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From Practice to Theory Gaps: a Roadmap from Case Studies Analysis on Living Labs

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Abstract

Living Labs (LLs) have been defined as collaborative spaces, innovation management tools, or open innovation networks, used to develop and validate new products or services by involving different actors within a real-life context. Dealing with a phenomenon that only recently has been institutionalized, where framework theories have been identified after the practice has already emerged, the present paper identifies theory-practice gaps based on a thematic analysis of in-depth case studies focusing on LLs experiences. Results suggest five main gaps to be addressed within future research, related to theoretical frameworks fragmentation, the involvement of users, the need for a clearer definition of LLs, and of an evolutionary approach to their analysis, the identification of a suitable theory for the real-life setting.

Keywords: open innovation, case studies, diffusion of innovations, knowledge transfer.

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1 Introduction

The relatively recent interest in Living Labs (LLs) meets a fragmented and scattered literature that is not yet mature. The debate in the literature is characterized by a large number of definitions that recognize LLs as different entities, depending on the perspective from which they are analyzed (Leminen and Westerlund, 2016). One of the most widely used definitions of LL is offered by ENoLL, the European Network of LLs, which defines LLs as "*user-centered open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings*". However, other definitions in the literature characterize LLs as experimentation platforms or innovation management tools to validate new products or services through inter-institutional collaboration (Almirall et al., 2012). Moreover, LLs are also seen as specific types of open innovation networks (Leminen et al., 2011; Ståhlbröst and Bergvall-Kåreborn, 2011), where collaboration among different stakeholders is pursued, also involving customers and users as co-developers (Leminen et al., 2015; Compagnucci et al., 2021, Thomas et al., 2024). Finally, LLs are analyzed as real-life settings, virtual or physical (Leminen et al., 2023), where innovation processes integrate interests and goals that vary depending on the nature of the actors participating with different levels of awareness in the space (Bergvall-Kåreborn, and Stahlbrost, 2009; Della Santa et al., 2024). The causes of this theoretical fragmentation, while recognized by many authors, have not been fully explored in the academic literature.

In one of the rare analyses of the emergence of LLs, Leminen and Westerlund (2019) recognize three distinct phases for what the authors call the "living lab movement." They refer to the first phase as "towards a new paradigm" (Leminen and Westerlund, 2019, p. 10), where LLs started to emerge mainly through American scholars, officially with PlaceLab at MIT. In the second phase, the "learning from experience phase" (Leminen and Westerlund, 2019, p.10), thanks to the rise of networked organizations such as ENoLL (Hossain et al., 2019), the living labs movement began to spread in European companies and universities, especially in the Northern European countries. Finally, in the third phase, the "*professional living lab phase*" (Leminen and Westerlund, 2019, p.10), LLs started to adopt a set of standardized tools or procedures in their activities (Leminen and Westerlund, 2017). During this phase, a large number of LLs emerged and scholars from different scientific fields started to study LLs as units of analysis to understand innovation processes and outputs (Greve et al., 2020; Leminen and Westerlund, 2019), as well as their creation and evolution (e.g. Tagliazucchi et al., 2024).

In the LL movement, practical experience is often related to entities that emerged spontaneously and only later found their theoretical label under the umbrella of LL, which, in turn, is grounded in an extensive and diverse body of literature. (Leminen and Westerlund, 2019). This leads to the need for a deeper exploration of the phenomenon, as the theoretical lenses applied to LL may not fully capture the complexity and articulation of the phenomenological issues that emerge from practice. Therefore, a top-down direction in the definition of the theory applied by some institutions that want to spread the LL method globally, such as ENoLL, has to face a bottom-up emergence of practical cases of LLs, referred to as "scattered initiatives" (Leminen and Westerlund, 2019, p. 5). These initiatives come from a variety of sectors and reveal phenomenological features that are not always covered by the interpretive umbrella of the existing literature. Although some theoretical reviews are already present in the LLs literature (e.g., Dutilleul et al., 2010; Hossain et al., 2019; Greve et al., 2020), this paper is based on a thorough review of 52 practice-based case studies on LLs, with the specific purpose of addressing existing gaps between practical experiences and the interpretative theoretical framework used. The paper adopts a thematic analysis (Gioia et al., 2013); ... the results allow to identify gaps that could be addressed in future empirical studies focused on the LL phenomenon, and to highlight theoretical perspectives that could capture the emerging nature of the LL phenomenon. The suggested future research avenues are related to the fragmentation of theoretical frameworks in the empirical study of LL, the need for a clearer definition of LL, questions regarding the degree of user involvement, the need for longitudinal and evolutionary analyses, and a more robust theoretically driven analysis of the spatial characteristics of LL.

The paper is structured as follows: in the first section, the research design and methodology are outlined; in the second section, results are presented and then discussed in the third section, outlining the main gaps between theory and practice; in the fourth section, conclusions and implications are drawn.

2 Research design

2.1 State of the art and purpose

Formally, the Living Lab (LL) concept entered European policy at the beginning of the century thanks to the European Network of Living Labs (ENoLL), which increased the number of LLs among European countries and the research interest in this topic (Hossain et al., 2019). According to ENoLL, three main theoretical frameworks are considered as important. The first one, Open Innovation (Chesbrough, 2003), is defined as a paradigm leading firm to exploit both internal and

external ideas, opening the innovation channels to external organizations. The second one, User Innovation (Von Hippel, 1976), substitutes a manufacturer-centric model with a user-centered innovation process, showing users as developers and emphasizing their role in innovating when serving their own needs. The third one, Innovation Ecosystem, defines a system of actors and relationships mutually interdependent, spatially bounded, and part of the same innovation processes (Granstrand and Holgersson, 2020). This theoretical framework also links LLs to the real-life setting and spatial dimensions (Leminen et al., 2023) and considers them as containers for innovation (Della Santa et al., 2024). This has led to an increasing number of authors over the years to study the sustainability aspects - both economic and environmental - of LLs (Hossain et al., 2019; Compagnucci et al., 2021; Beaudoin et al., 2022).

