# A Systematic Review of Living Lab Literature

**Journal of Cleaner Production (forthcoming)**

**Mokter Hossain***
Marie Curie Individual Research Fellow
Manchester Institute of Innovation Research
Alliance Manchester Business School
The University of Manchester
Denmark Building
M13 9NA UK
mokter.hossain@manchester.ac.uk

**Seppo Leminen**
Pellervo Economic Research,
Eerikinkatu 28 A,
Helsinki, Finland
&
Aalto University School of Business
Department of Marketing
P.O. Box 21230, FI-00076 Aalto, Finland
seppo.leminen@aalto.fi
&
Carleton University, Sprott School of Business
810 Dunton Tower, 1125 Colonel By Drive
Ottawa, Ontario, K1S 5B6
Canada

**Mika Westerlund**
Carleton University, Sprott School of Business
810 Dunton Tower, 1125 Colonel By Drive
Ottawa, Ontario, K1S 5B6
Canada

***corresponding author**

**Abstract**
A living lab is a physical or virtual space in which to solve societal challenges, especially for urban areas, by bringing together various stakeholders for collaboration and collective ideation. Although the notion has received increasing attention from scholars, practitioners and policy makers, its essence remains unclear to many. We therefore performed a systematic literature review of a sample of 114 scholarly articles about living labs to understand the central facets discussed in the nascent literature. In particular, we explored the origin of the living lab concept and its key paradigms and characteristics, including stakeholder roles, contexts, challenges, main outcomes, and sustainability. While doing this, we discovered that the number of publications about living labs has increased significantly since 2015, and several journals are very active in publishing articles on the topic. The living lab is considered a multidisciplinary phenomenon and it encompasses various research domains despite typically being discussed under open and user innovation paradigms. What is more, the existing literature views living labs simultaneously as landscapes, real-life environments, and methodologies, and it suggests that they include heterogeneous stakeholders and apply various business models, methods, tools and approaches. Finally, living labs face some challenges, such as temporality, governance, efficiency, user recruitment, sustainability, scalability and unpredictable outcomes. In contrast, the benefits include tangible and intangible innovation and a broader diversity of innovation. Based on our analysis, we provide some implications and suggestions for future research.

**Keywords**: Living labs; characteristics; open innovation; challenges; sustainability; literature review

## 1. Introduction

Scholarly studies into living labs date back over a decade (Ballon and Schuurman, 2015; Leminen et al., 2017a). The existing literature discusses living labs not just as an interesting topic that provides a multitude of research opportunities for innovative scholars but also as a novel tool, methodology and design for practitioners to overcome a variety of challenges and needs in today's world (e.g. Voytenko et al., 2016; Rodrigues and Franco, 2018). Currently, there is a large number of actively operating living labs around, although there is a high concentration in Europe (McPhee et al., 2017).

There are numerous definitions for the concept. The European Network of Living Labs (ENoLL), an umbrella organization for living labs around the world, defines them as "*user-centred open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings*" (openlivinglabs.eu/aboutus). ENoLL's definition agrees with many other definitions provided in the literature. For instance, Leminen et al. (2012: p.7) define living labs in much the same fashion as "*physical regions or virtual realities in which stakeholders form public-private-people partnerships of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts*."

Living labs encompass diverse contexts, such as local innovation activities started by citizens out of a desire to improve their everyday lives and the development activities of citizens, companies, non-profit organizations and other stakeholders in developed societies (e.g. Nyström et al., 2014). Furthermore, they can also be driven by different actors, such as users, providers, enablers and utilizers, and this affects the focus and duration of the collaborative innovation effort (Leminen et al., 2012). In general, they offer a space for testing, validation, development and co-creation in all stages of a design and commercialization process (Buhl et al., 2017; Leminen et al., 2017a). In this vein, living labs provide a platform for collective innovation and development and a source of information, as well as a testbed for novel products, services, systems and solutions (Almirall and Wareham, 2011; Leminen et al., 2015).

Sustainability is an important element of the living lab phenomenon, and several studies have addressed this (e.g. Bakici et al., 2013). Indeed, some studies analyse innovation and development activities that aim to improve everyday life in a sustainable way (e.g. Nyström et al., 2014). Others, meanwhile, look at transition labs to achieve change in sustainable development (Nevens at al., 2013), the link between sustainable innovation and living labs (Buhl et al., 2017), and the role of design, practice, and processes in environmental transformation (Bulkeley et al., 2016). Furthermore, studies have explored sustainable development in smart city activities (Leminen et al., 2017b) and in urban development and entrepreneurship (Rodrigues and Franco, 2018).

Despite the growing scholarly attention given to living labs over the years (Ballon and Schuurman, 2015; Leminen et al., 2017a), their essence remains underexplored. Thus, there is an urgent need to understand the evolution of the key facets, such as the characteristics and outcomes of living labs. To date, studies providing a comprehensive systematic literature review around the subject are nearly non-existent. To the best of our knowledge, Følstad (2008a) wrote the first such study, and this reviewed 32 papers to identify theoretical foundations, processes, methods and perspectives of living labs. Franz (2015), meanwhile, developed a more socially centred understanding of the phenomenon. After reviewing 45 studies, Schuurman et al. (2015) concluded that research into, and practice of, living labs was still at a nascent stage. Leminen and Westerlund (2016) identified eight major research streams in the existing literature at the time. Leminen et al. (2017a), meanwhile, reviewed 195 articles to gain an understanding of the emergence of the living lab movement. Finally, McLoughlin et al. (2017) performed a bibliometric analysis of 169 articles, while a recent study of Westerlund et al. (2018) used topic modelling for a set of 86 publications on the subject.

While the abovementioned studies have enriched our understanding of living labs from various perspectives, prior studies have consistently called for a more comprehensive review of the nascent literature in the field (e.g. McLoughlin et al., 2017; Westerlund et al., 2018). This study therefore aims to identify the central facets of living labs and establish a comprehensive understanding of the phenomenon through a systematic literature review. Our research questions are as follows: (i) What are the key characteristics of living labs? (ii) How are living labs and sustainable development related to each other? (iii) What are the essential future research needs suggested in the literature?
Thus, our study makes three contributions to the body of knowledge on the subject by (i) exploring the key paradigms of living labs with a specific focus on open and user innovation, (ii)

synthesizing the characteristics of living labs, and (iii) pointing out future research avenues for living labs.

This paper is structured as follows. Following this brief introduction, we describe the method in the second section, including the article search and selection process for the purpose of this review. Next, we perform the review to identify key characteristics and other key facets in the living labs literature. The subsequent section then gives the analysis and results of this study. The final section concludes this study by pointing out its implications and limitations, as well as suggesting future research avenues.

## 2. Method

The advent of ENoLL in November 2006 as the international federation for living labs in Europe, as well as the larger world, has brought a large number of living labs under an umbrella association. Since 2006, the publication of scholarly articles about the subject has grown. For this reason, we performed a literature review of the articles published over the past twelve years. Previous literature review studies have applied various approaches to identify relevant documents for analysis. Some authors searched for articles in a single database, such as the ISI Web of Science (WoS) (Dahlander and Gann, 2010), while others used multiple databases and selected a final set of articles after removing duplicated and irrelevant documents (Hossain, 2016). We took an approach somewhere in between, as was used by van der Have and Rubalcaba (2016), and searched for documents in the WoS and Scopus databases. However, although these two databases are considered to be the most comprehensive databases for academic articles, we are aware that some highly cited studies may not be included in them, so we used Google Scholar to identify such articles. Figure 1 illustrates an overview of the article search and selection process.

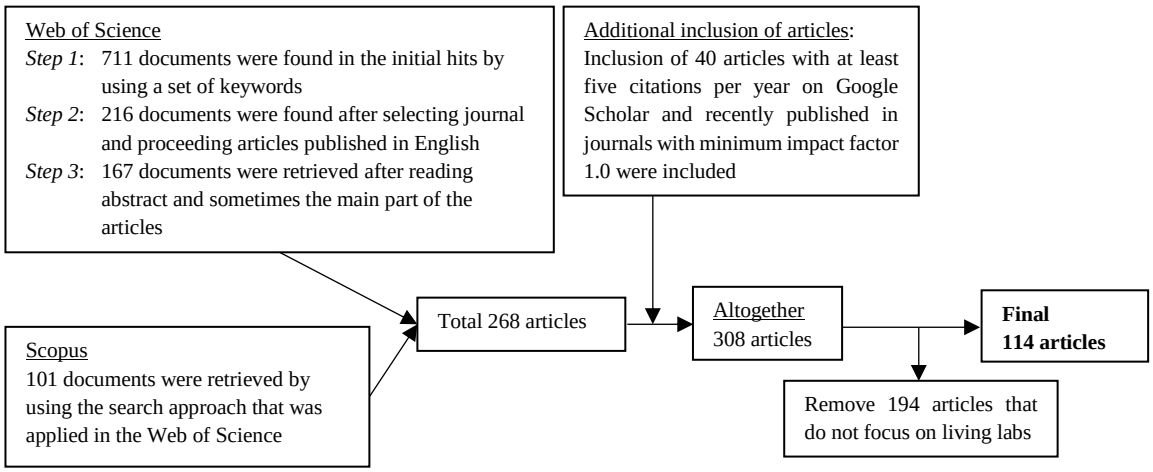


Figure 1. Article searching and selection process

The use of keywords is essential when searching for articles. Scholars have labelled the living lab phenomenon in several ways, so we used various keywords—namely *living lab*, *living labs*, *living laboratory*, *living laboratories* and *living labbing*—as the search terms. First, we

performed a search for articles in the WoS by selecting journal articles and proceedings articles. Gonzalez-Albo and Bordons (2011) explain that proceedings articles are journal articles that were initially presented at a conference, but they tend to be of similar standard to journal articles. Initially, we found 711 documents, of which 216 were journal or proceedings articles and written in English. We extracted the basic information, such as the title of the article, the list of authors, the name of the journal, the publication year, and the abstract as a CSV file, which was saved in a temporary folder. Next, we imported the CSV file into a spreadsheet and removed irrelevant information, such as the DOI number. Next, we read the abstract of each article, and occasionally the main text of an article, to ensure that living labs was the main focus of the article. Thus, we came up with 167 articles on the subject.

