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The International Journal of Justice and Sustainability

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/cloe20

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To cite this article: A. Berberi, C. Beaudoin, C. McPhee, J. Guay, K. Bronson & V. M. Nguyen (05 Aug 2023): Enablers, barriers, and future considerations for living lab effectiveness in environmental and agricultural sustainability transitions: a review of studies evaluating living labs, Local Environment, DOI: 10.1080/13549839.2023.2238750

To link to this article: https://doi.org/10.1080/13549839.2023.2238750

LOCAL ENVIRONMENT
https://doi.org/10.1080/13549839.2023.2238750

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Enablers, barriers, and future considerations for living lab effectiveness in environmental and agricultural sustainability transitions: a review of studies evaluating living labs

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ABSTRACT

Living labs are promoted as an effective open innovation approach that accelerates the adoption of innovations. However, there remain knowledge gaps about factors that influence their effectiveness, success, and application to sustainability transitions. Through a scoping review on the evaluation of living labs, we identified 43 enablers and 37 barriers to effectiveness and success of living labs organised around the themes of governance, processes, features of living labs, characteristics of participants, adaptability, social dimensions, training and research, technology, and elements beyond the living lab (e.g. conditions for transition to the real world). Key enablers included strong collaborative and iterative processes with networks and partnerships, while key barriers included issues with supporting technology, the time and cost of collaboration, and challenges ensuring the longevity of living labs. We also reviewed study objectives, knowledge gaps, and future considerations to identify priorities for future research about living lab effectiveness and provide recommendations for their implementation. We recommend the development of frameworks for measuring and monitoring the success of living labs, and explore other considerations to promote their effectiveness based on the enablers and barriers identified. Lastly, we discuss how our findings on living lab effectiveness and success related to this special issue. This paper contributes to the body of research by our team (Beaudoin et al. 2022; Bronson, Devkota, and Nguyen 2021) that aims to explore living labs in the context of conservation, environmental, and agricultural sustainability to facilitate transformative social-ecological change.

ARTICLE HISTORY
Received 3 January 2023
Accepted 8 June 2023

KEYWORDS
Living labs; evaluation; enablers; barriers; sustainability

Introduction

Living labs (LLs) are increasingly prominent examples of the type of novel gambit required to address society's complex socio-environmental challenges in environmental and agricultural sustainability transitions. LLs are an approach to open innovation that engages users in real-life environments to co-develop and test innovative practices, technologies, and solutions in collaboration

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/13549839.2023.2238750.

with researchers, practitioners, and other partners. The diversity in LL collaborators and its iterative innovation model ensures sustainability problems are addressed from multiple angles, ultimately facilitating long-term, multidimensional, and fundamental transformations required in environmental and agricultural sustainability transitions (Markard, Raven, and Truffer 2012). However, context-dependent challenges may arise in LLs, such as difficulty maintaining engagement and motivation of collaborators (Leminen and Westerlund 2019; Ståhlbröst and Bergvall-Kåreborn 2011), loss of knowledge via inadequate provision of knowledge exchange and learning environments (Hossain, Leminen, and Westerlund 2019), or insufficient support for sustaining and scaling-up innovation outcomes (Evans et al. 2015; Hossain, Leminen, and Westerlund 2019). Ultimately, despite the popularity of LLs and their overall promise of delivering benefits, there remains a knowledge gap around what factors facilitate or impede the effectiveness of LLs (Ballon, Van Hoed, and Schuurman 2018; Bronson, Devkota, and Nguyen 2021). As a first step in addressing this gap, our team has recently published a research agenda to help scholars further explore this evaluation challenge (Beaudoin et al. 2022).

LLs have been adopted across a variety of domains, such as urban LLs used to innovate ideas and scenarios for sustainable city transportation (e.g. APRILab, CASUAL, Green/Blue Cities, SubUrbanLab and URB@EXP; Voytenko et al. 2016), or rural LLs to innovate a collaborative platform that can enhance working and living in remote area (e.g. Homokháti Living Lab, Sekhukhune Living Lab, and Cudillero Living Lab; Guzmán et al. 2008). In the agricultural context, there has been a recent focus on the development of "agroecosystem living labs", as exemplified by the large networks of agroecosystem living labs in France and Canada. These networks work towards sustainability objectives using ecological principles or focus on the acceleration of the development and adoption of solutions to address urgent agri-environmental challenges, including climate change (McPhee et al. 2021). As a result of the variety of where the LL approach is adopted, and who is adopting the approach, there are several differing definitions of LLs circulating. Many rely on the LL definition provided by the European Network of Living Labs (ENoLL), an international non-profit organisation for LLs originally founded by the European Union (ENoLL 2022; Hossain, Leminen, and Westerlund 2019; McPhee et al. 2021). ENoLL's definition states that LLs are "user-centered, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" (ENoLL 2022). Furthermore, five key components help to recognise and distinguish LL: co-creation, real-life setting, multi-method approach, multi-stakeholder participation, and active user involvement (ENoLL 2022).

Our team's efforts (Beaudoin et al. 2022; Bronson, Devkota, and Nguyen 2021) contribute to a body of work exploring LL approaches in the context of environmental and agricultural sustainability transitions (McPhee et al. 2021). In this paper, we explore the broader LL literature to tackle the evaluation and promotion of successful LL practices to ensure that, if LLs are used in the social-ecological transition to tackle environmental and agricultural problems and facilitate the adoption of innovative solutions, they can do so effectively (Fischer-Kowalski and Rotmans 2009). Specifically, we acknowledge the need for *just sustainabilities* to ensure that we live within the limits of ecosystems while meeting the needs of – and ensuring the quality of life for – present and future generations in ways that are equitable and just (Castán Broto and Westman 2017). To do so requires building on insights from the social sciences to support transformative social change that can help us face current environmental crises (Lidskog, Standring, and White 2022). Our research is thus relevant for researchers and practitioners in the field of LLs but also for transdisciplinary teams in the broader field of conservation, environmental, and agricultural sustainability (e.g. social and natural scientists working with community and government partners).

Research on open innovation shows that careful development of collaborative relationships, networks, and appropriate resources are essential for the success of these projects (Guzmán et al. 2013a, 2013b). But what are the specific factors that lead to effective LL processes and outcomes? Studies have explored the benefits that arise from effective LLs, including broader diversity for innovation, enriching practice-based learning experiences, and increasing knowledge exchange for complex

issues (Hossain, Leminen, and Westerlund 2019; Schuurman, De Marez, and Ballon 2016). However, we also know that not all LL projects succeed. To foster success and broader impacts of LLs, we reviewed factors that facilitate (or hinder) LL effectiveness. Thus, we aim to identify key enablers and barriers of LL success, where a successful LL is seen as one that achieves its goals either in terms of outcomes and impacts, or in terms of successful collaborative and co-creation processes within the LL. We also explore common knowledge gaps and future considerations found in the literature to contextualise our findings.