Despite the main theoretical frameworks highlighted by ENoLL, academic researchers have not reached a consensus on the definition of LLs yet, also due to its continuous evolution in the domains of open and user innovation (Compagnucci et al., 2021). In addition, LLs encompass a diverse array of fields and sectors, as well as a broad spectrum of expertise (Hossain et al., 2019). As a result, a growing number of scholars have studied LLs as units of analysis to understand innovation processes and outcomes from different perspectives and diverse fields (Greve et al., 2020; Leminen and Westerlund, 2019; Leminem et al., 2017). Along with empirical studies, the first systematic reviews of the literature emerged, highlighting the fact that LLs cover multiple perspectives. For example, Dutilleul et al. (2010) analyzed the social innovation dimensions of European LLs; the authors defined three main aspects of LL as a setting: in vivo experimentation on social systems, innovation and product development approaches involving users, and innovation systems. Leminen and Westerlund (2016), conversely, recognized eight research avenues by defining LLs as: a system or network, a combined approach, a document real-life environment, a methodology, a tool for implementing public and user participation, a development project, a business activity, or an innovation management tool. Hossain et al. (2019) argued that LLs are considered simultaneously as landscapes, real-life environments, and methodologies, involving heterogeneous stakeholders and applying different business models, methods, tools, and approaches. Leminen and Westerlund (2019) proposed a longitudinal analysis of LLs, pointing out how this phenomenon, initially born to test ICT innovations from scattered initiatives, has been later extended to other areas of product and social innovation, and then institutionalized. Finally, Paskaleva and Cooper (2021) argued on the effectiveness and the impact of LLs in fostering innovative processes.

Although insightful, previous literature reviews have only marginally analyzed the theoretical lenses used to empirically study the LLs phenomenon. Therefore, this paper aims to capture how empirical and practice-based research has framed and analyzed LLs. Starting from a phenomenological analysis of in-depth case studies, the aim is to identify the theoretical gaps and to highlight the alignment or disconnection with the proposed reference theories. To this end, we use a thematic analysis (inspired by Gioia et al., 2013) based on a selection of in-depth case studies focused on LLs. We selected practice-based contributes that can be defined as case studies that "*comprise more detail, richness, completeness and variance – that is, depth – for the unit of analysis*" (Flyvbjerg, 2011, p. 301), that "*stress developmental factors*" (Flyvbjerg, 2011, p. 301), and that highlight a "*relation to the environment*" (Flyvbjerg, 2011, p. 301). Empirical contributions that adopt a qualitative methodology are preferred, as they are suitable for the collection of richer and more vertical data on a single experience, especially when a specific subject of inquiry is not yet fully known, and they can better inspire a theory-building process (Creswell, 2009). This allows us to infer about the interpretative and theoretical perspectives used to frame the empirical observation at a greater level of detail.

2.2 Selection of empirical contributions

The search was done using Scopus, one of the most prestigious academic literature databases (Chadegani et al., 2013). Table 1 shows the terms used for the search. The entire period available in the database until July 2022 was considered, resulting in 635 occurrences.

Table 1. Search string used on Scopus website.

Operators	Search string	Content
AND	"Living Lab*"	Title – abstract – keyword
	"Case study" OR "evidences" OR "experimentation"	Title – abstract – keyword

Source: Authors' elaboration

Some filters among the Scopus categories were applied, limiting the documents to articles and conference papers, yielding a total of 515 entries. Then, the keyword selection has been cleaned limiting to those strictly focusing on "living lab/s" or "living laboratories". Finally, all the papers but those ones in English have been eliminated, and the source type was limited to Journal or Conference Proceeding. The resulted 233 contributions were classified by author, year, title journal, DOI. Subsequently, during the reading of abstracts first and of full papers later, we excluded those papers:

- only had the pre-print version;
- not related to social science (for instance, we excluded paper explaining engineering outputs obtained within a LL, but not mentioning anything about the LL's experience, organization or processes);
- not in line with Flyvbjerg (2011) definition of in-depth case studies.

Based on the above criteria, we eliminated all empirical contributions that, although adopting a qualitative methodology, focused on multiple case studies lacking sufficient in-depth data; contributions that did not contain any case studies, despite passing the above-mentioned filters; and case studies that practically differed in terms of disciplines from those indicated. Among the 57 selected papers, 38 were journal articles, and 19 were conference proceedings. To select the final sample of empirical contributions, the conference proceedings were excluded to rely only on peer-reviewed and already published articles. The 38 articles resulting from the systematic search were integrated with a specific search in the main journals that have major contributions published on LLs, based on the review by Greve et al. (2020). For the search in the specific journals, the same keywords were adopted. Based on the above-mentioned criteria, 16 in-depth case study analysis were found. The final sample consisted of 52 in-depth case studies on LLs published between 2012 and 2022 in leading academic journals. The overall selection process is summarized in Figure 1.

2.3 Thematic analysis approach

The sample selection process led to the creation of a corpus of texts that were analyzed based on a thematic analysis approach, as outlined by Gioia et al. (2013). Each contribution was analyzed independently and then compared with the others. In an iterative manner, the contributions were analyzed by moving back and forth between the data and the emerging categories, following a three-step process. First, first-order codes were created by identifying the main topics analyzed in each case study, and by relying on the authors' definitions of LLs. Second, the first-order