We then performed a search in Scopus using the same list of keywords, resulting in 220 documents. Applying the same procedure we used for the WoS, we extracted the basic information in CSV format and imported it into a spreadsheet. We soon became aware of the overlap between the results from the two databases, so we removed the duplicated articles from the search results from the Scopus database. Like before, we ensured that the remaining articles focused on living labs, leaving us with 101 articles from the Scopus database. In total, we ended up with 268 (167+101) unique articles. Furthermore, we added another 40 highly cited articles identified through Google Scholar. Altogether, a list of 308 articles was compiled in a spreadsheet.

Upon listing 308 articles, we perceived a key challenge: The number of articles was quite high for a systematic literature analysis. Many previous studies had used samples of about 100 documents for their reviews (Pisoni et al., 2018). Furthermore, the academic rigour of some articles was found to be unsatisfactory for the purposes of this study. We downloaded all the listed articles, with the exception of a few of inaccessible articles that were either collected from our personal article repository or obtained via correspondence with the authors. To ensure that our sample showed sufficient scholarly rigour, we used a quality cut-off criterion, limiting the considered articles to those that had either received a minimum of five citations per year on Google Scholar or been published recently in a recognized journal, such as the *Journal of Cleaner Production*. In this way, we compiled a set of 114 articles to review in this study.

We uploaded all 114 articles to the Altas.ti platform, which is widely used for qualitative data analysis and recently for the purpose of conducting literature reviews (Hossain, 2016). We read all the articles and coded the various themes. Acknowledging the existing literature review studies for living labs, we adopted some of their identified themes and created new themes as we performed the coding. In the coding process, we found that many articles did not have relevant and significant findings or topics to code. The coding work was performed iteratively. It is important to note that our list of references does not include all the articles looked at, because if the same or similar findings were present in multiple articles, we refer only to the best one or two examples based on our discretion. Once the coding process was complete for all articles, we fine-tuned the codes and clustered them into groups. Next, we synthesized the results.

## 3. Analysis and results

### *3.1 Main publication outlets, trends and keyword analysis*

Studies of living labs have appeared in a broad range of journals and conference proceedings. In particular, the *Technology Innovation Management Review* is an open-access journal that has published the greatest number of special issues and articles about the subject to date (Westerlund et al., 2018). Moreover, the *Journal of Cleaner Production, Industrial Marketing Management* and *Technology Analysis & Strategic Management* are high-impact journals that have published articles on the topic. The publication trend for living labs had been accelerating between 2006 and 2014. There was also a significant jump in the number of publication in 2015 and the subsequent three years.

To understand the main research streams encompassed in the living labs literature, we examined the keywords listed in the articles. The keywords *living lab* and *living labs* appeared 26 times, while *user(s)* appeared 23 times. Living labs are considered to play a pivotal role in smart cities, and the keyword *smart city* appeared seven times. Other keywords—such as *innovation*, *health*, *community*, *sustainability*, and *system*—were also present in many articles. However, many articles did not include these keywords at all.

The existing literature considers living labs to be a multidisciplinary (Bergvall-Kåreborn et al., 2009) upper-level concept covering diverse activities, typologies, and types of open innovation. Prior studies have used the term 'living labs' in association with innovation systems, experimentation, user involvement in the product development process, and organizations facilitating an innovation network and offering relevant services (Leminen, 2013). The definition of living labs offered by ENoLL (2011) puts forward five key dimensions: innovation settings, operating environments, influence on innovation processes, user engagement, and expected outcomes (Edwards-Schachter et al., 2012). Similarly, Bergvall-Kåreborn et al. (2009) point out five key principles: openness, influence, realism, value, and sustainability. Many definitions stress the collaboration between different actors, combining technological research with user research (Rits et al., 2015).

Furthermore, living labs include a set of features and principles (Bergvall-Kåreborn et al., 2009; Guimont and Lapointe, 2016), namely technological infrastructure, an ecosystem of stakeholders, an open innovation process, a human-centric design approach, community involvement, and users' natural environments. Bergvall-Kåreborn and Ståhlbröst (2009) also point out that living labs are open innovation environments in real-life contexts for new products and services. Living labs aim to co-create innovation through the involvement of users in real-life settings (Dell'Era and Landoni, 2014). A review of the existing body of literature allows us to develop a framework comprising the main facets of the living lab phenomenon (Figure 2).

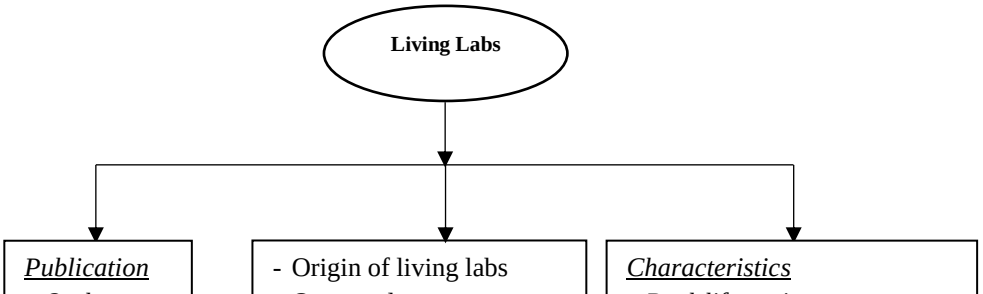

Figure 2. Main facets of the living labs phenomenon based on the existing literature

### *3.2 Origins and paradigms of living labs*

According to Tukiainen et al. (2015), the term 'living laboratory' was first used by Knight (1749). Nevertheless, the emergence of the contemporary living lab movement has been affected by three predecessors of living labs (Ballon and Schuurman, 2015). While the terms 'living lab', 'living laboratory' and 'living labbing' have been used interchangeably in the literature, there are two distinguishable approaches to living labs: the North American view and the European view. The early North American approach and the more recent European approach share the concept of involving users in innovation activities in real environments. The North American approach, however, considers living labs as demo-homes, home labs, or houses of the future, whereas the European approach views them as a platform to study users' everyday habits (Schuurman et al., 2011; Leminen and Westerlund, 2016).

Some studies suggest that the living lab concept originated from Prof. William Mitchell of the Massachusetts Institute of Technology (e.g. Bergvall-Kåreborn et al., 2009; Budweg et al., 2011; Schuurman et al., 2011). In addition, ENoLL credits him as the father of the concept (ENoLL, 2018), especially because Mitchell and his team played a significant role in boosting early living lab activities in Europe (Leminen et al., 2017a). Other studies (e.g. Folstad, 2008b; Leminen and Westerlund, 2016) identify pioneers in the field prior to Mitchell, such as Abowd and his colleagues at the Georgia Institute of Technology. The living lab concept appeared in scholarly discussion in the 1990s, when the EU began funding various large-scale living lab projects (Folstad, 2008a; Veeckman et al., 2013; Leminen et al., 2017a).

The characteristics of living labs are predominantly associated with various paradigms. The previous literature puts forward two main paradigms, namely open innovation and user innovation. These paradigms are discussed below.

#### *3.2.1 Living labs as an open innovation paradigm*

Living labs cover a range of fields and sectors and include a variety of expertise (e.g. Kviselius, Andersson, Ozan, and Edenius, 2009). Research notably and recurrently positions living labs within discussions of open and user innovation. For example, Schuurman et al. (2011) argue that living labs are closely linked with the open innovation paradigm, while several others consider living labs as a form of *open innovation* (Westerlund and Leminen, 2011) or *open innovation networks* (Leminen et al., 2012; Leminen et al., 2014; Leminen et al., 2016; Steen and van Bueren, 2017; Veeckman et al., 2013). Open innovation suggests that firms cannot entirely rely on their own research and development, so they instead need to acquire knowledge from external sources (Chesbrough, 2006). Open innovation networks, on the other hand, assume that different stakeholders—such as suppliers, customers, rival companies, and research units of universities and other institutions—get together to collaborate and innovate jointly (Jarvenpaa and Wernick, 2012).