Materials and methods

Research design

This scoping review is part of a larger project addressing, "What are the knowledge gaps for evaluating the effectiveness and social impacts of LLs focused on environmental and agricultural sustainability?", funded by a Canadian Social Sciences and Humanities Research Council (SSHRC) knowledge synthesis grant. The team co-created a research agenda for evaluating LLs (Beaudoin et al. 2022) and a literature dataset was developed for a scoping review (Bronson, Devkota, and Nguyen 2021). Here, we directly build on the work by Bronson, Devkota, and Nguyen (2021), which investigated evaluation assessment methods adopted within the LL literature to measure the impacts of LLs. We use the same dataset to analyse enablers and barriers to effectiveness of LL, and future research considerations.

Before conducting the review, an a-priori method protocol was developed by the research team using the Collaboration for Environmental Evidence Guidelines (2013) (Supplementary Material A). We address relevant method details and deviations from the a-priori protocol below.

Searching for articles

We compiled and modified search terms using relevant benchmark papers ($n = 8$, Supplementary Material A). Trial searches were iteratively conducted on Web of Science Core Collection (WoS) and Scopus databases until a comprehensive search string was developed. The finalised search string was: ["living lab*" AND (evaluat* OR performance OR effectiv* OR impact OR assess* OR metric OR measure* OR indicator)].

Searches for peer-reviewed articles and grey literature were performed on WoS, Scopus, and Google Scholar on 2 June 2020. Experts in the LLs field were also asked for relevant articles that may not have been found in the aforementioned databases. No restrictions were placed on publication year, and only English results were considered.

Article screening and study eligibility criteria

Our research team (AB, CB, JG, JS, SR) used Covidence Systematic Review Software (www.covidence.org) to screen the articles for inclusion/exclusion using pre-defined eligibility criteria. Eligibility criteria used were: (i) article matched LL definition (Hossain, Leminen, and Westerlund 2019), (ii) article discussed LL evaluation, and (iii) article discussed LL effectiveness. We conducted consistency checks on 5% of the total articles at title and abstract screening. Articles were selected at random using a double-blind method. A Kappa test assessed inter-reliability of outcomes and inconsistencies were reconciled by the research team before moving to the next phase (McHugh 2012). For full-text screening, Bronson, Devkota, and Nguyen (2021) uploaded articles to Voyant Tools online (www.voyant-tools.org) to text mine relevant key terms: agri*, sustainable*, evaluate*, and impact*. Articles output from Voyant Tools under these conditions were included in the final dataset.

Data extraction

Articles included from the screening phase were used to create a dataset with relevant extracted data: bibliographic information, description of LL(s) (location, sector, definition, LL studied), study objectives, enablers and barriers for LL effectiveness, knowledge gaps and future considerations, and social impacts (Supplementary Material B). Data extraction was performed by researchers AB, CB, JG, JS, and SR and consisted of copy-pasting text directly from the articles into Google Sheets.

Qualitative analysis: thematic analysis

Qualitative data (direct quotes from articles) were thematically analysed on Google Sheets using inductive coding to identify emerging themes (Braun and Clarke 2006). Three authors (AB, CB, VN) coded quotes for study objectives, enablers and barriers to LL effectiveness, knowledge gaps and future considerations, and social impacts from the included research articles. Three rounds of coding occurred for each category. The first round of codes served to extract distinct elements relevant to the category, the second round grouped similar codes, and the third round organised and structured the codes into broader themes. Each round of coding was reviewed by at least one other member of the research team. The thematic grouping was also informed both by counts (i.e. at least 10 articles mentioned enablers or barriers for each of the broader themes),

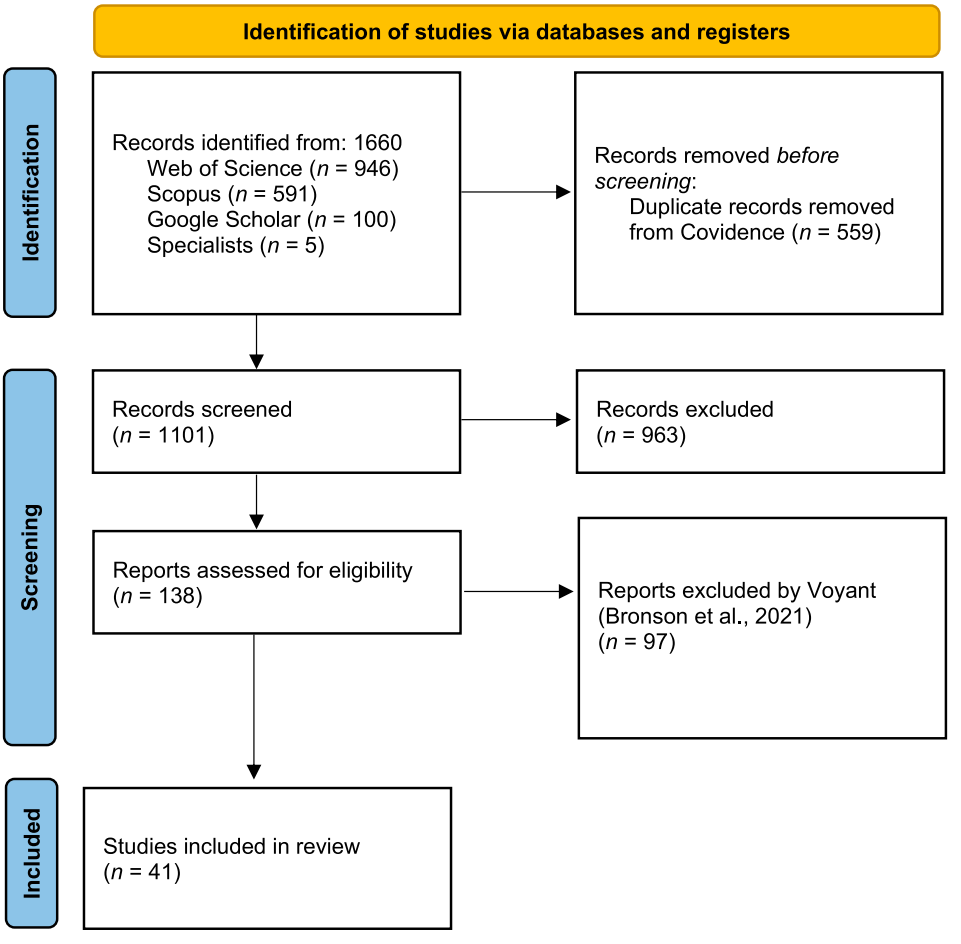

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA) flow diagram.

and the coder's knowledge of the LL literature (including perceived importance of various themes in the literature). We also explored potential relations between LL sectors and enablers, barriers, knowledge gaps, and future considerations through cross-analyses but did not pursue this further as no clear patterns emerged.

Results

Included articles and bibliographic information

The searches resulted in 1101 articles after duplicates were removed (Figure 1). After articles were screened using title and abstract with eligibility criteria, 138 articles were included as relevant for full-text screening. After full-text screening with Voyant Tools, 97 articles were excluded based on eligibility criteria (Bronson, Devkota, and Nguyen 2021). A total of 41 articles were included and advanced to data extraction and data analysis phases (Supplementary Material B).