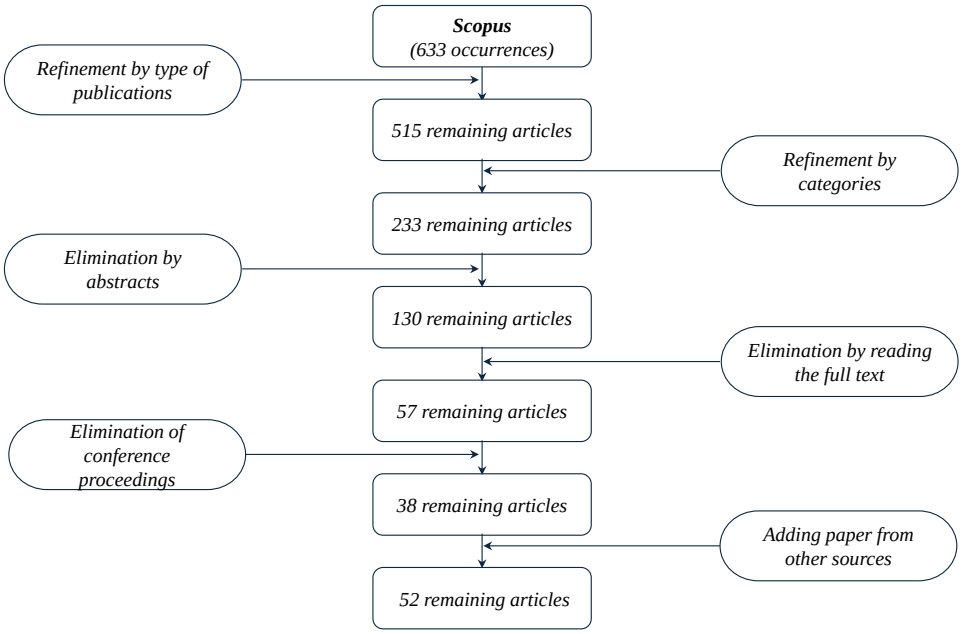

Figure 1. Selection of empirical contributions
Source: Authors' elaboration

codes were collapsed into phenomenological categories through an inductive process. At this stage of analysis, differences within and across papers were compared to identify phenomenological differences and similarities in the way LLs case studies were described and analyzed. These categories highlighted macro-themes analyzed within case studies and, once consolidated, became more theoretically related and abstract. Labels were created to be meaningful and explanatory of the emerged category. Third, once phenomenological categories were generated, they were integrated into a coherent and higher-order perspective. Three perspectives underlying and grouping the phenomenological categories emerged, as some categories focused on the actors involved in the LLs, others were more related to the processes carried out within the LLs, and some were concerned with spatial issues surrounding and within the LLs. Figure 2 summarizes the overall process and displays the first-order codes, the phenomenological categories, and the higher-order perspectives.

Two researchers carried out the analysis of the empirical contributions individually and autonomously. This was followed by team comparison and discussion until agreement was reached on the emerging codes. Once the higher-level categories were created, the researchers checked whether each code fit the emerging phenomenological categories and ensured that each higher-order perspective was consistent with the categories in order to clearly distinguish between them and to unambiguously assign the empirical contributions to only one of the three perspectives. When this was not the case, the team reviewed the empirical cases and discussed discrepancies until agreement was reached.

The researchers then reexamined the overall consistency of the analyzed case studies with all the emerging levels of coding for internal validation (Becker, 1970). Finally, within each perspective, the theoretical frameworks used by the original authors to frame the case studies were identified, whether they were explicitly stated in a literature framework section of the paper or

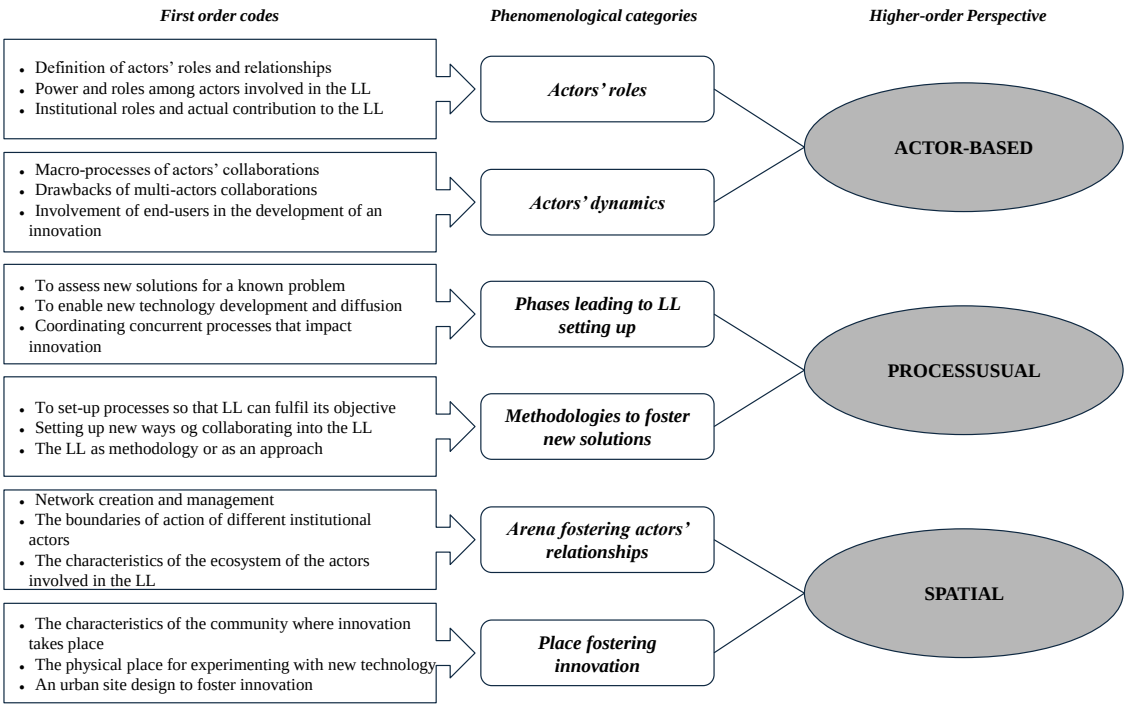

Figure 2. Data analyses and coding strategy
Source: Authors' elaboration

only mentioned in the introduction and keywords. Table 2 shows examples of coding for each perspective.

Table 2. Codification examples

Perspectives	Examples of keywords	Examples of focus of analysis
Actor-based	Citizen inclusion Co-innovation Collaborative innovation Multi-stakeholder network	Understanding the actors' dynamics and challenges within a living lab focused on public open innovation (Gasco, 2017)
Processual	Action research Participatory design Co-creation Generative experimenting	Developing of a methodological approach to involve key stakeholders in a transformation process within a higher education institute (Kretschmer and Dehm, 2021)
Spatial	Strategic action fields Ecosystems Cities Urban place	Analyzing the LL as a place to test new electromobility technologies (Joller and Varblane, 2017)

Source: Authors' elaboration

3 Results

The thematic analysis leads to three main perspectives adopted in the case studies of LLs: actor-based, processual, and spatial. Each of them draws attention to different phenomenological levels.

The first one, the actor-based perspective, focuses on the subjects taking part within the LL, highlighting the dynamics and roles of multiple actors. Accordingly, LLs are defined, for example, as "*intermediaries that focus on the mediation between users, public, or private organizations*" (Gasco, 2017, p.92) or as "*facilitator for multi-stakeholders' collaboration and knowledge sharing*" (Marone et al., 2020, p.14). The second one, the processual perspective, focuses on the processes leading to the creation of an LL or used by the LL itself to develop new solutions. LLs are then defined, for example, as "*a participatory approach that enabled communities to shape trial implementation*" (Masunaga et al., 2021, p.3). The third one, the spatial perspective, highlights the importance of understanding and considering the surrounding environment, including the involved actors, available resources, social and cultural dynamics, and existing infrastructures, which both influence and are influenced by LLs' activities. Within this perspective, LLs are then defined as "*a space with formal and informal relationships between all those involved in the process*" (Rodrigues and Franco, 2018, p. 784). Table 3 classifies the case studies on the basis of the emerged perspectives and phenomenological categories.