In the spirit of open innovation, living labs rely on external sources for innovation (Bergvall-Kåreborn et al., 2009). In so doing, they facilitate collaboration and help develop and validate new products and services. Thus, living labs as innovation networks follow the philosophy of open innovation (Nyström et al., 2014). Several studies into living labs compare them with open innovation and suggests that there are both similarities and differences between the two (e.g. Almirall and Wareham, 2008b; Bergvall-Kåreborn et al., 2009; Leminen, 2013). Some scholars argue that living labs take a structured approach to open innovation. For example, Almirall and Wareham (2008b) assume that living labs activate and create connections between stakeholders in an open innovation process. Conversely, Bergvall-Kåreborn et al. (2009) propose that living labs differ from open innovation. They point out that while living labs are often employed in a business-to-consumer setting with a clear focus on users, products, and services, the open innovation paradigm often focuses on the business-to-business context. Furthermore, Guzman et al. (2013) argue that living labs are practical approaches for implementing open innovation and delivering prototypes to private organizations for commercialization. Leminen (2013) positions open innovation as the way that companies manage innovation, since open innovation may be company-led or top-down. In conclusion, living labs emphasise public–private–people partnerships and the importance of users (Westerlund and Leminen, 2011), whereas open innovation includes a more limited collaboration between companies.

### *3.2.2 Living labs as a user innovation paradigm*

Several studies into living labs examine the similarities and differences with user innovation. For example, Ståhlbröst and Bergvall-Kåreborn (2011) propose that a living lab is an innovation intermediary community that shares the view of a user innovation approach. Edvardsson et al. (2012), meanwhile, point out that a living lab is a context for user innovation and distinguish it from other innovation approaches based on the dimensions of ‘in situ’ (in a use situation) and ‘ex situ’ (outside the use situation). Leminen (2013) in turn explains that users or user communities solve their needs through user involvement, and this approach can be either community-led or bottom-up. Moreover, Almirall et al. (2012) map living labs in a landscape of various forms of user involvement, proposing that while both the lead-user approach and living labs view users as co-creators, living labs apply in real-life environments.

In summary, user involvement is a key element of living labs (Mulder et al., 2008). The literature for the subject discusses users, citizens, end-users in living labs, and their crucial roles in innovation activities (Leminen et al., 2015). For instance, Eriksson et al. (2005) stress that citizens and civil societies are sources of innovation in living labs. Bergvall-Kåreborn and Ståhlbröst (2009) add that a key asset of living labs is the differences in users in society. In addition, the nature of user participation depends upon the type of a living lab (Leminen et al., 2012), but at the minimum, users can provide different contents, designs, texts, pictures, audio and video (Folstad, 2008b). In so doing, living labs help develop new products and services by engaging users with heterogeneous knowledge, ideas and experiences (Hielkema and Hongisto, 2013). However, both the active and passive roles of users are necessary in living labs for user-driven innovation (Leminen et al., 2015). In general, user involvement indicates a shifting of innovation towards the users, thus co-creating with them (Leminen et al., 2014).

### *3.3 Key characteristics of living labs*

As mentioned previously, the term 'living labs' is an upper-level one that covers multiple topics, so its key characteristics have been discussed from various perspectives. Table 1 shows the key elements found in the extant literature. Among them, Følstad (2008b) identifies several characteristics of living labs: context (e.g. context research, familiar context, real-world context), users (involving users as co-creators), activity (e.g. co-creation, technical testing, evaluation), challenges (discovery), and innovative outcomes (e.g. large-scale solutions). Mulder et al. (2008) in turn propose six elements of living labs: user involvement, service creation, infrastructure, governance, innovative outcomes, and methods and tools. They underline the importance of methods and tools, arguing that the ENoLL has been recognized in Europe as a primary source for the methods and tools applied in living labs.

Table 1. Key characteristical elements of living labs

| Characteristics | References |
|---|---|
| Real-life environments (context) | Bergvall-Kåreborn et al., 2009; Følstad, 2008b; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016 |
| Stakeholders | Bergvall-Kåreborn et al., 2009; Følstad, 2008b; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016 |
| Activities | Følstad, 2008b; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016 |
| Business models and networks | Bergvall-Kåreborn et al., 2009; Leminen and Westerlund, 2016; Mulder et al., 2008; Voytenko et al., 2016 |
| Methods, tools and approaches | Mulder et al., 2008; Bergvall-Kåreborn et al., 2009; Leminen and Westerlund, 2016 |
| Challenges | Følstad, 2008b; Guzman et al., 2013; Leminen, 2015 |
| Outcomes | Følstad, 2008b; Leminen and Westerlund, 2016; Mulder et al., 2008 |

| | |
|---|---|
| Sustainability | Nyström et al., 2014; Leminen et al., 2016; Bakici et al., 2013; Nevens at al., 2013; Rodrigues and Franco 2018 |

Furthermore, Bergvall-Kåreborn et al. (2009) point out five key components: ICT and infrastructure, management, partners and users, research, and approaches. They share the views of Følstad (2008b) and Mulder et al. (2008). Leminen and Westerlund (2016), meanwhile, identify four key aspects in nine identified research avenues for living labs, namely (i) systems (networks and ecosystems), (ii) milieu (real-life environments) and approach, (iii) user and public involvement, and (iv) the activity, project, or management tool. Finally, Voytenko et al. (2016) list geographical embeddedness, experimentation, learning, participation, user involvement, leadership, ownership, evaluation, and refinement as key characteristics of living labs, thus aligning with most of the previously identified key characteristics of living labs. We will elaborate on the various characteristics in the following subsections.

### *3.3.1 Real-life environments*

The experiences of users in Nordic countries has boosted the use of living labs for real-life experimentation in Europe (Edwards-Schachter et al., 2012). Whereas living labs are innovation infrastructures shared by various stakeholders (Guzman et al., 2013), they are also real-life environments in which to experiment, develop, co-create, validate and test existing products, services and systems, as well as develop new products and services with stakeholders (Folstad, 2008a; Leminen et al., 2012). Unlike conventional laboratory settings, living labs assume real-life environments. The previous literature documents a diverse set of environments, ranging from a single isolated place to broader environments such as educational institutes, people's homes and workplaces, and even a city or a part thereof (Nyström et al., 2014; Leminen et al., 2017b). The prior studies address the impact of real-life environments on innovation through living labs differently, however.

The *first stream of literature* considers real-life environments as landscape(s) intertwined with user and stakeholder activities (Leminen et al., 2017b). These studies assume that a contribution to the innovation and development process means exploring the context of use, the users, and the environment of use. Living labs are therefore seen as providing an environment in which to evaluate experiences and experiment in a real-world context within a familiar usage context (Schuurman et al., 2011). Conversely, Almirall and Wareham (2011) propose that high-level innovation is highly transferable across various international contexts, whereas low-level innovation is geographically and spatially constrained. They argue that living labs as infrastructures create tacit, experiential, and domain-based knowledge. Bergvall-Kåreborn et al. (2009) distinguish living labs as a user-centric space that prepares the users for open and distributed innovation and engages relevant stakeholders in real-life contexts in creating sustainable value. Such environments acts as a means to engage companies, citizens, researchers and public organizations for various purposes, such as learning (Hakkarainen and Hyysalo, 2013).

The *second stream of literature* portrays living lab methodologies as innovation activities in a real-life environment. For example, Edwards-Schachter et al. (2012) apply the living lab

methodology to identify user needs, preferences and expectations for innovation opportunities in social innovation spaces. Dell'Era and Landoni (2014), meanwhile, describe living labs as a design methodology to analyse user needs in different real-life environments. Hence, living labs are experiential environments where participants engage in a creative space to design and experience products and services (Dvarionene et al., 2015).

The *third stream of literature* focuses on the meaning of real-life environments. Such studies assume that living labs aspire to gather feedback from various contexts and innovation activities (Nyström et al., 2014). Surprisingly, the meaning of real-life environments is not well explored in the living labs literature. For instance, Leminen et al. (2015) attempt to analyse the role of real-life environments through paradoxical tension to induce new innovations. Finally, Bergvall-Kåreborn et al. (2015) differentiate between the concepts of place and space in living labs.

### *3.3.2 Stakeholders*

The existing literature about living labs emphasizes the presence of multiple stakeholders and highlights the makeup of public–private partnerships (3Ps) (e.g. Feurstein et al., 2008; Almirall and Wareham, 2011) or public–private–people partnerships (4Ps) (e.g. Bergvalll-Kåreborn et al., 2009a; Veeckman et al., 2013). Whereas the former encompasses collaboration with citizens, companies and public authorities (Almirall and Wareham, 2011), the latter puts forward the notion that companies, public agencies, universities, various institutions, and users participate in innovation activities in living labs (Westerlund and Leminen, 2011). In other words, living labs assume a quadruple helix (i.e. a collaboration between business, research and education, public administration, and civil society/users) (Hyysalo and Hakkarainen, 2014).

In contrast to many other forms of innovation, living labs involve heterogeneous stakeholders such as academics, developers, industry representatives, citizens, and users, as well as various public and private organizations in living lab networks (Ballon and Schuurman, 2015; Schuurman et al., 2011). The previous literature largely takes the view that multiple different stakeholders participate in innovation activities. For example, living labs involve users in a way that can be addressed by companies, public organizations, policy makers, and research institutions (Almirall and Wareham, 2008a). Evans et al. (2015) add that living labs bring a broad variety of stakeholders—such as researchers, students, citizens, user communities, external people, non-profit organizations, small firms, consultants, university estates, and facilities staff—together to co-create knowledge for sustainable products and services in real-world settings.