Bibliographic metrics (article type and publication year) varied across the 41 included articles (Figure 2). More than half were peer-reviewed literature ($n = 22$), whereas grey literature ($n = 2$) was the least common. We found an overall increase from the first publication year ($n = 2$ in 2009) to the year we conducted searches ($n = 4$ in 2020), with the highest number of articles published in 2016 ($n = 6$).

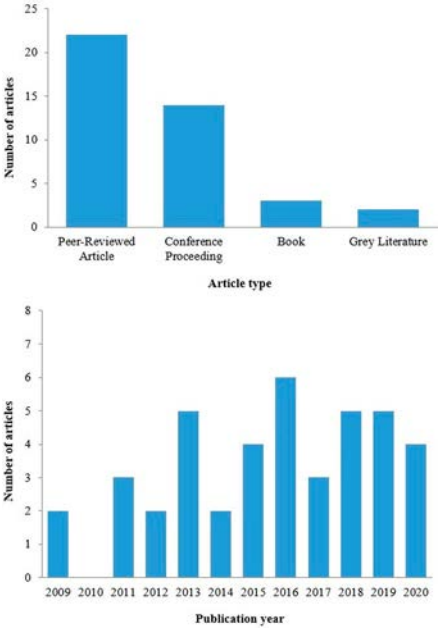

Figure 2. Bibliographic metrics of included articles in the scoping review ($n = 41$).

Living lab geographic location and sector

Most articles studying the evaluation of LLs were based in Europe (Figure 3), which aligns with the well-known emergence and historical growth of the LL movement: although the LL approach was pioneered in the United States, Europe became the dominant location for LL implementations starting in 2003 (Leminen and Westerlund 2019).

We classified LL sectors using sectors from ENoLL (2022). One article was excluded because it did not specify the LLs studied, so it could not be classified by sector (Salminen et al. 2011). Figure 4

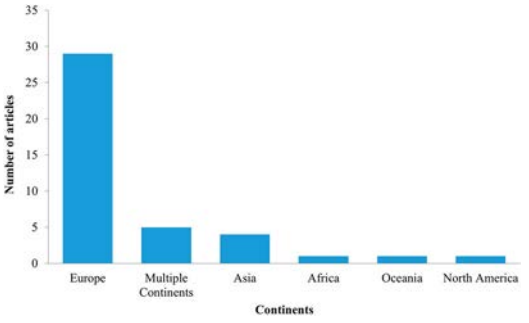

Figure 3. Geographic distribution of living labs studied across included articles ($n = 41$).

demonstrates the spread of sectors across 40 articles, with Media being the most common LL sector and Artificial Intelligence being the least common LL sector. Each sector was counted once per article, and multiple sectors per article were accounted for when needed (Supplementary Material B).

Given the wide spread of sectors represented in our dataset, our presentation of results is not specific to the environment or agriculture sector. Yet, these results will inform our discussion about how LLs can effectively be mobilised to successfully implement innovative solutions to environmental and agricultural challenges and effectively contribute to social-ecological transitions. More specifically, we note that LLs in the environment and agriculture sector started to be represented in our literature dataset in 2013, and were consistently represented in publications from subsequent years. This points to the growing application of LLs in the environmental and agricultural sector.

Article study objectives and living lab definitions

As expected, given our sampling strategy, the most common study objective within our dataset was to investigate LL evaluation models (9 articles), and more specifically to examine different frameworks, tools, and criteria for evaluating LLs. Other common study objectives were understanding LL designs, LL user engagement, LL actors and relationships (all cited by 8 articles). The least common study objective focused on identifying different types of LLs and their distinct features (4 articles) (Supplementary Material B).

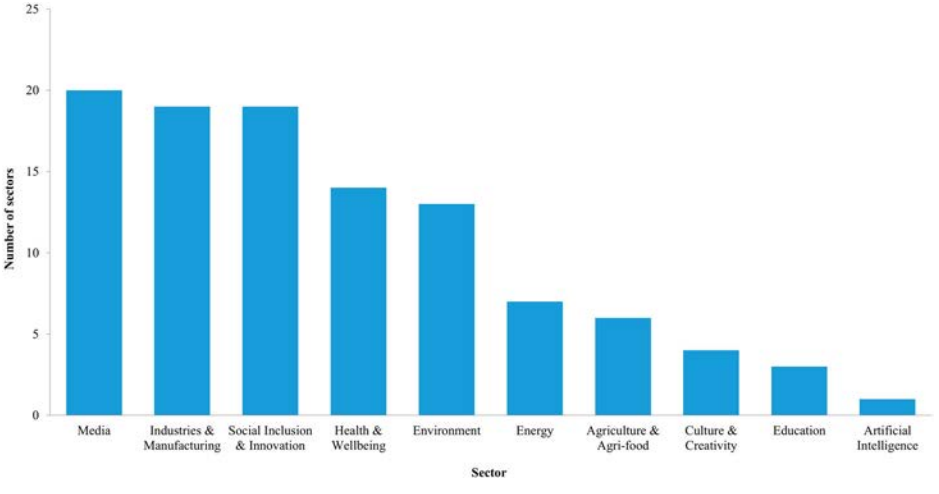

Figure 4. ENoLL living lab sectors. Living labs with multiple sectors were accounted for in the analysis ($n = 40$).

Figure 5. Word cloud depicts the 40 most frequent words used to define living labs across the 41 included articles, excluding the words "living" and "lab" due to redundancy. "Urban living labs" is abbreviated to "ulls."

Of the 41 included articles, 38 articles defined LLs (Supplementary Material B). The word cloud shown in Figure 5 demonstrates the variability in LL definitions across the 38 articles, where the most common words were "innovation" and "users". Definitions of LLs were not uniform but aligned with early definitions emphasising the user-centric nature of LLs that operate in real-world environments (Leminen and Westerlund 2019).

Enablers and barriers

Most articles highlighted enablers to the effectiveness and success of a living lab (43 individual enablers identified with a total of 337 mentions of these different enablers across 38 articles), and many barriers were identified but less frequently mentioned (37 individual barriers identified with only 155 total mentions of these different barriers across 36 articles). The enablers and barriers were grouped into nine broad overarching themes (see Table 1 for an overview of the overarching themes and Supplementary Material B for a detailed list).

Figure 6 shows each overarching theme and the individual enablers and barriers that compose them. Notably, we found that barriers can oftentimes be enablers and vice versa, but it is the way, quality, or level at which the practice was mobilised that determined if it was an enabler or barrier. This was especially the case for practices that are ubiquitous in the LL framework such as collaboration (e.g. Hagy et al. 2017; Nesti 2018; Osorio et al. 2019). Another example is data collection on the innovation from LL participants: having reliable data in real-life settings versus unreliable data collection is respectively an enabler or a barrier (e.g. Callari et al. 2019; Georges, Schuurman, and Vervoort 2016; Pigot and Giroux 2015). A third example is with motivation: maintaining motivation and positive attitudes among participants over the duration of a LL, while avoiding participant fatigue (Georges, Schuurman, and Vervoort 2016), is key to its longer-term success (e.g. Ley et al. 2015; Ogonowski et al. 2013). Each theme is further unpacked in the following section.