Table 3. Classification of contributions for perspectives and phenomenological categories

Perspectives	Phenomenological categories	Empirical contributions as classified
Actors-based *(Who)*	Actors' dynamics	Claude et al., 2017; Gasco, 2017; Georges et al., 2015; Hakkarainen and Hyysalo, 2013; Hyysalo and Hakkarainen, 2014, Nguyen et al., 2022; Svensson, 2015; Waes et al., 2021
	Actors' roles	Blezer and Abujidi, 2021; Marone et al., 2020; Mukama et al., 2022; Nguyen and Marques, 2022; Toffolini et al., 2021
Processual *(How)*	Phases leading to LL setting-up	Alaoui and Lewkowicz, 2014; Amenta et al., 2019; Arnould et al., 2022; Bartelt et al., 2020; Boersma et al., 2022; Dekker et al., 2021; Kretschmer and Dehm, 2021; Lasarte et al., 2021; Logghe and Schuurman, 2017; Malakhatka et al., 2021; Schuurman et al., 2013; Taylor, 2021
	Methodologies to foster new technology / solution	Cellina et al., 2020; Dietricht et al., 2021; Engels et al., 2019; Haukipuro et al., 2019; Hughes et al., 2018; Katzy et al., 2012; Lovell et al., 2018; Lupp et al., 2021; Lusikka et al., 2020; Masunga et al., 2021; Schuurman et al., 2016; Zwierenberg et al., 2017
Spatial *(Where)*	Arena fostering actors' relationships	De Vita and De Vita, 2021; Engez et al., 2021; Feche et al., 2021; Haug and Mergel, 2021; Hernández-Pérez et al., 2022; Vilarino er al., 2018
	Place fostering innovations	Canzler et al., 2017; Campos et al., 2019; García-Llorente et al., 2019; Criado et al., 2021; Edwards - Schacter et al., 2012; Joller and Varblane et al., 2017; Rodrigues and Franco, 2018; Temmerman et al., 2021; Turku et al., 2022

Source: Authors' elaboration

To understand and compare the theories used to frame the different phenomenological categories, for each contribution, and within each perspective, we complemented the analysis by detecting the theoretical framework employed by the authors. Table 4 summarizes the results of this analysis, and the theoretical frameworks are grouped according to their lowest common denominator. For example, multi-actor collaboration approaches, 4P and triple or quadruple helix models are grouped based on their focus on a plurality of actors from different institutions. Similarly, collaborative approaches aimed at involving the end users, whether based on co-design or other user engagement toolkits, are grouped into a single category. The same also for theories about regional innovation systems or innovation ecosystems.

Table 4. Classification of contributions for perspectives and phenomenological categories

Perspectives	Theoretical frameworks adopted	N° of empirical contributions
Actor-based	Not mentioned	5
(Who)	Quadruple helix / multi-actor collaboration	3
	Collaborative design	2
	Regional Innovation System / Open Innovation	2
	Socio-technical regimes	1
Processual	Not mentioned	9
(How)	Action research / Experiment literature / test bed literature	5
	Co-creation approach / Participatory design approach	4
	Open innovation	3
	New product development process	2
	Social capital theory	1
	Theory of evaluation	1
Spatial	Not mentioned	4
(Where)	Co-creation approach	4
	Social innovation / Public-Private-People partnership (4P model)	3
	Socio-technical transitions	1
	Ecosystem theory	3

Source: Authors' elaboration

3.1 Actor-based perspective

Within the actors-based perspective, studies focus on the actors participating in LLs, by emphasizing actors' dynamics (e.g., Gasco, 2017; Nguyen et al., 2022) and drawbacks (e.g., Hyysalo and Hakkarainen, 2014), or actors' background and the roles they play in the LL (e.g., Marone et al., 2020; Toffolini et al., 2021; Nguyen et al., 2022). LLs are indeed seen as entities connecting inter-institutional actors and end users, supporting the exchange of ideas and knowledge (Gasco, 2017).

LLs are mainly analyzed within theoretical frameworks related to multi-actor collaborations, often linked to the Quadruple Helix (QH) model, which expands on the Triple Helix model by

incorporating the social sphere (Carayannis and Campbell, 2009). According to Nguyen et al. (2022), who focused on the smart city context, LLs stimulate changes in power relations among citizens and other stakeholders, acting as intermediaries transferring citizens' information and opinions. Hence, the LL becomes the intermediary transferring citizens' information and opinions to other stakeholders. Effective integration of citizens and users is crucial in LLs (Claude et al., 2017; Svensson, 2015), so as the motivation in participating in them (Georges et al., 2015). However, as LLs bring actors of different natures to interact through co-creation, co-production and knowledge exchange (e.g., Claude et al., 2017; Hyysalo and Hakkarainen, 2014), conflicts may arise. For example, a different degree of influence and decision-making power within the LL may lead to different forms of collaborative dynamics (Georges et al., 2015, Nguyen et al., 2022). As the group of actors converging in the same LL becomes more heterogeneous, issues on effective communication may also emerge (Gasco, 2017; Waes et al., 2021). Additionally, diversity in actors' strategies and needs, which continuously evolve as the innovation process unfold, may complicate collaborative dynamics (Hyysalo and Hakkarainen, 2014).

When focusing on actors' roles in LLs, approaches of multi-actor collaborations frame the case studies. Authors focus on redistributing roles in LLs based on tasks, types of interaction (Toffolini et al., 2021), technological contexts (Mukama et al., 2022), and purposes (Blazer and Abujidi, 2021). The empirical studies then analyze the roles of the public actor and the government, the industrial actor, the academia and research institutions, and the users, as in QH model, but explicitly recalling it only in one case.