According to Westerlund and Leminen (2011), living labs comprise four key actors: *enablers, providers, users*, and *utilizers*. Enablers refer to the organizations that make it all possible, those that enable the activities of living labs and support them by promoting them or allocating financial backing or space for living labs. Enablers could be public actors, financiers, or non-governmental organizations (such as towns), municipalities, and regional development organizations (Leminen et al., 2012). Providers, meanwhile, are development organizations—such as educational institutes, universities, or consultants—that bring knowledge and expertise, as well as innovation support activities (Leminen et al., 2016). Users represent the citizens or end customers, and they are active or passive actors that participate in living labs in various roles.

Finally, utilizers are the public or private organizations that will benefit from the results of innovation activities in many ways (Leminen et al., 2012).

Living labs are used to structure user participation in real-life settings (Schuurman and De Marez, 2012). In so doing, living labs involve users in the innovation process by providing cohesion, offering support, developing competencies and promoting participants (Almirall and Wareham, 2008a). They can be open or closed in terms of participation. Open living labs imply that anyone can participate, while in closed living labs, participating users are pre-selected (Dell'Era and Landoni, 2014). The open approach is simple to implement, and it helps gather diverse feedback. The closed approach, in contrast, enables living labs to remain highly focused, and this approach requires engaging appropriate participants to solve problems.

Leminen et al. (2014) identify four user roles in living labs: informant, tester, contributor and co-creator. Users may participate in activities, such as technological services, training sessions and conversion meetings (Guzman et al., 2013). Utilizers, meanwhile, are the private or public organisations that will benefit from the outcomes of the innovation and development activities. They initiate and promote 'living labbing' (Mulder, 2012) to advance their own activities. Finally, the existing literature identifies numerous roles for participants (Juujärvi and Pesso, 2013; Leminen et al., 2014, 2015;Nyström et al., 2014). Among them, Nyström et al. (2014) list what is perhaps the most comprehensive set of 17 roles in open networks: advocate, accessory provider, builder, contributor, coordinator, co-creator, facilitator, gatekeeper, informant, instigator, messenger, orchestrator, planner, producer, tester, and webber. Moreover, they point out four approaches to the roles: structuralist, symbolic interactionist, resource-based and action-based approaches. Stakeholder roles are very intertwined with living lab activities.

*3.3.3 Activities*

The main body of the living labs literature reveals and describes the innovation activities conducted in living labs. The activity is one of the most used perspectives when understanding living labs, and the literature provides a comprehensive analysis of innovation and collaboration activities, such as testing, validation, experimentation and co-creation. For example, Almirall and Wareham (2008a) identify three activities for living labs: (i) they provide services around the user experience by engaging companies; (ii) they support lead users as entrepreneurs; and (iii) they organize users in the innovation process. Mulder et al. (2008) in turn suggest that living labs represent sensing, prototyping, validating, and refining complex solutions in multiple real-life settings. Living labs are suitable for developing, co-creating, validating, and testing technologies (Almirall et al., 2012; Leminen and Westerlund, 2016). Policy makers use them to design, explore, experience, and refine new policies and regulations in real-life settings. Importantly, living labs are facilitated rather than managed, because they do not assume any authority over the individual participants (Westerlund and Leminen, 2011), and they are considered an ongoing business activity (Leminen and Westerlund, 2016).

Living labs can be distinguished from test beds, which emphasize the controlled testing of technologies in a laboratory setting (Ballon et al., 2005). Indeed, in a test bed setup, users are involved as passive participants. In contrast, living labs encapsulate a broad variety of innovation activities, and users are generally considered active participants. Many living labs are of course

used to test ICT and services (Buhl et al., 2017), but co-creation as part of the living labs experience seems to be very important (Folstad, 2008a). Similarly, the core elements in the living lab terminology include co-creation, co-production, an experimental environment, real-life, users, and producers (Franz, 2015). Westerlund and Leminen (2011) identify different approaches to user involvement. Indeed, a user may be both an object and a subject in innovation-development activities (Ballon et al., 2005). When a user is an object, it refers to he or she revealing their own (user) needs and experiences, and this relates to a customer-centric model. When a user is a subject, in contrast, the experience includes co-developing or co-creating innovation, and this relates to a user-driven model. Users' collaboration with other living lab actors is important for value co-creation (Leminen et al., 2012). Living labs stress a shared infrastructure through the management of participating user communities, controlled and real environments for product validation, logical infrastructure for user innovation, living lab strategies, business models, technology transfer processes, and tools to facilitate innovation sharing (Guzman et al., 2013). A living lab entails iterative testing and feedback (Veeckman and van der Graaf, 2015).

Living labs represent a form of experimentation wherein the innovation and learning processes are explicitly specified (Voytenko et al., 2016). Living lab experiments allow understanding the society's technological requirements and the social impacts of innovation (Hakkarainen and Hyysalo, 2013). An iterative process of experimentation over a period of time provides a coherent base for technological applications (Evans et al., 2015). Almirall and Wareham (2008a) argue that living labs could be better portrayed as an organization's activity for technological transfer and the promotion of a city.

Living labs are intermediaries, and they need vital support from other types of intermediaries. Intermediaries who can mediate between developers and users are crucial, and general process facilitation is not enough (Hakkarainen and Hyysalo, 2013). Almirall and Wareham (2011) propose living labs as open innovation intermediaries assuming a private-public-people partnership. Intermediaries also need to provide technical configuration and substance issues for living labs (Hakkarainen and Hyysalo, 2016). Dvarioniene et al. (2015) consider the stakeholder involvement process as an investment in the future. Living labs provide the opportunity for comprehensive analysis of potential solutions (Franz 2015), and they are useful in gaining multi-dimensional input for innovations (Ståhlbröst, 2013). They also help identify a community's needs and support technological innovations in local governance (Almirall and Wareham, 2008). Living labs increase the innovative capacity of an organization by promoting user involvement, and engaging actors who can help acquire knowledge and develop business models is essential to capture value. Living labs are therefore appropriate when collaboration between industry, research organisations, user communities, civil society, and administrations is essential (Guzman et al., 2013).

To simplify the broad variety of documented living lab activities, Almirall and Wareham (2011) suggest grouping diverse innovation activities into two categories: exploitation and exploration. Exploitation covers activities targeting efficiency, implementation, execution, production, selection, choice and refinement, whereas exploration covers activities like capturing, discovering, generating, and creating new knowledge and competences (March, 1991). These activities can be performed through variations, risks, experiments, plays, flexibility, and innovation.

### *3.3.4 Business models and networks*

An emerging stream of literature investigates living labs from the business model perspective (Rits et al., 2015). While business models and networks are somewhat similar and closely intertwined concepts, there are also clear differences between them (Zott and Amit, 2010). The business model and the living lab share a similar objective. However, studies of business models typically focus on a single organization, whereas living labs encompass a broad variety of stakeholders. Living labs explore the feasibility of a business model of complex solutions in real-life contexts (Almirall and Wareham, 2011). Value proposition as a key element of a business model is challenging to communicate in the living lab context, because living labs mean different things to different stakeholders (Schaffers and Turkama, 2012). Many living labs rely on sustainable business models, however, because they operate through project-based funding associated with universities or urban-development agencies. The role of technology may be understood in terms of value appropriation and creation (Dell'Era and Landoni, 2014).

Studies predominantly suggest that living labs include multiple stakeholders. For example, Leminen et al. (2012) identify diverse types of living labs. Living labs are by definition networks, because they include multiple stakeholders in innovation and development activities (Nyström et al., 2014), so the bulk of living lab literature considers living labs as networks or ecosystems and uses the components, actors, activities and resources of living labs to describe such networks (Veeckman et al., 2013; Leminen et al., 2016). Moreover, living labs are complex and require the careful development of networks and their components (Leminen et al., 2016). For example, living labs provide resources, including physical or virtual spaces, in an open environment (Guzman et al., 2013). Resources for living labs also include facilities, such as co-designs, test beds, and management tools to support the interaction between stakeholders.

Although a growing body of literature conveys living labs as networks, explicit studies of living lab networks and their structures are still rare. Among them, Mulder et al. (2008) argue that living labs are not just networks of infrastructure and services but also networks of real people with rich experiences, while Westerlund and Leminen (2011) discuss regional and global living lab networks of multiple actors. Leminen and Westerlund (2012) in turn explore a single living lab network encompassing the networks of participating stakeholders. Such living lab networks share the mutual objectives of different stakeholders, but if necessary, they can replace the knowledge and competence coming from the living lab network. Furthermore, Schuurman et al. (2013) characterize living labs as innovation networks with six defining elements: a natural setting, multiple stakeholders, multiple methods, short- and long-term views, user-centricity, and infrastructure. Moreover, Leminen (2015) categorises living labs as networks including a network of living labs, a network in the innovation system, a network of cross-border collaboration, or single and dual living lab networks in the living lab literature.