Table 2 presents descriptions of the most frequently mentioned individual enablers and barriers. The top three enablers all highlight the importance of dialogue and exchange of information in LLs. Aligning with the definitions of LLs as user-centric, interpersonal skills and relationships are key to

Table 1. Overarching themes that emerged from the analysis of enablers and barriers in the articles reviewed.

Overarching theme	Description
Governance	Processes that organise the functioning of living labs (e.g. structure, institutions, collaboration and coordination, resources).
Process	Processes specific to the LL framework (e.g. methodology, iteration, prototyping, evaluation).
Features of LLs	Key characteristics that play a role in the overall operations of LLs (e.g. complexity, real-life setting, early involvement, focus, infrastructure).
Characteristics of participants	Elements tied to the actors that participate in LLs (e.g. motivation, expectations, experience, needs).
Adaptability	The ways in which LLs cope with change, uncertainties, and the broader context (e.g. openness and flexibility or lack of openness and flexibility).
Social dimensions	Dimensions of social interactions in LLs that range from micro to macro scales (e.g. community, ethics, relationships, shared understandings or lack thereof, trust or lack thereof).
Training and research	Education, training, and research (or lack thereof) in LLs.
Technology	Use of technology not as the targeted innovation, but as an element to support LL processes.
Beyond the LL	Processes and elements that extend beyond the initial project or LL network (e.g. transition of the innovation to real-world adoption).

ensure effective and successful LL processes (ENoLL 2022). Notably, the top barriers relate to resources – including ability to use technology, capacity to collaborate, and resources and competence to sustain LLs long-term – which are necessary to facilitate the conditions that enable effective LLs (i.e. iteration, collaboration, partnerships).

Understanding the enablers and barriers

Half of the articles in our review mentioned enablers and barriers related to the overarching theme of *governance* (Table 1), while the second and third most frequent enablers were *collaboration* and *partnerships*. Collaboration was seen as enabling success in LLs while low collaboration was seen as a barrier to success. Some recommendations to strengthen LL collaboration include to: (i) build collaborative arrangements that include the diversity of LL actors, (ii) openly communicate what the collaborative relationship involves and what is uncertain, and (iii) help actors maintain their willingness to collaborate as the LL projects evolve (Hyysalo and Hakkarainen 2014). Similarly, partnerships and networks were an enabler whereas a lack of coordination was a barrier. Conversely, time and cost of collaborations was the second most frequently mentioned barrier (Table 2). Thus, having financial resources and external support to carefully plan and facilitate collaborations helps ensure success of LLs. Some of these trade-offs were explicitly mentioned in the literature, with some acknowledging the trade-offs between structure and flexibility (e.g. centralisation provides structure and homogeneity to facilitate decision-making but can constrain innovation; Davies 2018; Hagy et al. 2017; Moro and Puerari 2015; Veeckman et al. 2013; Von Wirth et al. 2019), and effectiveness versus efficiency (e.g. while the LL approach can be time consuming, it can also save time by focusing on the needs of users and facilitating access to the tacit knowledge of users; Dell'Era, Landoni, and Gonzalez 2019; Nesti 2018).

When looking at the overarching theme *process*, three quarters of the articles mentioned enablers while less than a quarter mentioned barriers (Table 1). The iterative process of LLs was the most frequently mentioned individual enabler (Table 2). For example, the iterative process involves LL users using products or practices, bringing results to LL partners to discuss improvements together, and repeating these two steps until best results are reached (e.g. HomeLabs; Davies 2018). In terms of process, considering methodology helped ensure success while methodological issues hindered success and effectiveness. Having iterative processes, prototyping activities, evaluation, and space for new ideas were all seen as enablers, with evaluation specifically highlighted as having the potential to support effective planning of LL processes (Georges, Schuurman, and Vervoort 2016; Mastelic, Sahakian, and Bonazzi 2015). For example, short assessments, such as two-minute interviews with LL users, can be an effective way to evaluate user involvement and adjust as needed (Salminen et al. 2011).

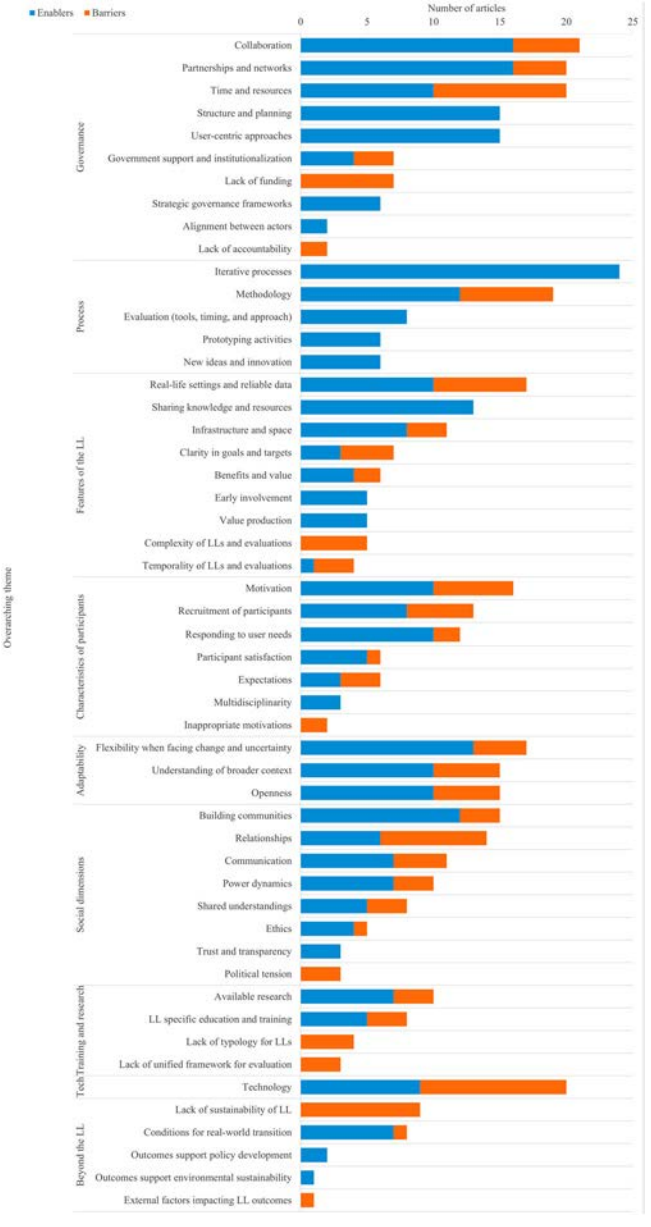

Figure 6. Number of articles mentioning enablers and barriers for living lab effectiveness. Many elements can be both enablers and barriers depending on how it was framed in an article.