For instance, Mukama et al. (2022) analyzed an energy LL for poor urban environments, and classified actors' roles based on motivation and legitimacy. The institutional actor related to government is referred as a "*dominant stakeholder*" (Mukama et al., 2022, p.6), gaining in power and legitimacy but incapable to comprehend the urgency to solve the community requirements. Industry is defined as a *"definitive stakeholder"* (Mukama et al., 2022, p.5), due to the effective legitimacy and power, and its urgency to implement the innovation. Finally, the academic stakeholder is the "*dependent stakeholders*" (Mukama et al., 2022, p.5), as it has the legitimacy and urgency but lack power "*to impose their developments or innovations on the community*" (Mukama et al., 2022, p.5). Toffolini et al. (2021) used the concept of boundary object (Star and Griesemer, 1989) by referring to the convergence of actors from different institutions into the LL. According to them, a collaboration is possible by exploiting the LL structure that combines high flexibility with a level of standardization (Toffolini et al., 2021). The authors recognized four different groups of users based on their roles, ranging from "*efficiency factors*" to "*agricultural citizens*" (Toffolini et al., 2021, p. 161), who promote innovation initiatives and processes. Finally, Blazer and Abujidi (2021) utilized the Funding Mix Framework (by Gualandi and Romme, 2019) and the stakeholder typology proposed by Westerlund & Leminen (2011) – i.e., Enabler, Provider, Utilizer, User and Researcher – to analyze the roles of the stakeholders taking part in an Urban LL (ULL), demonstrating how roles depend on LL purposes, being more technological, civic or social oriented.

3.2 Processual perspective

Within the processual perspective, case studies focus on steps and activities to set up the LL, or to develop and test the new technology or solution. LLs are seen as methodologies for implementing innovation processes (e.g., Arnould et al., 2022; Amenta et al., 2019), and for structuring users' involvement (Schuurman et al., 2013), or as approaches to facilitate new product development by involving end users (Haukipuro et al.; 2019, Masunaga et al., 2021).

Several processes are involved in the LL set up, and what makes LLs innovative is the way they are created. Overall, the processes leading to the LL are framed within co-creation or action research approaches (e.g., Boersma et al., 2022; Logghe and Schuurman 2017), defined as "*a collaborative, action-based process between researchers and participants, who work together in making socio-technological changes by promoting the multi-faceted understanding of a complex issue in its real-life context*" (Kretschmer and Dehm, 2021, p.5). LLs are then seen as a cyclical process (Kretschmer and Dehm, 2021), through which participants identify a problem, collect, and analyze data, and "*iteratively take and reflect upon actions*" (Kretschmer and Dehm, 2021, p.5). Some empirical contributions then highlight stage-based processes, exploiting a bottom-up, participatory approach in the creation of LLs. As instance, in analyzing the setting up of LLs in some urban areas, Amenta et al. (2019) defined a five phases process, from the co-exploring phase aimed to obtain a common understanding of the territory, until the co-governance phase aimed to make solutions transferable to further cases by developing decision models. Arnould et al. (2022) proposed a three-stage process for LL creation. First, within the planification phase, the guidelines of the LL are defined, as well as an analysis of the real environment and the identification of stakeholders and users. Then, the exploration phase allows to define a shared vision of the real environment and to formalize the LL, by evaluating users' needs and expectations. Finally, in the creative co-design phase, solutions and ideas are provided thanks to a co-creation activity based on collective workshops.

LLs are also seen as methodologies that enable new technologies and innovative solutions to known problems, allowing the development of novel solutions. In this case, LLs are analyzed within frameworks linked for example to new product development (e.g., Haukipuro et al., 2019) and co-creation (e.g., Katzy et al., 2012), emphasizing user involvement. Innovative ideas are not planned and implemented in a top-down direction, but co-created within an open-ended innovation process (Masunaga et al., 2021). This facilitates the success and acceptance of solutions once on the market (Haukipuro et al., 2019). Although empirical contributions still focus on processes, the emphasis is on the technological side, with case studies mainly focused on technologies and solutions brought about by LLs, and on the innovative process centralized on LLs (e.g., Haukipuro et al., 2019). The LL is then seen as the tool "*allow*[ing] *businesses to develop new, better and more personalized services to citizens*" (Lusikka et al., 2020, p.1). The advantages of LLs as enablers of technologies are also highlighted. For example, Dietricht et al. (2021) compared LLs with co-design projects, arguing that while the co-design process is easily evaluable and provides a step-by-step approach replicable in other technological contexts, LLs promote a broader approach that involves end users from the earliest stages, but could be vaguer and less efficient. The same LL may also enable multiple technologies and solutions, and host a variety of innovative projects under an open innovation framework (Schuurman et al., 2016).

3.3 Spatial perspective

Within the spatial perspective, the focus is on the surrounding environment and on the relationships between space, actors, and technologies, within the LL. This perspective highlights how contextual nature, infrastructures, and spatial dimensions of the LL shape the social and cultural dynamics. The emphasis is then on the space, being physical or virtual, its characteristics, and how it shapes the actors' relationships and the innovative process. LLs are perceived as arenas where relationships among actors unfold (e.g., Canzler et al., 2017; Hernández-Pérez et al., 2022;), or as the place where innovations are implemented (e.g., Temmerman et al., 2021; Turku et al., 2022).

The LL can be seen as the arena where formal and informal relationships among actors take place, and then defined as "*user-centric innovation environment*" (Villarino et al., 2018, p.17).

As such, it is analyzed as an ecosystem (e.g., Engez et al., 2021), or as the space within which co-creation approaches unfold (De Vita and De Vita, 2021; Haug and Mergel, 2021). For example, Haug and Mergel (2021) viewed LL as an environment based on public value creation, which provides a place to establish interactions between the public administration and its stakeholders. The LL then becomes the "encountering space" (Hernández-Pérez et al., 2022, p.6) where actors work together to achieve innovation (Hernández-Pérez et al., 2022). Transforming the space into a place where multiple stakeholders come together and participate in the innovation process (Hernández-Pérez et al., 2022), the LL can also influence the whole community. It can also take on the form of an urban space, so that to be physically bounded within a city, and the resulting innovative solution strictly depends on the actors who populate it (Engez et al., 2021), or of a rural space whose stakeholders are the promoters of change (Feche et al., 2021).

The focus may be then shifted to the place and the innovations that are developed, evaluated or tested within LLs. The environment defines the physical space where that technology/solution will be used (Temmerman et al., 2021) and, in line with the social innovation theoretical frameworks, the innovation process may impact the social cohesion and the engagement of the community in which takes place (Temmerman et al., 2021). The LL therefore becomes a "functional place" in an urban environment (Edwards - Schacter et al., 2012), or the place for social innovation (e.g., Temmerman et al., 2021). The emphasis is on the "*social and cultural practices, consumption, everyday life and social learning*" (Turku et al., 2022, p. 9) where the innovation activities are carried out, and LLs configure as collaborative platforms (Temmerman et al., 2021). Joller and Varblane (2017) stated that, in case of radical innovations, LL should not be seen as a mere test bed, which alone would not be sufficient for investigating on social acceptance and market success, as it is only focused on the technical side. Rather, the LL would provide a tool for broad exploration of new solutions in a controlled environment, before technology deployment in the society (Joller and Varblane, 2017). In line with this, Cazler et al., (2017) considered LLs as "*incubation spaces for technological transition*" (p. 26), and studied the emergence and change of socio-technical systems.