Leminen et al. (2012) highlight four types of living labs driven by different network actors. These are driven by different actors and share similar stakeholders, but the aims and the durations of them differ considerably. Leminen et al. (2016) identify three types of network structures in living labs: the distributed multiplex network structure, the distributed network structure, and the centralized network structure. Moreover, the authors argue that there are

relationships between different network structures and the driving party, as well as innovation outcomes. They suggest that the distributed multiplex network structure enhances the emergence of radical innovations, whereas incremental innovations are often linked with distributed and centralized network structures. In addition, the authors suggest that a combination of a provider- or utilizer-driven living lab with a distributed multiplex network structure supports the emergence of radical innovation. Finally, Rodrigues and Franco (2018) propose living labs as open networks promoting entrepreneurship. In summary, living labs show various types of business models and network structures.

### *3.3.5 Methods, tools and approaches*

Organizations increasingly apply living labs in their innovation and development processes. Consequently, the previous literature describes these processes through their methods, approaches and tools. With regard to approaches, living labs have been discussed through various designs and their combinations (Leminen and Westerlund, 2016), suggesting that there are varying perspectives for the living lab approach. For example, it may stand for methods and techniques that emerge as best practice (Bergvall-Kåreborn et al., 2009). Leminen (2013) proposes that a coordination approach includes both top-down and bottom-up configurations, while the participation approach includes inhalation-dominated and exhalation-dominated options. Schuurman and De Marez (2012) point out that living labs differ from the other innovation approaches in their high degree of realism and involvement, where the users become partners in the innovation process. Living labs are relevant to measuring human behaviours and interactions (Centellegher et al., 2016), and they provide an environment of innovation in which to engage all relevant stakeholders in different phases to co-create value. For instance, Almirall et al. (2012) argue that living labs engage a group of users in the innovation process and keep them engaged iteratively throughout the process. Similarly, Brankaert et al. (2015) underline the importance of actively involving relevant stakeholders from the initial to the final stages of the innovation process. Finally, Hakkarainen and Hyysalo (2013) propose that living labs help in developing context-wise insights into development and acceptance processes.

Edwards-Schachter et al. (2012) argue that, as a method, living labs stress users' involvement in innovation for an organization. They view living labs as spaces for social innovation, where a method is applied for collaborative contextual innovation. Indeed, the living lab method is applied to explore a variety of user needs, or specific categories of user needs, where context is an important element and users are allowed to interact with new products and services in everyday life (Dell'Era and Landoni, 2014). Participation may be open to any potential users or limited to preselected users based on the nature and practice of the living lab. Design-driven methods work in real-life settings and are led by professional designers looking for new solutions. Several methods are applied in living labs, including ethnography and lead user innovation. Participants in living labs produce drawings, pictures, figures, and other representations to illustrate solutions to a particular problem (Guzman et al., 2013).

ENoLL has been recognized in Europe as a major source of the various methods and tools used in different living labs (Mulder et al., 2008). The previous literature also suggests a number of methods, including the collection and analysis of system logs, behavioural data, ethnographic research, questionnaires, focus groups, and observation in living labs. Thus, living labs provide

the tools to validate technologies and facilitate the development of products and services according to the needs of users. Overall, living labs represent a promising tool to stimulate co-creation by including diverse target groups (Franz, 2015). This approach needs particular methods and tools to find relevant user data, however (Mulder et al., 2008). Living labs often include just a small number of users, as is frequently reported (Folstad, 2008a). For example, living labs may recruit user panels with specific characteristics to develop and test products and services (Schuurman and De Marez, 2012). However, living labs differ widely in their use of methods and tools (Leminen and Westerlund, 2017), and the developed technologies need to be malleable, adaptable or multi-useable (Almirall and Wareham, 2008a). Finally, living labs are often used in the ICT sector to explore new applications (Brankaert et al., 2015), and they are recognized as a means to tackle the innovation challenges that are faced by ICT service providers (Folstad, 2008a).

*3.3.6 Challenges*

The previous literature also suggests the importance of close collaboration between participants in living labs in order to accelerate innovation activities. In so doing, stakeholders bring heterogeneous resources and knowledge into joint activities, and there may be a collision of ideas between stakeholders and between a context and stakeholders (Leminen and Westerlund, 2012). Although prior studies are quite unified in their view of close collaboration and the benefits it brings to different stakeholders, they stress challenges related to the methods and concepts of living labs. These challenges are diverse and associated with the type of living lab and the context in which it operates. They include *temporality*, *governance*, *unforeseen outcomes, efficiency*, *the recruitment of user group(s)* and *the sustainability and scalability of their innovation activities*.

The previous literature discusses the *temporality* of living labs and their activities. For example, Leminen et al. (2012) suggest that utilizer-driven living labs often have a short-term focus on organizational needs. Key participants may leave living lab activities, and there will be a need to replace such players (Leminen and Westerlund, 2012). The long-term value of living labs is also often difficult to demonstrate to businesses, user communities, and society (Guzman et al., 2013).

Next, the *governance* of living labs is challenging due to the multifaceted situation (van Geenhuizen et al., 2013), and project management tools that assume linear thinking do not support activities (Westerlund and Leminen, 2011). Living labs comprise multiple stakeholders who are often beyond organizational boundaries, and they cannot manage or control stakeholders but rather just motivate them to engage in innovation activities (Ståhlbröst and Bergvall-Kåreborn, 2011; Leminen and Westerlund, 2012). Diverse competences and the interests of the actors may complicate technology development projects (Hakkarainen and Hyysalo, 2013), and stakeholders may provide negative feedback that may be difficult to embrace (Dvarionene et al., 2015).

Furthermore, prior studies report that living labs steer innovation activities through their results with multiple stakeholders (Ståhlbröst, 2008), and such results often lead to *unforeseen outcomes* (Leminen et al., 2017b). Hence, living labs cannot guarantee the achievement of the anticipated

results, and their activities often lead to unforeseen outcomes due to feedback from users. In fact, Almirall and Wareham (2008) propose that a living lab faces challenges in gaining support for better products and social readiness.

Moreover, the *efficiency* of innovation activities depends on learning in the innovation process (Leminen and Westerlund, 2012). Scholars frequently suggest that collaborative learning in real-life environments is one of the main rationales for setting up a living lab (Hakkarainen and Hyysalo, 2013). Hence, the success of living labs depends on transferring knowledge between different parties. Often, a painful and conflicting effort is required to establish a valuable learning environment. Learning is lost on many occasions as groups disband and the outcomes of a living lab are commercialized by people unrelated to the project (Almirall and Wareham, 2008).

Furthermore, living labs research so far describes both passive and active user participants (Leminen et al., 2015). As regards passive user participants, *recruitment of user groups* may be challenging because new technologies may attract people with certain personal traits (Bergvall-Kåreborn and Ståhlbröst, 2009). Conversely, active user participants have their own interest in innovation activities (Nyström et al., 2014). User participation is high when sustainability is highly relevant to participants (Buhl et al., 2016). User engagement should therefore not be taken for granted, even if the activities seek to solve real-life problems faced by the participants. Co-creation is an ambition rather than a certainty in some living labs (Folstad, 2008a).

Finally, living labs require long-term funding to *sustain and scale up* their innovation activities (Guzman et al., 2013; Evans et al., 2015). They may rely heavily on public funding, which limits their growth (Almirall and Wareham, 2008). The underlying assumption is that the intended goal emerges based on the achieved results of living lab activities among the stakeholders. Living labs face challenges, such as a lack of standardization and insufficient criteria for living lab performance (Schaffers and Turkama, 2012). In summary, the challenges that living labs face are diverse and vary significantly from one instance to another.

### *3.3.7 Outcomes*

The living lab literature provides diverse results for innovation outcomes, although by definition, living labs assume innovation activities that take place among stakeholders. Past studies describe outcomes as a part of the innovation activities rather than focusing on differentiating or categorizing innovation outcomes. More specifically, prior studies present the outcomes of living labs in two different ways: (i) tangible and intangible innovation and (ii) a diversity of innovation. However, some outcomes may be both intangible and intangible, based on their contexts.

Table 2. Main outcomes of living labs

| Outcome type | Major outcomes | References |
|---|---|---|
| Tangible innovation | Design | Evans et al., 2015; Buhl et al., 2017 |
| | Product | Ballon et al., 2005; Mulder et al., 2008; Leminen and Westerlund, 2012; Veeckman et al., 2013; Dell'Era and |

| | | |
|---|---|---|
| | | Landoni, 2014; Nyström et al., 2014; Evans et al., 2015; Leminen et al., 2015; Leminen et al., 2017 |
| | Prototype | Leminen and Westerlund, 2012; Nyström et al., 2014; Leminen et al., 2015 |
| | Solution | Ballon et al., 2005; Leminen and Westerlund, 2012; Leminen et al., 2017 |
| | System | Ballon et al., 2005; Nyström et al., 2014; Leminen et al., 2015; Leminen et al., 2017 |
| Intangible innovation | Concept | Nyström et al., 2014; Leminen et al., 2015 |
| | Idea | Nyström et al., 2014; Leminen et al., 2015; Leminen et al., 2017 |
| | Intellectual property rights | Mulder et al., 2008 |
| | Knowledge | Mulder et al., 2008 |
| | Service | Ballon et al., 2005; Dell'Era and Landoni, 2014; Evans et al., 2015; Mulder et al., 2008; Veeckman et al., 2013 |
| Diversity of innovation | Incremental innovation | Almirall and Wareham, 2011; Nyström et al., 2014; Leminen et al., 2015, 2016 |
| | Market innovation | Liedtke et al., 2012 |
| | Mid- and ground-level innovation | Almirall and Wareham, 2011 |
| | Product innovation | Schaffers and Turkama, 2012; Buhl et al., 2017 |
| | Radical innovation | Nyström et al., 2014; Leminen et al., 2015, 2016 |
| | Service innovation | Schaffers and Turkama, 2012; Buhl et al., 2017 |
| | Social innovation | Liedtke et al., 2012; Edwards-Schachter et al., 2012; Rodrigues and Franco, 2018 |
| | Systemic innovation | Schaffers and Turkama, 2012 |
| | Technological innovation | Liedtke et al., 2012; Rodrigues and Franco, 2018 |