Over half of the articles identified enablers and nearly half identified barriers that were tied to the overarching theme *features of LLs* (Table 1). These are defining characteristics of the aims, activities, and contexts of LLs (Steen and Van Bueren 2017). While many features of LLs act as enablers (sharing knowledge, early involvement, value production), many of these features could be either enablers or barriers. For example, real-life setting was generally seen as an enabler, but could introduce a reliability trade-off and issues with data collection because there is less control over measurements in real-life settings relative to controlled settings (Pigot and Giroux 2015). This duality was also apparent with concepts such as (lack of) clear focus for LLs, (im)proper infrastructure, and (lack of) value for

Table 2. Top 3 frequently mentioned enablers and barriers to effective living labs.

Category	Ranking	Enablers/ Barriers	Description*
Enablers	1	Iterative processes	Iterative processes for data collection, feedback, and monitoring to increase LL efficiency. This also includes identifying changing expectations and arising obstacles throughout the LL process.
	2**	Collaboration	Participatory approaches (e.g. co-design and co-creation) and identifying strategies for supporting long-term collaboration (e.g. building teamwork and problem-solving skills).
	2**	Partnerships and networks	Identify and facilitate actions to support partnerships and networks. This can include developing social activities for communication, informal interactions, and networking opportunities.
Barriers	1	Technology issues	Technology is not properly used or understood, or it is underused. There are also risks such as unpredictable technical problems or failures.
	2	Time and cost of collaboration	There are constraints (e.g. time and cost) tied to highly structured collaboration approaches. Mismatches between capacity and expected collaboration outcomes can lead to increased workload for LL partners.
	3	Lack of sustainability of LL	Lack of resources, initiative, and competence for LL processes and outcomes to be diffused beyond the project.

*Descriptions are summarised second codes. See Appendix B for a full list of second codes.
**Equal rank due to equal code count.

stakeholders. The complexity of LLs and their evaluation was also identified as a barrier, especially in large-scale projects with many stakeholders and multi-activity LLs. There is also a trade-off between complexity and growth, as a growing LL becomes more complex and thus more difficult to manage (Van Geenhuizen 2018).

Over half of the articles mentioned enablers tied to the overarching theme *characteristics of participants* (Table 1). Again, many enablers acted as barriers (e.g. high motivation or loss of motivation; managing expectations or having too high expectations; responding to user needs or users feeling unheard, recruiting the "right" or the "wrong" participants for the LL). Additionally, multidisciplinarity among participants is an enabler as multiple perspectives can add value to the LL outcome (Callari et al. 2019). However, caution must be taken when recruiting LL participants, as inappropriate motivations can be a barrier (e.g. seeking more power rather than an improved outcome; Giboreau 2018; Leonardi et al. 2014).

Adaptability, under the form of flexibility, creativity, openness and understanding of the broader context, was seen as an enabler by around half of the articles while a lack of adaptability was seen as a barrier. Flexibility in LLs was seen as supporting openness (Moro and Puerari 2015), while a trade-off was identified between the diversity and openness of LLs and the need for evaluation models to be replicated across LLs (Mastelic, Sahakian, and Bonazzi 2015).

Around half of the articles identified enablers and barriers tied to *social dimensions* (Table 1). Most social dimensions were identified as enablers, but acted as barriers if they were lacking (e.g. building community or lack of community, shared understandings or lack of shared understandings, good or poor communication, long-term relationships or challenging relationships, recognition and empowerment or power imbalance, trust or lack of trust which can influence the quality of input received from participants; Benavent et al. 2011).

Around a quarter of articles identified enablers and barriers tied to *training and research* (Table 1). Education, training, and research were generally identified as enablers to successful and effective LLs, while barriers included the lack of skills and expertise in LLs, the lack of research about participatory approaches, the absence of an established LL typology (to understand the differing needs and priorities of different types of LLs), and the lack of unified models to establish and evaluate LLs. In fact, projects and LLs who follow models or guidelines for LLs (e.g. LL analysis model, LL process reference model, stages of implementation) have a higher chance of success (Chen and Chou 2010; Guzmán, del Carpio, et al. 2013a; Guzmán, García, et al. 2013b; Luo et al. 2012; Schuurman, De Marez, and Ballon 2016; Smit et al. 2011).

The overarching theme *technology* was understood as the use of technology to support LL processes (e.g. applications to support data collection or communication among participants). The theme of *Technology* was considered both an enabler and a barrier (Hagy et al. 2017) and was mentioned by about a quarter of the articles (Table 1), with technology issues being the most frequently mentioned barrier (Table 2). For example, technology issues include complex technology being too difficult to test or adopt among participants, and unpredictable technical problems or failures (Ogonowski et al. 2013; Schuurman et al. 2013).

Finally, factors *beyond the LL* also influence the success of LLs as identified by about a quarter of the articles (Table 1). This includes supporting effective transition of the innovation to the real world (e.g. inspirational events or political support that facilitate the implementation of innovations; Guzmán et al. 2013b; Hagy et al. 2017), and outcomes that support policy development and environmental sustainability. Barriers to the perceived success of LLs include, among others, the lack of facilitating conditions to transition innovations to the real world. The lack of sustainability and long-term viability of LL processes and outcomes was the third most frequently mentioned barrier (Table 2).

Future considerations for living lab research

We identified 19 knowledge gaps (from 25 articles), understood as previously known gaps identified by the authors in the introduction and/or literature review section of articles. We further identified 19 future considerations, defined as elements identified by the authors in the discussion and conclusion as a result of their analysis which need to be investigated in future work, from another distinct set of 25 articles. We then grouped the knowledge gaps and future considerations in four broader themes: outcomes, actors and relationships, LL processes, and approach and research (Table 3 and Figure 7).

The most frequent knowledge gaps identified in the articles were the need to further understand how to create and use appropriate infrastructure (e.g. configuration of space, use of equipment and technology, design of real-world conditions, mobile LLs; 5 articles), how to develop and use effective models and frameworks for LLs and their evaluation – including how to adapt these models to new contexts and LLs of various scales (5 articles), better understanding the role of LLs in the social-ecological transition (4 articles), better understanding the complex, networked and multidirectional nature of LLs (4 articles), and the need for more data to be collected throughout LL processes and about LLs (4 articles). The most frequently mentioned future considerations were the need

Table 3. Overarching themes that emerged from the analysis of knowledge gaps and future considerations in the articles reviewed.