Overall, LLs promote technology interaction in real-life contexts (Canzler et al., 2017), contribute in improving urban areas in which they are settled (Turku et al., 2022) and cities sustainability (Rodrigues and Franco, 2018). LLs are indeed increasingly analyzed through the lens of sustainability, considering their connections to natural and living systems, experimentation in real-world settings, and rootedness in specific territories. Even more emphasis is devoted to the significance attributed to the end product due to its considerable social value (e.g., Rodrigues and Franco, 2018; Canzler et al., 2017; Campos et al., 2019), and the recognition of a distinctive and interconnected network of institutions and individuals (García-Llorente et al., 2019). The spatial perspective ultimately delves into the interconnectedness between LLs and their environments, the surrounding infrastructures and broader sustainability goals, in addressing societal challenges and promote sustainable community development.

4 Discussion

The results capture some inconsistencies emerging from the analysis of practice-based empirical contributions on LLs and the institutionalized definitions and theoretical lenses, so as the former do not fully accommodate in the apparatus which is consolidating in the LLs literature. Conversely, some widely evoked theoretical models have not yet fully explored: some hints emerge for improving the way in which these frameworks can be usefully applied in empirical research. In the next

paragraphs, five critical gaps are highlighted that need to be tackled to enhance the academic debate on LLs.

4.1 Theoretical frameworks fragmentation

As Leminen and Westerlund (2019) argued, the institutionalization of the LL movement is a recent process. In this process, collective organizations promoting LLs, such as ENoLL, started to emerge with the aim of promoting LLs as a suitable model (Leminen and Westerlund, 2019), in which the boundaries between different disciplines are increasingly blurred (Guzman et al., 2013). LLs have thus shifted from being considered, at the earliest stages, as a phenomenon based on ongoing and sporadic practical experiences with no overarching theoretical frames, to a phenomenon that, in recent years, has been rooted within specific theoretical frameworks. According to the ENoLL, LLs are indeed defined as open-innovation ecosystems, and the main theoretical frameworks to study them are recognized in the Open Innovation (Chesbrough, 2003), the User Innovation (Von Hippel, 1976, 1986, 2007) and the Innovation Ecosystem theory (Granstrand and Holgersson, 2020; Thomas and Autio, 2020). ENoLL itself also recognizes the QH model (Carayannis and Campbell, 2009) as suitable to analyze the diversity and dynamics of actors participating in LLs. However, our results show that these theories, well distant to offer a conceptual support to which most authors adhere, are scantly explicitly mentioned. For example, Open Innovation is directly cited in two of the analyzed contributions (e.g., Schuurman et al., 2013, 2016); User Innovation is never explicitly identified as framework, even if several contributions recall elements of user and citizen involvement; and the Ecosystem literature is mentioned only in three of the analyzed contributions (e.g., Engez et al., 2021). As a consequence, there emerges that, in the observed case studies, there is no systematic adoption of theories that are in the way of being institutionalized to frame the LLs phenomenon.

Overall, a fragmented literature emerges, with a high variety of theories and lenses of analysis, used to frame and interpret the LL phenomenon. For example, we traced participatory approaches, such as co-design, participatory action research and cocreation approach (e.g., Arnould et al., 2022), the socio-technical systems theory (e.g., Feche et al., 2021), and multi-level perspective theory (e.g., Canzler et al., 2017). The QH model is directly cited only once (e.g., Nguyen and Marques, 2022), while several contributions rely on multi-actor collaborations (e.g., Blezer and Abujidi, 2021) and public-private-people models (e.g., Rodrigues and Franco, 2018). In addition, results also highlight the lack of stated theoretical lenses on a number of case studies, which therefore only implicitly recall the models or theories of reference. This fragmentation may be linked to the fact that the LL phenomenon is recent and cross-sectoral (Leminen and Westerlund, 2019; Følstad, 2008; Compagnucci et al., 2021; Greve et al., 2021), so that the variety of academic disciplines to which it is linked favors the application of different discipline-specific frameworks, and makes it challenging to identify universal theoretical frameworks for LLs analysis and interpretation (e.g., Dutilleul et al., 2010, Greve et al., 2021). Besides that, results also evidence that within the same phenomenological perspective – namely actor-based, processual, and spatial – a variety of frameworks are recalled. Sometimes, the theories are used across different levels of analyses. For example, within the actor-based perspective, theories such as the Regional Innovation System (e.g., Toffolini et al., 2021) are applied together with theories looking at multi-actor collaboration (Nguyen et al., 2022); within the process perspective, theories afferent to the experimental literature (e.g., Lovell et al., 2018) stand alongside the Open Innovation (e.g., Schuurman et al., 2013). Finally, within the environmental perspective, theories afferent to the co-creation approach (e.g., Haug and Mergel, 2021) come with theory related to ecosystem literature (e.g., Engez et al., 2021). We then account for a cross-sectoral fragmentation of theories,

which is not strictly related to institutionalized frameworks, like those offered by ENoLL. The variety of adopted theoretical approaches provides a broad set of interpretative tools that can enrich the analysis of LLs as both a conceptual and an empirical phenomenon. However, this fragmentation also exposes this body of literature to criticisms regarding a lack of rigor in aligning the phenomenological level of analysis with the chosen investigative lens. For example, future empirical research could delve deeper into the phenomenon of LLs in relation to open innovation theories across various levels of analysis (Bogers et al., 2017).

4.2 LL's ontology

The ontological debate regarding what can be and not be considered as a LL is far from being exhausted. A plurality of definitions persists, contributing to the unresolved issues in identifying LL peculiar elements. This is further complicated by the extension of LLs to an increasing number of different disciplines. Case studies may focus strictly on technology development and testing, new solutions to be implemented in the healthcare sector, or related to public policies. In such cases, the innovation process itself may exhibit different shapes and dynamics, as does the LL. Consequently, the fragmented empirical basis does not facilitate the emergence of a comprehensive definition. At the same time, different performance indicators may be used to analyze and define the effectiveness and impact of the LL.