Tangible outcomes include designs, products, prototypes, solutions and systems, whereas intangible outcomes include concepts, ideas, intellectual property rights, knowledge and services (Buhl et al., 2017; Dell'Era and Landoni, 2014; Evans et al., 2015). Ballon et al. (2005) address products, services, solutions and systems when differentiating living labs from test and experimental platforms. Knowledge, new products and services, and intellectual property rights are innovation outcomes in living labs (Mulder et al., 2008). Translating a latent user need into a novel product or service offering can be challenging, but a living lab may provide solutions and prototypes (Leminen and Westerlund, 2012). In innovation outcomes, products and services are coupled with the living lab environment and various approaches (Veeckman et al., 2013). The

objectives of living labs may target the development of a wide variety of products, systems, and services (Nyström et al., 2014; Leminen et al., 2015).

The diversity of innovation suggests many innovation outcomes for living labs, with most being incremental (Almirall and Wareham, 2011). The stakeholders' roles in diverse incremental and radical innovations in real-life contexts are therefore crucial (Nyström et al., 2014). Product and service innovations are typical outcomes of living labs (Schaffers and Turkama, 2012), but systemic innovations can also be outcomes of living labs and their ecosystems. Product and service innovations can be linked with innovation designs (Buhl et al., 2017). The role of space in the emergence of social innovations is important (Edwards-Schachter et al., 2012; Liedtke et al., 2012). Social and technological innovations can also be outcomes, with the real-life environment supporting the development and testing of such innovations (Rodrigues and Franco, 2018). Network structures and the driving parties of living labs can also be combined for incremental and radical innovations (Leminen et al., 2016). Most studies, however, address incremental innovations, and very few explore radical innovations.

*3.8 Sustainability*

Sustainability is a global issue, and sustainable development is an increasingly important topic, yet many living labs do not seem to explicitly focus on them. Sustainable innovation and living labs are closely related to each other, and development and sustainability are implicitly embedded in many scholarly studies into living labs. For example, some studies analyse innovation and development activities that look to improve the everyday life of citizens in a sustainable way (Nyström et al., 2014; Leminen et al., 2016). Despite advancements in collaborative innovation for smart cities (Bakici et al., 2013), there are limited studies on sustainable development in the existing literature.

Transition labs provide arenas for change, and they focus on sustainable development in urban settings, such as smart cities (Nevens at al., 2013). Bulkeley et al. (2016) propose that design, practice, and process (three elements of living labs) play critical roles in urban development and environmental transformation. Leminen et al. (2017b) in turn discuss platforms and sustainable development in activities for smart cities. Rodrigues and Franco (2018) put forward living labs as vehicles for urban development and entrepreneurship.

Sustainability is considerably relevant at the individual, organizational, societal and governmental levels, and living labs mainly focus on sustainable products and services (Liu et al., 2014). In addition, Buhl et al. (2016) argue that user engagement can be stimulated by focusing on sustainability challenges and encouraging users to express their opinions in order to have sustainable outcomes. Living labs can address sustainability issues, for example, by selecting the right materials and environmentally friendly processes to reduce a social and economic impact (Ståhlbröst, 2012). Furthermore, living labs emerge as a type of collective governance and experimentation to address sustainability, especially in urban areas (Voytenko et al., 2016).

The sustainability of living labs increases when networks of cross-border collaborations strengthen creativity and innovation (Bergvall-Kåreborn et al., 2009). Living labs provide an environment in which to bring different actors together to contribute to sustainable development

(Buhl et al., 2016). In this vein, Rodrigues and Franco (2018) find that living labs are the 'cradle' for some entrepreneurships and a vehicle for economic and social development. They can address pressing urban problems, such as building design, green infrastructure, and low-carbon technologies through experiments by integrating users and stakeholders (Evans et al., 2015). In the context of a living lab, sustainability refers to its viability and responsibility to the community among which it operates (Bergvall-Kåreborn et al., 2009). Thus, living labs can be concerned with environmental, economic and social effects. However, some scholars argue that most living labs lack a sustainable business model because they operate under project-based funding (Schaffer and Turkama, 2012). Sustainable living labs also face difficulties in assessing products and services (Buhl et al., 2017). Overall, living labs contribute to societal development in urban areas by engaging relevant stakeholders.

## 4. Implications, limitations, and future research avenues

This study aimed to review the accumulated literature about living labs in order to understand the central facets presented in the nascent research. We conducted a thematic, systematic literature review for a sample of 114 scholarly articles about living labs from a variety of disciplines. Our findings about living labs and their key characteristics provide some significant contributions to the body of knowledge for living labs for both scholars and practitioners. We now point out the theoretical contributions, managerial implications and suggest some future research avenues.

### *4.1 Theoretical implications*

This study provides three theoretical implications for the living lab literature. Firstly, we highlight the paradigms of living labs, particularly open and user innovation. Secondly, we analyse the key characteristics of living labs as discussed in the literature. Thirdly, we address the role of living labs in sustainable development.

*Paradigms of living labs:* Open innovation and user innovation are paradigms that are frequently referred to and reported as keywords in studies. These two paradigms are often intertwined with the description and analysis of living labs. However, the concept of the living lab is not yet well integrated into the open innovation and user innovation literature. Open innovation mainly focuses on bipolar relations between firms, whereas living labs assume multiple stakeholders and consider the importance of the real-life environment. User innovation, in turn, assumes that users or user communities are valuable in overcoming challenges (von Hippel, 2007). Living labs assume that innovation activities take place between a broad variety of stakeholders rather than focusing solely on innovation activities within the user community or between a user community and a firm. Co-creation is a core innovation activity that take place in a living lab with its diverse stakeholders and users. Mainstream open innovation scholars rarely cite living labs as a form of open innovation. In other words, they remain largely beyond the well-acknowledged open innovation literature.

*The key characteristics of living labs:* The existing literature comprises various research streams (Leminen et al., 2012) and suggests various characteristics for living labs. These characteristics are diverse, especially as each living lab has its own unique objectives, operation, finance, and actors. Moreover, living labs are described as an approach, method, context, environment, experimentation, network, business model, and intermediary. However, the usage and

explanations of such terms in the previous literature are very inconsistent. Acknowledging this diversity, we conclude that the definitions for living labs and their usage varies significantly in the literature. Nonetheless, our literature review revealed eight key characteristics of living labs: (i) real-life environments; (ii) stakeholders; (iii) activities; (iv) business models and networks; (v) methods, tools and approaches; (vi) innovation outcomes; (vii) challenges; and (viii) sustainability.

*Living labs and sustainable development:* Sustainable development is implicitly embedded in some scholarly studies, but most seem to ignore it. However, there are some recent exceptions. Living labs allow complementary sets of projects to offer holistic solutions to tackle unsustainable issues (Evans et al., 2015), and they are valuable for their contribution to sustainable development. Furthermore, living labs emphasize sustainability through continuous learning and development, and they can take significant responsibility for economic, social and ecological effects.

### *4.2 Managerial implications*

Living labs have been said to offer multiple benefits to businesses, societies and users. Furthermore, living labs support stakeholders by integrating policymaking and business-development issues. A wider use of living labs enhances the inclusion and usefulness of their applications in society. Thus, living labs are vital for transforming everyday knowledge generation into models, methods and theories. For example, living labs are particularly valuable to different stakeholders for the opportunities they bring, because they provide the possibility to obtain user feedback and insights, conduct experiments, and involve a number of users in the innovation process. They tap into tacit knowledge that can be incorporated into products and services (Franz, 2015). Communicating the aim, scope, and framework of the process in a transparent manner can help maximize the benefits from the stakeholders' various contributions (Dvarionene et al., 2015). Gaining valid knowledge input is a key concern for an effective application, however.

Many companies consider living labs to be a valuable option for developing, testing, and improving their services with the help of users (Guzman et al., 2013), because living labs support innovation and result in usable products and services. They offer governance and a structure for perceiving users' insight and filtering problems to promote user entrepreneurship (Hakkarainen and Hyysalo, 2013). According to Juujärvi and Pesso (2013), collaboration between stakeholders is crucial for the creation of innovative services, and in particular, creating networks and engaging users are keys for a successful living lab. Stakeholders not only help create new services—they also develop mutual understanding among themselves, which is very useful for solving local problems. Living labs offer the opportunity for all stakeholders to develop a city together in a real-life setting.

### *4.3 Limitations and future research avenues*

This study has several limitations. Firstly, while it adopts the systematic literature review approach on a set of articles published over the past 12 years, it does not include publications beyond that period. Secondly, this study identified the most significant publications during the selected period and narrowed down the sample to comprise studies in the disciplines of

innovation management, business, engineering, and computer and information science. Thirdly, although our sample was quite extensive, covering multiple disciplines and articles published over a long period, we were not able to encompass all living lab publications. We suggest future research avenues as follows.