Overarching theme	Description of knowledge gaps and/or future considerations
Outcomes	Better understanding key performance factors, how to measure performance and impacts of LLs, and how LLs could contribute to the environmental and energy sustainability transition. Transitions of innovations from the LL to the real world was also a gap.
Actors and relationships	Achieving long-term involvement of actors and better understanding the roles and attributes of different actors involved in LLs were both knowledge gaps and future considerations. There were also knowledge gaps about user typology, ethics and relationships between actors and future research should look at actor diversity and engagement.
LL processes	Many processes that are constitutive of LLs need to be better understood. Infrastructure related issues were both a gap and future consideration. Other knowledge gaps include the capacities of LLs, and better understanding co-creation, complexity, and knowledge transfer. Future research should look at governance, technology, attributes of LLs, and evaluation.
Approach to LL design and research about and within LLs	Knowledge gaps and future considerations need to attend to effective models or frameworks for developing and evaluating LLs, the impacts of LL design and feedback methods on LLs themselves (e.g. qualitative, quantitative, action research). There was also a need for more data as part of LL activities and about LLs (e.g. for monitoring, to enable comparative research). The need for a typology of LLs and toolkits for non-experts were identified for future consideration.

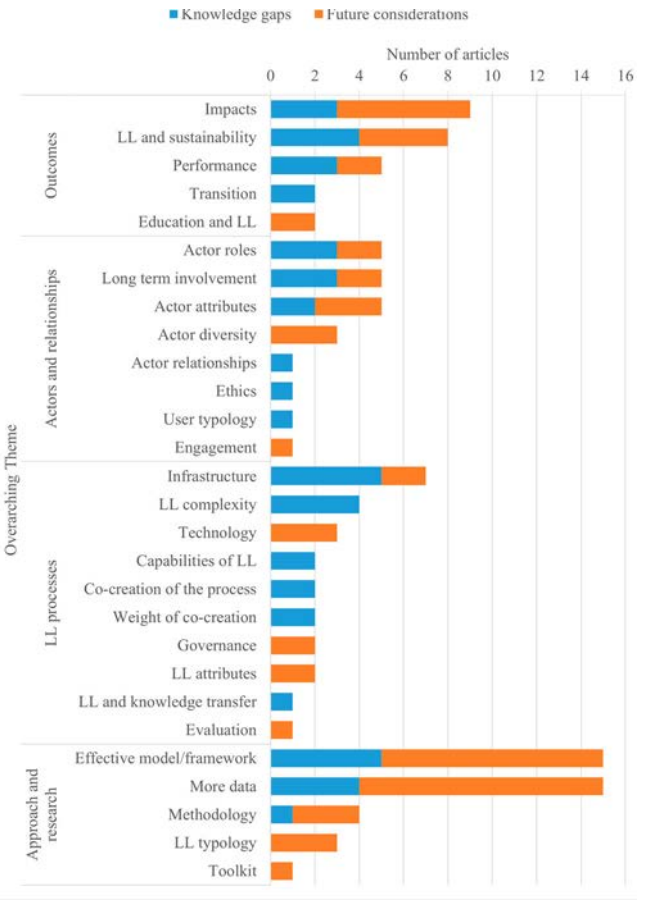

Figure 7. Number of articles mentioning knowledge gaps and future considerations for living lab effectiveness and success research.

for more empirical quantitative and qualitative data to compare LLs (e.g. large representative samples, long-term assessments, different scales of analysis about the performance of LLs, more user feedback, more analysis of existing practices and tools; more data about outcomes and impacts; 11 articles); the need for effective models and frameworks that define stages and processes for effective LL practices in ways that are adaptable to various contexts (10 articles); and consideration of the impacts of LLs and how to assess their short and long-term impacts beyond the project, including tracking changes after innovation implementation (e.g. user experience, social change, place-making, increased knowledge) (6 articles). In the context of social-ecological transitions, we encourage researchers to focus future efforts on better understanding which frameworks enable LLs to have short and long-term impacts that support sustainability.

Social impacts of living labs

Only 15 of the 41 articles touched on the social impacts of LLs. As *just sustainabilities* emphasises the need for ecological and social transformations to come hand in hand, we must attend to the social impacts of LLs to ensure they can effectively contribute to the social-ecological transition. Social impacts reported in our article dataset could be seen at the individual level (e.g. sense of belonging, improved quality of life), the community level (e.g. improved cultural heritage or environmental

sustainability), the economic level (e.g. diversifying the economy), and in terms of collaborative capacity building (e.g. co-creation is valued, education and training as part of LL activities). For example, co-producing in LLs can lead to scientific literacy and scientific empowerment of participants, enabling them to participate more informally in environmental policies (Nesti 2018). However, in our review, there was an overall lack of emerging themes across the 15 articles that mentioned social impacts, further highlighting the need for social impacts to been studied in LL effectiveness literature.

Discussion

Living labs hold great potential as a novel method for innovating technologies or practices that might help us address the grand social and environmental challenges of our time (Hossain, Leminen, and Westerlund 2019; McPhee et al. 2021). Our review highlights key features of LL design and processes that are necessary for LLs to effectively target social and environmental challenges, and thus their potential to deliver on this promise for productive social-ecological change. We build on our findings to make specific recommendations regarding the development and evaluation of successful LLs. We also outline limitations of our review, as well as ties to themes from the special issue "Living Labs: Perspectives on Regenerative Approaches for Place-Based Socio-Ecological Transitions".

Overall, our findings demonstrate the potential for LLs to be used as levers for the social-ecological transition, but also highlights the need for more researchers to track social-ecological impacts tied to their LL efforts, especially in the environmental and agricultural sustainability sector. Very few studies discussed social impacts, suggesting that it remains a knowledge gap in the literature on evaluation of LLs and their outcomes. While most of the barriers and enablers of successful LLs identified in our analysis do not directly attend to the social-ecological transition, they must be considered when applying LLs in this field for innovative solutions to be developed, implemented, and adopted by the broader public to support durable social-ecological transformations. LLs can only be a practical tool for the social-ecological transition if we understand how they should operate and be evaluated to maximise effectiveness. The LL programmes at Agriculture and Agri-Food Canada (AAFC) are a great example of diverse participants and farmer end-users collaborating in effective LLs to innovate on-farm agroecosystems solutions via the social-environmental transition (AAFC 2021; McPhee et al. 2021).

Developing frameworks for evaluating success of living labs

Across the literature, conducting evaluations was consistently presented as a way to promote the effectiveness and success of LLs (e.g. Guzmán et al. 2013b; Smit et al. 2011). However, the lack of unified frameworks for evaluation was often cited as a barrier (e.g. Chen and Chou 2010; Kovács 2016; Mastelic, Sahakian, and Bonazzi 2015), a finding our research team has previously highlighted (Bronson, Devkota, and Nguyen 2021). Analysis of knowledge gaps among articles in our dataset highlight the need for improving the ways in which we evaluate LLs and measure their impacts. For example, Van Geenhuizen (2018) suggests there is a need to better understand causality – or the specific mechanisms between an LL and its broader impacts – within the evaluation of LLs. We argue that the enablers and barriers for effective LLs identified through this scoping review could inform specific dimensions for the development of effective evaluation practices or common frameworks that enable comparison of LLs across sites and settings. Our findings highlight that, at minimum, evaluation metrics and measurement frameworks should attend to the following key dimensions of LLs: governance, processes, features of LLs, characteristics of participants, adaptability, social dimensions, training and research, and technology. The various enablers and barriers identified in this paper (Figure 6) could also be used to derive precise indicators and specific criteria that could or should be measured when evaluating the effectiveness, success and impacts of LLs.

