# ASSESSING WATER-ORIENTED LIVING LABS (WOLLs)

Assessing Water-Oriented Living Labs through the Harmonization Cube, opens new opportunities for coordinated assessment, analysis, synergic development, harmonization, and networking of regional Water-Oriented Living Labs initiatives. While the Harmonization Cube can be applied as it is, the authors believe this process would benefit from tailoring of the Harmonizarion Cube to the water sector.

The Harmonization Cube provides detailed evaluation criteria for the six foundational elements of any Living Lab:

**1) governance**
**2) service creation**
**3) infrastructures**
**4) methods & tools**
**5) user involvement**
**6) innovation outcomes**
i.e., the six faces of the cube

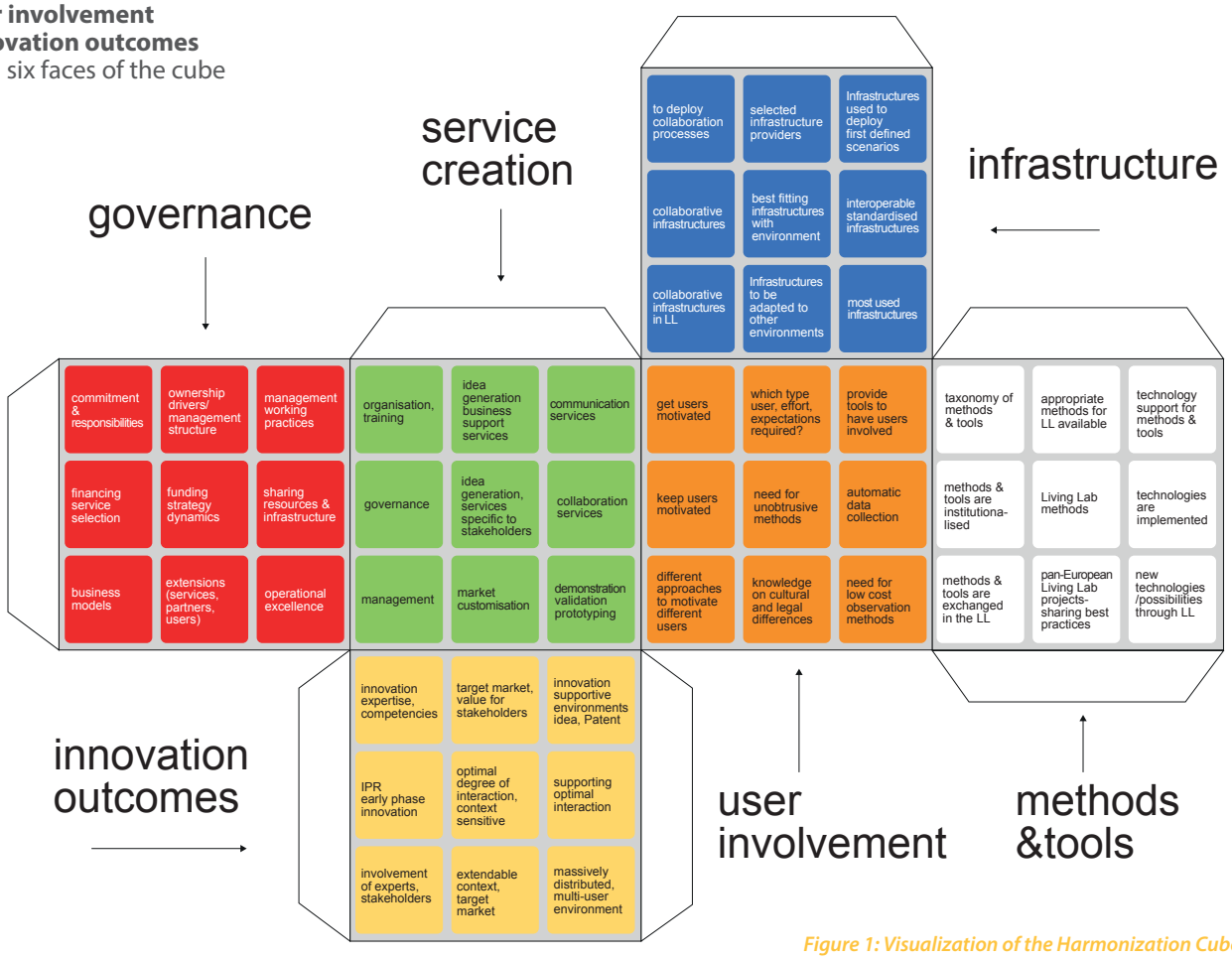
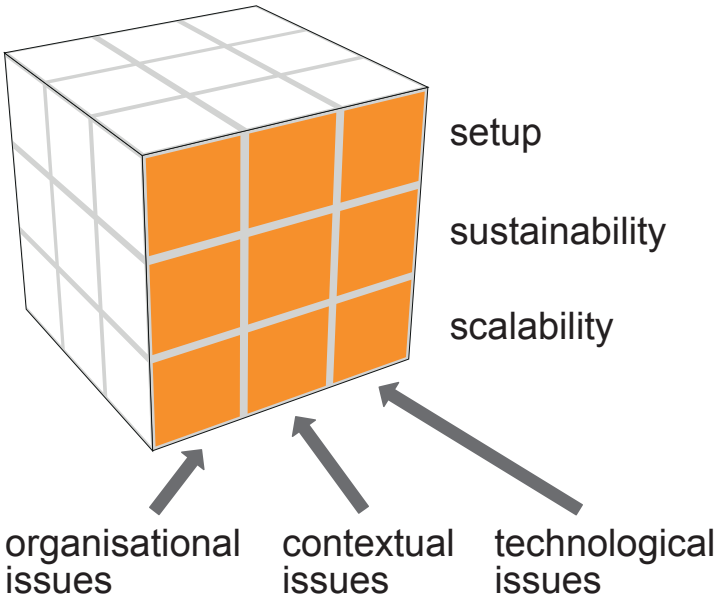