For instance, some authors define LLs as specific types of Test and Experimentation Platforms (TEPs), sometimes synonymous with test beds (Engels et al., 2019) or a field trial (Hakkarainen and Hyysalo, 2013). On the one hand, LLs may have characteristics similar to testbeds in terms of improving technological efficiency; on the other hand, the contribution to innovation made by LLs is not only technical, but also linked to the social context in which the technology is embedded. While technologies in both TEPs and LLs can be deployed in a realistic setting, within a LL, the realistic setting extends beyond the assessment of the interaction between a single technology and a single user. It encompasses the ecosystem of actors within the LL who are willing to test the technology within the community and society. At the core of LLs, innovation is adopted within a real social context populated by users, who may participate in the innovation process to varying degrees, and by actors who anticipate problems or opportunities and drive the innovation process forward. Therefore, considering LLs simply as a test bed or field trial seems to apply a reductive lens to their study, as it fails to capture all the features characterizing the entire innovation process typically occurring within a LL. Future empirical research should thus focus on identifying differences between LLs and other kinds of TEPs, upscaling and sustainability of LLs, and better investigate indicators to measure the impact arising from innovation processes within LLs.

4.3 User Innovation in LLs

One of the key elements of LLs is user involvement, as supported by previous literature reviews (e.g., Hossain et al., 2019) and as evidenced by the present analysis (e.g., Dekker et al., 2021; Edwards-Schacter et al., 2012; Haukipuro et al., 2019). LLs emerge as user-driven and user-centered open innovation ecosystems (Georges et al., 2016). Users are not merely observed in their interaction with technologies, but are actively involved in the innovation process (e.g., Dietricht et al., 2021; Boersma et al., 2022), and their feedback is collected to harness the creative power of user communities (Leminen et al., 2015).

In the systematization of LLs literature, user involvement has been conceptualized drawing from User Innovation (UI), according to which users develop new products and services for their own benefit (Von Hippel, 1976), either autonomously or through co-creation processes (Von

Hippel, 2007). However, results show that the types of interaction with the users in LLs range from situations where users are active co-creators, to cases in which users are observed while passively interacting with new technologies. Results show cases in which users take on an explicit evaluative function (e.g., Temmerman et al., 2021 focused on the active role of citizens in taking strategic decisions to change an urban area), but also cases where users' role in the innovation process is marginal (e.g., Engels et al., 2019 studied the human-technology interaction with a complex technology). Some inconsistencies arise, as users are mainly seen as active subjects in UI, bringing direct modifications to products and services or suggesting modifications to the manufacturer. Therefore, we contend that UI theory should be more explicitly addressed, and accommodate the phenomenological settings of LLs. Furthermore, we observed that, in some contributions, UI theories have not always been explicitly stated as frameworks. Case studies have indeed extensively used collaborative approaches as frameworks to analyze user involvement, without theoretical elaboration on how UI theory could potentially complement them.

In our opinion, the adoption of a UI framework would fit well with LL phenomenology, when focusing on actors' involvement and dynamics. For instance, the concept of lead users (Von Hippel, 1986), defined as innovating users who serve "*as a need forecasting laboratory for marketing research*" (p. 791) and have "*real life experience with novel product or process concepts of interest*" (p. 796), may better shape the role of users as one of the actors involved in LLs. Similarly, the idea to facilitate design interactions with users through "*toolkits for user innovation*" (Von Hippel, 1976) offers suggestions on mechanisms to engage users in LLs activities. Future research may then delve deeper to understand how to extend and adapt UI models to LLs, which toolkits may be more useful and applicable based on the type of innovation and the context of technology use, to encompass also the interactions between users and other stakeholders acting in LLs. Furthermore, our findings suggest the significance of a more structured elaboration on integrating UI theory with other collaborative theories, such as collaborative design and multi-actor collaboration. This integration could indeed further enhance the theoretical frameworks employed in investigating LLs.

4.4 Evolutionary traits in LL

One of the main elements in the recent systematization of the LLs literature is its link with helix models. According to the Triple Helix (TH) model (Etzkowitz and Leydesdorff, 2000), a triadic relationship between university, industry and government is outlined. The TH system works with a set of *components* (the three spheres of interest - Industry, Academia and Government), and *relationships* between the components, and *functions* (the competencies of the system components) (Ranga and Ezkowitz, 2013). Within the Quadruple Helix (QH) model, a fourth sphere is added, involving societal-based innovation and user stakeholders (Carayannis and Campbell, 2009). On one hand, TH and QH models address the multi-stakeholder involvement in LLs; on the other hand, the helix metaphor refers to the evolution of the structure of the LL, as the balance between the spheres changes and evolves over time (Leydesdorff, 2012). Through processes of substitution, collaboration, technology transfer, or networking among the different spheres (Ranga and Ezkowitz; 2013), new equilibria are established, the actors' roles evolve over time, as well as the organization within which relationships unravel and objectives are pursued. TH and QH models would, therefore, allow an evolutionary analysis of LLs, with a focus on the actors and the configuration of the LL itself, seen as a dynamic and constantly changing process. However, the results highlighted few studies whose main aim is to analyze the design process of LLs (e.g., Alaoui and Lewkowicz, 2014) or phases specific to LL setup (e.g., Amenta et al., 2019; Arnould et al., 2022)-even when considering more recent studies than the sample (e.g., Tagliazucchi et al., 2024).

Adopting a QH-like evolutionary perspective in LL analysis would overcome some of the aforementioned ambiguities in LL definitions. For example, instead of considering LL and testbed as two separate and unrelated types of TEPs, the evolutionary model makes it possible to conceive the transition from one form to the other as the result of a specific evolutionary path. Along this path, relationships between actors may evolve, learning processes may be triggered, a broader set of goals may emerge. Ultimately, LLs may arise as an evolution of TEPs forms of interaction. Similarly, the difficulties in building and managing a LL could lead to its involution over time. In addition to the dynamic evolution, contributions may comprehensively analyze component and functions of a LL. Future empirical research may then adopt longitudinal approaches and theoretical frameworks accommodated into evolutionary perspectives, either centered on the change in the governance of a LL or on the presence of dynamic capabilities (Teece et al., 1997), to gain new insights into LLs evolutionary phases and their outcomes.