Thus, the field of LL research and practice should focus on analysing existing and producing new models and frameworks for LLs and their evaluation based upon the criteria for success identified in this scoping review. Furthermore, future research and practice should also focus on:

- Tools for generating reflexivity to adapt evaluation models to varying contexts (also identified as a gap in Bronson, Devkota, and Nguyen (2021); and Beaudoin et al. (2022);
- Gathering more empirical data about LLs processes (including evaluation) and impacts to strengthen our understanding of LLs and improve outcomes (e.g. conducting larger studies with bigger samples, testing hypotheses in LLs, collecting data based on common indicators that enable comparison, and collecting both quantitative and qualitative empirical data);
- Using outcomes of LLs to inform subsequent methodological decisions and investigating the strengths and weaknesses of different methodological frameworks, including participatory research designs, fuzzy set analysis, and exploratory methodologies (echoing Bronson, Devkota, and Nguyen 2021 which uncovered tensions between methods for the evaluation of specific projects versus universal frameworks for assessments LLs; also prioritised in Beaudoin et al. 2022);
- Establishing a typology of different types of LLs that can inform the design of effective processes in different contexts with different targeted impacts (McPhee et al. 2021 have identified features specific to agroecosystem LLs within a proposed typology of place-based living labs, but other types and typologies could also be identified); and,
- Creating practical toolkits for LLs and their evaluation that can serve as resources for those establishing new LLs and LL projects (could include visual toolkits for non-experts or guides with instructions; also prioritised in Beaudoin et al. 2022).

Study limitations

Scoping reviews provide an overview of key concepts and knowledge gaps in emerging fields, such as LLs (Munn et al. 2018). Our scoping review was conducted with an a-priori method to minimise bias, and each step was peer-reviewed by research members to increase the reliability of findings. However, there are still limitations to the scoping review approach. Our scoping review was limited to English language articles, which may have missed key LL articles in other languages. Additionally, although we conducted searches across three databases (WoS, Scopus, Google Scholar), the majority of included articles were peer-reviewed literature (Figure 2). Our findings may under-represent insights from other LL stakeholders included in grey literature (e.g. reports from non-academics). Searching other databases, or including internet searches, may yield more relevant grey literature. Moreover, most articles in our review focused on LLs in Europe (Figure 3) and therefore our geographic scope was limited. Although this represents the fact that many LLs are based in Europe (Leminen and Westerlund 2019), it highlights the bias toward LLs from developed countries and the studies focused on them. This highlights a corresponding gap in LL literature focused on, or emerging from, other continents. Also, our findings are limited by the scope of our dataset that focused on the evaluation of LLs.

Although scoping review methodology entails capturing and comparing a wide breadth of studies in the field, our review specifically compares studies on LLs driven by different institutions (e.g. corporation, government, university), which may overlook each institution's unique structure and ideological commitments that can influence their definitions of "innovation". In turn, decontextualization during our review's comparison between LL studies may have led to depoliticised results. Our analysis, however, did reveal that government support and institutionalisation was considered as an enabler by most who mentioned it (Davies 2018; Guzmán et al. 2013b; Kovács 2016; Moore, Horne, and Doyon 2020), but also sometimes a barrier (Moro and Puerari 2015; Osorio et al. 2019; Van Geenhuizen 2018) even though it was not the most common identified barrier or enabler. Although articles typically are not explicit with their institution's perspectives on "innovation",

and a LL consortium can represent a variety of institutions, we suggest future studies on LL consider stating each involved institution's positionality on innovation. This will help future readers and future reviews draw clearer connections between results on social-ecological change and transitions to *just sustainability*, an inherently political field.

According to the articles included in our scoping review, future research on LL effectiveness should highlight the diversity of LL partners and provide opportunities for their perspectives and knowledge to be disseminated. In addition to creating opportunities to increase representation of diverse stakeholders in LLs, it is also important for future research to identify obstacles that impede these stakeholders from disseminating their perspectives and knowledge, and how these obstacles vary in different regions of the world.

Ties to the special issue: governance, power dynamics and co-creation

Our analysis has many implicit links to different dimensions of LLs highlighted by this special issue, showing the potential for LLs to contribute to social-ecological change and sustainability transitions. Governance emerged as the most frequently cited overarching theme in this literature in terms of ensuring effectiveness and success of LLs, with 31 out of the 41 articles mentioning enablers and barriers tied to governance (e.g. strategic governance frameworks, user-centric governance, collaboration and partnerships, and the cost and constraints of collaboration and co-creation; Table 1). This shows that (in)effective governance can make or break a LL. The literature also addresses power dynamics. Addressing power dynamics through empowerment and recognition of participants' value and contributions was seen as a way to ensure success for LLs. This can be done through early involvement (Kovács 2016) or by considering LL participants as research partners rather than research subjects (Davies 2018). Furthermore, some successful LLs explicitly address ethics, for example by evaluating power distribution and respect (Van Geenhuizen 2018). Conversely, power imbalances such as centralised decision-making (Moro and Puerari 2015) and strategic exclusion, disempowerment, and oppression (Delina 2020) are barriers to effective and successful LLs. The review also revealed that power can be wielded to orient LL processes towards economic profitability rather than sustainability (Van Geenhuizen 2018). We also note that modes of governance and power dynamics may differ across cultural and geographical contexts. Overall, governance and power dynamics thus greatly influence LLs, and in turn their ability to support just and sustainable social-ecological change.

Collaboration and co-creation are essential features of the LL process; thus it is not surprising that they emerged as key enablers of effective LLs. In fact, LLs are co-creation platforms (Hagy et al. 2017) that support various types of learning, for example learning through trial and error (Nesti 2018). LLs generally include iterative processes, including feedback and monitoring that enables learning between different groups (e.g. users and developers; Hyysalo and Hakkarainen 2014), as well as learning to identify and address problems as they arise (Guzmán et al. 2013b). There is increasing recognition that co-creation and collaborations are imperative to developing effective environmental and agricultural solutions (e.g. Berkes 2009; Cash et al. 2006; Nguyen et al. 2019), and thus investing in sustained collaborations and partnerships via LLs may further enable the implementation of these environmental and agricultural solutions in the real-world. LLs may also be a mechanism, infrastructure, or platform where the best practices for research implementation (e.g. co-production, knowledge exchange, participatory approaches) discussed in the environmental or agricultural literature may be applied or implemented.