*Figure 1: Visualization of the Harmonization Cube.*




Each face of the cube includes a 3x3 evaluation matrix: on the horizontal axis **organizational**, **contextual** and **technological** perspectives; and on the vertical axis the three development phases of a LL life cycle: **setup, sustainability, and scalability**.

Each foundational element of a Living Lab can hence be assessed, using 3x3=9 criteria, to establish its development phase and opportunities to further increase their impact on the implementation of (water) innovations, by improving its organizational set-up, the way it interacts with its environment (contextual) and the way it leverages technologies to optimise support for the research, development, and innovation processes.

*Figure 2: The 9 evaluation perspectives of the cube.*

### user involvement

| | | |
|---|---|---|
| get users motivated | which type user, effort, expectations required? | provide tools to have users involved |
| keep users motivated | need for unobtrusive methods | automatic data collection |
| different approaches to motivate different users | knowledge on cultural and legal differences | need for low cost observation methods |

### service creation

| | | |
|---|---|---|
| organisation, training | idea generation business support services | communication services |
| governance | idea generation, services specific to stakeholders | collaboration services |
| management | market customisation | demonstration validation prototyping |

### infrastructure

| | | |
|---|---|---|
| to deploy collaboration processes | selected infrastructure providers | Infrastructures used to deploy first defined scenarios |
| collaborative infrastructures | best fitting infrastructures with environment | interoperable standardised infrastructures |
| collaborative infrastructures in LL | Infrastructures to be adapted to other environments | most used infrastructures |

### governance

| | | |
|---|---|---|
| commitment & responsibilities | ownership drivers/ management structure | management working practices |
| financing service selection | funding strategy dynamics | sharing resources & infrastructure |
| business models | extensions (services, partners, users) | operational excellence |

### innovation outcomes

| | | |
|---|---|---|
| innovation expertise, competencies | target market, value for stakeholders | innovation supportive environments idea, Patent |
| IPR early phase innovation | optimal degree of interaction, context sensitive | supporting optimal interaction |
| involvement of experts, stakeholders | extendable context, target market | massively distributed, multi-user environment |