The existing literature mainly documents incremental innovations. Few studies explicitly highlight radical innovation in the living lab context (Nyström et al., 2014; Leminen et al., 2016). Studies exploring the commercial value of living lab activities are also sparse. A collaborative real-life environment that engages various types of participants is a key requirement of living labs. However, there may be a dissonance between the aim of living labs and the existing reality (Almirall and Wareham, 2008a). The benefit or value of living labs for stakeholders may be perceived (Leminen and Westerlund, 2012), but the literature remains silent about quantifying and expressing the value of living labs in clear, measurable values. Living labs run mainly based on national or regional funding, and most funding for them is project-based. Therefore, very sustained funding is vital to keeping living labs active for a long period (Guzmán et al., 2013). Future research could provide insights into quantifying how beneficial living labs are with clear, measurable values and how their funding can be sustained.

The previous literature also lacks comparative studies to identify the best performing and most effective management approaches for living labs. Although both scholarly and managerial studies into living labs suggest many benefits for different stakeholders, their nature and real contribution remain little known. Stakeholders wishing to set up a living lab and its activities, as well as firms considering developing one, find limited reference models for developing and managing a living lab. Creating an appropriate business model to apply products and services in practice is a pivotal challenge for living labs. Furthermore, they comprise numerous types of stakeholders, and while various stakeholders certainly help to explore a problem from various perspectives, it can be challenging to keep all stakeholders focused on the main objective of a project. Future research could explore the stakeholders of living labs from various perspectives.

It may also be very insightful to understand the various facets of living labs, especially considering that there are a large number of living labs, as well as even more project initiatives in those living labs. Many scholars interested in living labs argue that they are a form of open innovation and user innovation. Future studies could explore various types of open innovation activities that are performed in different initiatives. To deepen our understanding, a comprehensive exploration of the relationship between structures and users in living labs as a context for user participation from the co-creation perspective is necessary. This will be crucial in linking and exploring public policy and innovation management initiatives in future.

Furthermore, it is necessary to synthesize the multi-scalar aspects of various living labs. A rigorous analysis of the suitability of living labs for methodologies, products, services, costs and benefits would be beneficial in helping the living labs community to understand when and where living labs offer the greatest benefits for the diverse stakeholders. In addition, the contribution of living labs to smart cities has not been comprehensively analysed (Leminen et al., 2017b). What is more, there is limited knowledge about how living lab networks are structured and organized in practice (Leminen et al., 2016). Some scholars propose three elements for living labs: openness, empowerment and realism. A deeper understanding of how these three elements bolster each other in a living lab project is crucial.

Living lab networks can be distinguished in accordance with the different types of living labs based on their coordination and participation factors, and this is an under-researched area in the literature (Leminen, 2013). In addition, future studies could consider the longitudinal perspectives of living labs and related projects. Westerlund and Leminen (2011) argue that living labs are not projects but rather a systematic method of innovation. Exploring how the role of the users changes over time in different projects and contexts is therefore crucial, as is a cross-country and longitudinal analysis of innovation in living labs. Understanding how living labs perform in multifaceted situations, as well as the power distribution in the networks and governance, is essential. The support that living labs receive from other intermediaries is also under-researched in the literature. Finally, developing a balanced understanding could be ensured by linking the freshness of the living lab phenomenon with the high heterogeneity in living lab cases. We believe that this study will inspire such future research.


## Acknowledgements

The lead author is grateful to the European Commission for the Marie Skłodowska-Curie Individual Fellowship grant to explore the living lab phenomenon (proposal number: 749423).


## References


Almirall, E., & Wareham, J. (2008a). Living labs and open innovation: Roles and applicability. *eJOV: The Electronic Journal for Virtual Organization & Networks*, *10*.

Almirall, E. & Wareham, J. (2008b) The role of living labs in open innovation, In European Living Labs – a new approach for human centric regional innovation Eds. J. Schumacher & V-P Niitamo. Berlin: Wissenschaftlicher Verlag Berlin, pp. 148-165.

Almirall, E., & Wareham, J. (2011). Living Labs: arbiters of mid-and ground-level innovation. *Technology Analysis & Strategic Management*, *23*(1), 87-102.

Almirall, E., Lee, M., & Wareham, J. (2012). Mapping living labs in the landscape of innovation methodologies. *Technology innovation management review*, *2*(9), 12-18.

Bakıcı, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. *Journal of the Knowledge Economy*, *4*(2), 135-148.

Ballon, P., Pierson, J., & Delaere, S. (2005). Test and experimentation platforms for broadband innovation: Examining European practice. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1331557

Ballon, P., & Schuurman, D. (2015). Living labs: concepts, tools and cases. *Info*, *17*(4).

Bergvall-Kåreborn, B., Eriksson, C. I., Ståhlbröst, A., & Svensson, J. (2009). A milieu for innovation: defining living labs. In *ISPIM Innovation Symposium*.

Bergvall-Kareborn, B., & Stahlbrost, A. (2009). Living Lab: an open and citizen-centric approach for innovation. *International Journal of Innovation and Regional Development*, *1*(4), 356-370.

Bergvall-Kåreborn, B., Eriksson, C. I., & Ståhlbröst, A. (2015). Places and spaces within Living Labs. *Technology Innovation Management Review*, *5*(12), 37-58.

Brankaert, R., Ouden, E. D., & Brombacher, A. (2015). Innovate dementia: the development of a living lab protocol to evaluate interventions in context. *Info*, *17*(4), 40-52.

Budweg, S., Schaffers, H., Ruland, R., Kristensen, K., & Prinz, W. (2011). Enhancing collaboration in communities of professionals using a Living Lab approach. *Production Planning & Control*, *22*(5-6), 594-609.

Buhl, J., von Geibler, J., Echternacht, L., & Linder, M. (2017). Rebound effects in Living Labs: Opportunities for monitoring and mitigating re-spending and time use effects in user integrated innovation design. *Journal of Cleaner Production*, 151, 592-602.

Bulkeley, H., Coenen, L., Frantzeskaki, N., Hartmann, C., Kronsell, A., Mai, L., Marvin, S., McCormick, K., van Steenbergen, F., & Palgan, Y. V. (2016). Urban living labs: governing urban sustainability transitions. *Current Opinion in Environmental Sustainability*, *22*, 13-17.

Centellegher, S., De Nadai, M., Caraviello, M., Leonardi, C., Vescovi, M., Ramadian, Y., Oliver, N., Pianesi, F., Pentland, A., Antonelli, F., & Lepri, B. (2016). The Mobile Territorial Lab: a multilayered and dynamic view on parents' daily lives. *EPJ Data Science*, *5*(1), 3.

Chesbrough, H. W. (2006). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

Dahlander, L., & Gann, D. M. (2010). How open is innovation?. *Research Policy*, 39(6), 699-709.

Dell'Era, C., & Landoni, P. (2014). Living Lab: A methodology between user-centred design and participatory design. *Creativity and Innovation Management*, *23*(2), 137-154.

Dvarioniene, J., Gurauskiene, I., Gecevicius, G., Trummer, D. R., Selada, C., Marques, I., & Cosmi, C. (2015). Stakeholders involvement for energy conscious communities: The Energy Labs experience in 10 European communities. Renewable Energy, 75, 512-518.

Edvardsson, B., Kristensson, P., Magnusson, P., & Sundström, E. (2012). Customer integration within service development—A review of methods and an analysis of insitu and exsitu contributions. *Technovation*, *32*(7-8), 419-429.

Edwards-Schachter, M. E., Matti, C. E., & Alcántara, E. (2012). Fostering quality of life through social innovation: A living lab methodology study case. *Review of Policy Research*, *29*(6), 672-692.

ENoLL (2018), Bill Mitchell, Father of the Living Lab Concept, passed away this weekend http://www.openlivinglabs.eu/news/call-papers-living-labs-openlivinglab-days-2018 (22.02.2018).

Eriksson, M., Niitamo, V. P., & Kulkki, S. (2005). State-of-the-art in utilizing Living Labs approach to user-centric ICT innovation-a European approach. *Lulea: Center for Distance-spanning Technology. Lulea University of Technology Sweden: Lulea*.