4.5 A space theory for the real-life setting

The definition of the real-life setting is a fundamental element in LLs (Hossain et al., 2019) and requires in-depth analysis (Bergvall-Kåreborn et al., 2015). On the one hand, replacing the experimental and controlled approach of a traditional lab with an open lab based on a real-world environment incentivizes and facilitates collaboration between different stakeholders (Della Santa et al., 2024). On the other hand, it allows the analysis of users in their everyday life and the implementation of a co-creation process (Bergvall-Kåreborn and Ståhlbröst, 2009; Thomas et al., 2024). The real-life characteristic of LLs allows to observe and analyze the interaction of the innovation process within the environment and the context in which it is embedded. However, some flaws emerged in the conceptualization of the spatial dimensions of LLs. Drawing from empirical cases, we observe that the spatial definition of a LL takes on very different characteristics at a practical level, thus increasing the entropy of LL characterization. In particular, the real-life setting spans a variety of contexts, from relatively small-scale and geographically limited LLs, such as buildings designed to be nearly zero energy (Ascione et al., 2022) or the *house of presents* analyzed by Zwierenberg et al. (2017), to large-scale LLs covering entire geographic region, such as the agriculture LL analyzed by Toffolini et al. (2021).

The results highlight how spatial aspects are often used as a central factor in defining LLs – for example, by explicitly linking them to urban settings, socio-technical niche, user-centered ecosystems – with respect to other forms of collaboration or other places of experimentation. However, results also highlight how, within the spatial perspective, there is the highest theoretical fragmentation; the ecosystem theory is mentioned only once (Feche et al., 2021), as is the socio-technical transition frame (Canzler et al., 2017), while frames related to co-creation approaches are then mentioned in the analysis of LLs as a place of innovation. The results seem vague about the most appropriate theoretical lenses to analyze the real-life setting. Providing a theoretical foundation for the real-life setting dimension can lead to a more specific conceptualization of the space in which innovation processes are rooted, helping to better define the open context and the participatory and co-creative approach of LLs. This further development in the analysis of collaborative spaces is also considered necessary in the recent academic debate (see for example: Della Santa et al., 2024; Fuglsang and Hansen, 2022). Overall, future research should further explore the spatial differences in LLs to define their characteristics, in order to provide an appropriate theoretical basis for a clear characterization of the real-life setting.

5 Conclusions

This paper aims to identify the gaps and inconsistencies we can observe when we critically discuss the transition from practice to theory in a still relatively young domain, that of LLs. Overall, the study contributes to the evolving academic debate on LLs by analyzing a set of empirical contributions, in line with in-depth case study methodology (Flyvbjerg, 2011). We identified three main perspectives used in investigating phenomenologically LLs, namely actor-based, processual, and spatial. The actor-based perspective focuses on actors' dynamics and their roles; the methodological perspective deals with processes for LLs setup and methodologies for testing new technologies; the spatial perspective analyzes LLs as spaces where innovative solutions unfold. The different theoretical frameworks used and the plurality of definitions lead to some fragmentation in empirical research on LLs.

The results suggest five main gaps that require further research on LLs. First, a fragmentation of the literature emerged when comparing theoretical frameworks developed at the institutional level with those used in case studies. Furthermore, similar theories are used to study phenomenological elements of LLs at different levels of investigation, calling for greater consistency between the theoretical and applied levels of investigation. Second, a number of definitions for LLs have emerged, as well as definitional ambiguity when LLs are confronted with other forms of TEPs. Third, the conceptualization of the role of users as actors in the innovation process cannot be disentangled from the type of innovation tested within the LL, and that a more grounded investigation based on UI theory could help define the modalities of users involvement. Fourth, longitudinal studies and an evolutionary approach would deepen the processes and setup of LLs, considering them not as a static element, but as dynamic and constantly changing. Finally, the need to define a more consistent theoretical framework for the real-life setting is pointed out: even if fundamental in the definition of LLs, it lacks a theoretically driven in-depth analysis.

Bridging these gaps would not only advance the academic debate but could also have practical and managerial implications. For example, understanding the evolution and establishment processes of LLs can lead to new projects and experiences in support of current cutting-edge technologies. It would also allow to broaden the reflection on the upscaling and growing impact of LLs, even within cities, and to identify a practical contribution to the development of smart cities. The actors to be involved are multiple, and best practices from early LLs experiences can be capitalized to increase knowledge and awareness on how to expand the scope and achievable goals within a LL. Since spatial characteristics are at the core of LLs and what distinguishes them most, a theory-driven analysis of these elements, which also focuses on economic, environmental and social sustainability issues, would further expand the potential of LLs as real places of innovation that ultimately serve local communities. As LLs are a recent phenomenon, emerging from practical experiences and only subsequently institutionalized, guiding empirical research to fill practical-theoretical gaps can help all stakeholders, public and private, who are about to start a LL or who are working within LLs, to identify good practices and approaches to implement.

This study is not without limitations. First, it does not use citation scores or other quantitative indicators to assess the relevance and impact of the collected set of papers, nor does it take into account the journal or social science discipline to which they belong: this may certainly limit the scope of the results, but it clearly highlights how the academic debate has empirically evolved around a recent phenomenon. Second, the methodology of data collection, even with its extensive focus on practice-based case studies, would necessarily overlook other empirical contributions. In addition, given a sample based only on qualitative work, the systematization of the literature within different perspectives may not cover all possible conceptual nuances of the current debate.

Finally, despite the insightful results highlighted, the deliberate choice we made in the research design to exclude theory-testing contributions based on quantitative analysis limits the possibility of drawing once-and-for-all conclusions and of adopting a normative approach.

Further studies might then strengthen or complement the present contribution, further broadening the findings, placing emphasis on cutting-edge elements of interest in the debate on LLs. Hopefully, this study will inspire more empirical investigations for understanding the impact of LLs on society. Further longitudinal studies could for example explore the emerging trends regarding the spatial perspective as closely intertwined with sustainability issues (e.g., Bagoudou Labo et al., 2024; Dogan et al., 2023). In addition, there are different tools that can be used, such as drawing from UI theories, for effective integration and interaction with users and communities: a topic that has not yet been systematically analyzed in the LL literature. The present study can also serve as a valuable starting point for the systematization of knowledge on the phenomenology of LLs. For example, only by having a thorough understanding of the phenomenon of LLs is it possible to collect and systematize good operational practices: we hope that future contributions can address the managerial issues of how LLs should operate to maximize their impact and effectiveness, providing standards, guidelines or regulations, even under a normative approach. Overall, we are confident that future studies will be able to explore the potential of LLs as a phenomenon emerging in response to the needs of communities.

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