### methods & tools

| | | |
|---|---|---|
| taxonomy of methods & tools | appropriate methods for LL available | technology support for methods & tools |
| methods & tools are institutiona-lised | Living Lab methods | technologies are implemented |
| methods & tools are exchanged in the LL | pan-European Living Lab projects-sharing best practices | new technologies /possibilities through LL |

*Figure 3: General evaluation criteria per foundational element.*

Based on this methodology, a practical suite of methods and assessment tools can be developed that allows for applying the methodology on existing Living Labs and new ones that start from scratch. It can be used to assess and analyse the six foundational elements analysing each of these foundational elements more in detail, to determine the maturity level of Living Labs in their natural development cycle, from set-up, to sustainability and scalability.

To apply the tailored Harmonization Cube methodology to Water-Oriented Living Labs, first a long-list of candidate (Water-Oriented) Living Labs with focus on the water sector needs to be mapped, consisting of demo-type and platform-type environments for the development, testing, and validation of water related innovations, and that match Water Europe's definition of WOLLs.

To assess and analyse these candidate Water-Oriented Living Labs, a tailored version of the Cube and a practical tool can be developed. Such a tool should tailor the 3x3 =9 evaluation criteria towards the basic requirements of Research, Development, and Innovation in the water sector; the so-called "WOLL metrics". Where needed these criteria can be further developed and fine-tuned in line with specific requirements of the Water Europe's Vision. A participative approach to further develop and detail these so-called WOLL metrics with practitioners from the water sector, and specifically by representatives of Water-Oriented Living Lab candidates is recommended.

Scoring the WOLL metrics through a specifically develop tool would allow us to "assess" to which extent a Living Lab meets the main objectives of the WOLL foundations (as defined above under "The characteristics of Water-Oriented Living Labs") as well as the common principles for fostering well-functioning Living Lab ecosystems.

# CONCLUSION

According to our literature review, there appear to be limited studies demonstrating a robust set of approaches, metrics, analysis methods or an overarching framework for the evaluation across Living Lab contexts. The ones found are often case-specific and not widely applicable. However, this is not the case for the Harmonization Cube (LLAM) model which has been specifically developed for a comprehensive assessment of Living Labs taking into account main relevant aspects that characterise and determine well developed and functioning Living Labs.

For these reasons, this paper recommends developing an assessment process and tool for Water-Oriented Living Labs based on the Harmonization cube, being the best available assessment method. The methodology should be tailored to the water sector, and from that a suite of practical methods and assessment tools can been developed that allows for applying the methodology on existing Living Labs and new ones that start from scratch. It can be used to assess and analyse the six foundational elements inherent to any Living Lab's functioning and development, i.e.:

**1) governance**
**2) service creation**
**3) infrastructures**
**4) methods & tools**
**5) user involvement**
**6) innovation outcomes.**

Analysing each of these foundational elements more in detail, against specific (to be developed) WOLL metrics, would allow to determine the maturity level of Living Labs in their natural development cycle, from set-up, to sustainability and scalability. Besides, such a "standardized" but tailored methodology, would foster building bridges between existing Livign Labs i.e., to learn from each other, benchmark successful approaches and exchange best practices. It would also facilitate alignment, and knowledge sharing with Living Lab initiatives from other sectors based on a joint Livign Lab concept and harmonized language promoted by the European Network of Living Labs.

Finally, tailoring the tool to the specific context of innovations for the water sector, allows for a participative approach with key stakeholders in the water sector. This could be done through dedicated workshops with regional, national, or European stakeholders, to focus the evaluation criteria in the methodology and tool on the contribution to a defined mission statement, such as for instance in the Water Europe Vision for a Water-Smart Society, as such laying the foundations, and a roadmap for the development of a network of well-grounded and interoperable Water Europe Living Labs (WELLs).

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# NOTES


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# WATER-ORIENTED LIVING LABS

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## DEFINITIONS, PRACTICES AND ASSESSMENT METHODS

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