Evans, J., Jones, R., Karvonen, A., Millard, L., & Wendler, J. (2015). Living labs and co-production: university campuses as platforms for sustainability science. *Current Opinion in Environmental Sustainability*, *16*, 1-6.
Feurstein, K., Hesmer, A., Hribernik, K. A., Thoben, K. D., & Schumacher, J. (2008). Living Labs: a new development strategy. *European Living Labs-a new approach for human centric regional innovation*, 1-14.
Franz, Y. (2015). Designing social living labs in urban research. *Info*, 17(4), 53-66.
Følstad, A. (2008a). Living labs for innovation and development of information and communication technology: a literature review. *The Electronic Journal for Virtual Organizations and Networks* 10, 99-131.
Følstad, A. (2008b). Towards a living lab for development of online community services. *Electronic Journal for Virtual Organizations and Networks*, 10, 47-58.
Gonzalez-Albo, B., & Bordons, M. (2011). Articles vs. proceedings papers: Do they differ in research relevance and impact? A case study in the Library and Information Science field. *Journal of Informetrics*, 5(3), 369-381.
Guimont, D., & Lapointe, D. (2016). Empowering Local Tourism Providers to Innovate through a Living Lab Process: Does Scale Matter?. *Technology Innovation Management Review*, *6*(11), 18-25.
Guzman, J. G., del Carpio, A. F., Colomo-Palacios, R., & de Diego, M. V. (2013). Living labs for user-driven innovation: a process reference model. *Research-Technology Management*, 56(3), 29-39.
Hakkarainen, L., & Hyysalo, S. (2013). How do we keep the living laboratory alive? learning and conflicts in living lab collaboration. *Technology Innovation Management Review*, *3*(12), 16-22.
Hakkarainen, L., & Hyysalo, S. (2016). The evolution of intermediary activities: Broadening the concept of facilitation in living labs. *Technology Innovation Management Review*, *6*(1), 45-58.
Hielkema, H., & Hongisto, P. (2013). Developing the Helsinki smart city: The role of competitions for open data applications. *Journal of the Knowledge Economy*, *4*(2), 190-204.
Hossain, M. (2016). Grassroots innovation: A systematic review of two decades of research. *Journal of Cleaner Production*, 137, 973-981.
Hyysalo, S., & Hakkarainen, L. (2014). What difference does a living lab make? Comparing two health technology innovation projects. *CoDesign*, *10*(3-4), 191-208.
Jarvenpaa, S. L., & Wernick, A. (2012). Open innovation networks: The evolution of bureaucratic control. In *Collaborative Communities of Firms* (pp. 9-33). Springer, New York, NY.
Juujärvi, S., & Pesso, K. (2013). Actor roles in an urban living lab: what can we learn from Suurpelto, Finland?. *Technology Innovation Management Review*, *3*(11), 22-27.
Knight, T. (1749). Reflections upon Catholicons, or Universal Medicines. London: Printed for T. Osborne in Gray's-Inn
Kviselius, N.Z., Andersson, P., Ozan, H. & Edenius, M. (2009). Living labs as tools for open innovation", Communications and Strategies, 74, 490-504.
Leminen, S., Westerlund, M., & Nyström, A. G. (2014). On becoming creative consumers–user roles in living labs networks. *International Journal of Technology Marketing*, *9*(1), 33-52.
Leminen, S., & Westerlund, M. (2012). Towards innovation in Living Labs networks. *International Journal of Product Development*, *17*(1-2), 43-59.
Leminen, S., & Westerlund, M. (2016). A framework for understanding the different research avenues of living labs. *International Journal of Technology Marketing*, 11(4), 399-420.
Leminen, S. & Westerlund, M. (2017). Categorization of Innovation Tools in Living Labs. *Technology Innovation Management Review*. 7(1): 15–25. (JUFO 1)
Leminen, S., Niitamo, V. P. & Westerlund, M. (2017a) A Brief History of Living labs: From Scattered Initiatives to Global Movement. OpenLivingLab days 2017. August 29–September 1, 2017. Krakow, Poland
Leminen, S., Nyström, A. G., Westerlund, M., & Kortelainen, M. J. (2016). The effect of network structure on radical innovation in living labs. *Journal of Business & Industrial Marketing*, *31*(6), 743-757.
Leminen, S., Nyström, A. G., & Westerlund, M. (2015). A typology of creative consumers in living labs. *Journal of Engineering and Technology Management*, *37*, 6-20.
Leminen, S., Rajahonka, M., & Westerlund, M. (2017b). Towards Third-Generation Living Lab Networks in Cities. *Technology Innovation Management Review*. 7(11): 21-35.
Leminen, S., Westerlund, M., & Nyström, A. G. (2012). Living Labs as open-innovation networks. *Technology Innovation Management Review*, *2*(9), 6-11.
Leminen, S., Westerlund, M., & Nyström, A. G. (2014). On becoming creative consumers–user roles in living labs networks. *International Journal of Technology Marketing*, *9*(1), 33-52.
Leminen, S. (2013). Coordination and participation in living lab networks. *Technology Innovation Management Review*, *3*(11), 5-14.
Liu, H., Zhou, G., Wennersten, R., & Frostell, B. (2014). Analysis of sustainable urban development approaches in China. *Habitat International*, *41*, 24-32.
March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71-87.
McLoughlin, S., Maccani, G., Prendergast, D., Donnellan, B., & LERO, N. (2018), Living Labs: A Bibliometric Analysis. Hawaii International Conference on System Sciences (HICSS)
McPhee, C., Santonen, T., Shah, A., & Nazari, A. (2017). Reflecting on 10 Years of the TIM Review. *Technology Innovation Management Review*, 7(7), 5–20
Mulder, I., Velthausz, D., & Kriens, M. (2008). The living labs harmonization cube: Communicating living lab's essentials. *The Electronic Journal for Virtual Organizations and Networks*, *10*, 1-14.
Mulder, I. (2012). Living labbing the Rotterdam way: Co-creation as an enabler for urban innovation. *Technology Innovation Management Review*, *2*(9), 39-43.

Nevens, F., Frantzeskaki, N., Gorissen, L., & Loorbach, D. (2013). Urban Transition Labs: co-creating transformative action for sustainable cities. *Journal of Cleaner Production*, 50, 111-122.

Nyström, A. G., Leminen, S., Westerlund, M., & Kortelainen, M. (2014). Actor roles and role patterns influencing innovation in living labs. *Industrial Marketing Management*, *43*(3), 483-495.

Pisoni, A., Michelini, L., & Martignoni, G. (2018). Frugal approach to innovation: State of the art and future perspectives. *Journal of Cleaner Production*, *171*, 107-126.

Rits, O., Schuurman, D., & Ballon, P. (2015). Exploring the benefits of integrating business model research within living lab projects. *Technology Innovation Management Review*, *5*(12), 19-27.

Rodrigues, M., & Franco, M. (2018). Importance of living labs in urban Entrepreneurship: A Portuguese case study. *Journal of Cleaner Production*, *180*, 780-789.

Schaffers, H., & Turkama, P. (2012). Living Labs for cross-border systemic innovation. *Technology Innovation Management Review*, *2*(9), 25-30.

Schuurman, D., & De Marez, L. (2012). Structuring user involvement in panel-based Living Labs. *Technology Innovation Management Review*, *2*(9), 31-38.

Schuurman , D., De Moor, K., De Marez, L., & Evens, T. (2011). A Living Lab research approach for mobile TV. *Telematics and Informatics*, *28*(4), 271-282.

Schuurman, D., De Marez, L., & Ballon, P. (2013). Open innovation processes in living lab innovation systems: insights from the LeYLab. *Technology Innovation Management Review*, *3*(11), 28-36.

Schuurman, D., De Marez, L., & Ballon, P. (2015). Living Labs: a systematic literature review. Open Living Lab Days 2015.

Ståhlbröst, A., & Bergvall-Kåreborn, B. (2011). Exploring users motivation in innovation communities, *International Journal of Entrepreneurship and Innovation Management*, 14(4), 298-314.

Ståhlbröst, A. (2008). *Forming future IT: the living lab way of user involvement* (Doctoral dissertation, Luleå tekniska universitet). http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A999816&dswid=-3775

Ståhlbröst, A. (2012). A set of key principles to assess the impact of Living Labs. *International Journal of Product Development*, *17*(1-2), 60-75.

Ståhlbröst, A. (2013). A living lab as a service: Creating value for micro-enterprises through collaboration and innovation. *Technology Innovation Management Review*, *3*(11), 37-42.

Tukiainen, T., Leminen, S., & Westerlund, M. (2015). Cities as collaborative innovation platforms. *Technology Innovation Management Review*, *5*(10), 16-23.

van der Have, R. P., & Rubalcaba, L. (2016). Social innovation research: An emerging area of innovation studies?. *Research Policy*, 45(9), 1923-1935.

Van Geenhuizen, M. (2013). From ivory tower to living lab: accelerating the use of university knowledge. *Environment and Planning C: Government and Policy*, *31*(6), 1115-1132.

Veeckman, C., & van der Graaf, S. (2015). The city as living laboratory: Empowering citizens with the citadel toolkit. *Technology Innovation Management Review*, *5*(3), 6-17.

Veeckman, C., Schuurman, D., Leminen, S., & Westerlund, M. (2013). Linking living lab characteristics and their outcomes: Towards a conceptual framework. *Technology Innovation Management Review*, *3*(12), 6-15.

Von Hippel, E. (2007). Horizontal innovation networks—by and for users. *Industrial and Corporate Change*, *16*(2), 293-315.

Voytenko, Y., McCormick, K., Evans, J., & Schliwa, G. (2016). Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda. *Journal of Cleaner Production*, *123*, 45-54.

Westerlund, M., Leminen, S., & Rajahonka, M. (2018). A Topic Modelling Analysis of Living Labs Research. *Technology Innovation Management Review*, 8(7), 40–51.

Westerlund, M., & Leminen, S. (2011). Managing the challenges of becoming an open innovation company: experiences from Living Labs. *Technology Innovation Management Review*, *1*(1), 19-25.

Zott, C., & Amit, R. (2010). Business model design: an activity system perspective. *Long Range Planning*, 43(2-3), 216-226.