Evaluation, which itself can be co-created, can also assess how learning evolves over time in each LL. Knowledge sharing, including sharing tacit knowledge, in LLs was seen to be a key enabler of success (Ogonowski et al. 2013; Guzmán et al. 2013b). These elements tie back to the broader approach taken by our research team. We co-created a research agenda with LL experts through a Delphi process to identify gaps in the evaluation of LLs (Beaudoin et al. 2022). This demonstrates how universities are supporting LLs by using co-creation techniques like those used in LLs to

advance knowledge about LLs. In our current review, academics partnered with the AAFC and the Le laboratoire en innovation ouverte (LLio), respectively a government body and a college centre for the transfer of social practices, illustrating that actors with differing professional responsibilities and constraints play different roles when generating knowledge about LLs. In our case, universities served a coordinating research role to bring together experts and practitioners from different LLs within and beyond government contexts to co-create valuable knowledge about LLs. The gaps identified by the team raised questions about the evaluation of the wider impacts of LLs as well as who participates in the evaluation process and in what ways (Beaudoin et al. 2022; Bronson, Devkota, and Nguyen 2021), thus they could help tackle questions of justice and collaborative governance in LLs to help work towards *just sustainabilities*. We also acknowledge the role that some universities play in hosting or creating LLs, yet we caution those involved in such initiatives to keep in mind the definition and key features of LLs. In fact, not everything that calls itself a "living lab" respects the criteria and approach set for LLs which can lead to confusion about how to evaluate their effectiveness.

Conclusion

Our review highlights that there is underrepresentation of LLs and LL evaluations in the grey literature, outside of Europe, and in environmental and agricultural contexts. We also found a lack of measurement of social impacts of LLs. Most relevant for those interested to develop, study, or participate in a successful LL are the identified enablers and barriers to effectiveness in LLs (see Table 1 and Figure 6). We offer some suggestions for practitioners and participants about key elements that can be leveraged to drive success in LLs. We also offer this synthesis to researchers and practitioners who should build on key enablers and barriers to develop more robust frameworks and metrics for LL evaluation (e.g. using the enablers and barriers to derive indicators of effectiveness or success). Indeed, while there are limits to this review, it confirms the need for such frameworks. Furthermore, the results of the scoping review and the broader research process raises the complexity of LLs as collaborative, participatory, and co-creation spaces. It is key that we keep asking questions about who is involved, how, and in what way to ensure that we not only have effective LL features that produce desirable outcomes, but that these outcomes can be obtained in just, equitable ways through meaningful participation of all stakeholders.

Overall, this work is essential for the effective mobilisation of LL frameworks and approaches in the context of environmental crises and social-ecological transitions. By providing guidance on how to promote but also evaluate the effectiveness of LLs, our work contributes to conversations on how to ensure that scholars and practitioners wanting to use a LL approach in the context of social-ecological transitions can maximise their chances of achieving both an effective process (e.g. co-creation, establishing shared meanings, sharing knowledge, social learning) and desired outcomes (e.g. improved social-ecological alignment; adoption of conservation, environmental, or agricultural solutions; increasingly collaborative environmental governance). Beyond guiding the practice of LLs, knowing more about the enablers and barriers to effective LLs can also help scholars and practitioners decide if the LL framework is appropriate and aligns with their goals, or if another approach is better suited.

Acknowledgements

We wish to thank Samuel Richard and Julie Sell for their contributions to the data collection in this study and R. Sandra Schillo, Steve Joncoux, and Jean-François Jasmin for their conceptual contributions as collaborators in the overall research project. We also thank Heather MacDonald from Carleton University MacOdrum Library for her expertise on review approaches and techniques. The review idea was spearheaded by authors CM, KB, VMN, and review methods by AB. Article screening and data extraction were conducted by authors AB, CB, and JG. Data analysis and writing was conducted by authors AB, CB, and VNM. All authors contributed during the draft and final approval of the publication.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Social Sciences and Humanities Research Council of Canada [Knowledge Synthesis Grant "Living Within the Earth's Carrying Capacity" Grant number: 872-2019-1020, 2020-2021].

References

AAFC. 2021. "Living Laboratories Initiative." Accessed December 26, 2022. https://agriculture.canada.ca/en/science/living-laboratories-initiative.

Ballon, Pieter, Miriam Van Hoed, and Dimitri Schuurman. 2018. "The Effectiveness of Involving Users in Digital Innovation: Measuring the Impact of Living Labs." *Telematics and Informatics* 35 (5): 1201–1214. https://doi.org/10.1016/j.tele.2018.02.003.

Beaudoin, Christine, Steve Joncoux, Jean-François Jasmin, Albana Berberi, Chris McPhee, R. Sandra Schillo, and Vivian M. Nguyen. 2022. "A Research Agenda for Evaluating Living Labs as an Open Innovation Model for Environmental and Agricultural Sustainability." *Environmental Challenges* 7 (100505), https://doi.org/10.1016/j.envc.2022.100505.

Benavent, Josep, Jordi Colobrans, Sergi Marí, Joan C. Castro, and Josep M. Colome. 2011. "Lessons Learned from Users: The Development of the Livinglab4carers Platform Case." Paper presented at the 2011 17th International Conference on Concurrent Enterprising, 1–8. IEEE.

Berkes, Fikret. 2009. "Evolution of Co-Management: Role of Knowledge Generation, Bridging Organizations and Social Learning." *Journal of Environmental Management* 90 (5): 1692–1702. https://doi.org/10.1016/j.jenvman.2008.12.001.

Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Bronson, Kelly, Rachana Devkota, and Vivian Nguyen. 2021. "Moving Toward Generalizability? A Scoping Review on Measuring the Impact of Living Labs." *Sustainability* 13 (2): 502. https://doi.org/10.3390/su13020502.

Callari, Tiziana C., Louise Moody, Janet Saunders, Gill Ward, Nikki Holliday, and Julie Woodley. 2019. "Exploring Participation Needs and Motivational Requirements When Engaging Older Adults in An Emerging Living Lab." *Technology Innovation Management Review* 9 (3): 38–49. https://doi.org/10.22215/timreview/1223.

Cash, David W., W. Neil Adger, Fikret Berkes, Po Garden, Louis Lebel, Per Olsson, Lowell Pritchard, and Oran Young. 2006. "Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World." *Ecology and Society* 11 (2): 8–20. https://doi.org/10.5751/ES-01759-110208.

Castán Broto, Vanesa, and Linda Westman. 2017. "Just Sustainabilities and Local Action: Evidence from 400 Flagship Initiatives." *Local Environment* 22 (5): 635–650. https://doi.org/10.1080/13549839.2016.1248379.

Chen, Yu-Tso, and Wu-Hsien Chou. 2010. "Constructing Living Labs Analysis Model for Designing and Evaluating Living Labs Systems." Paper presented at the 2010 IEEE International Technology Management Conference (ICE), 1–8. IEEE.

Collaboration for Environmental Evidence. 2013. "Guidelines for Systematic Review and Evidence Synthesis in Environmental Management. Version 4.2. Environmental Evidence.".

Covidence Systematic Review Software, Veritas Health Innovation, Melbourne, Australia. April 13, 2022. www.covidence.org.

Davies, Anna. 2018. "Homelabs: Domestic Living Laboratories Under Conditions of Austerity." In *Urban Living Labs*, edited by Simon Marvin, Harriet Bulkeley, Lindsay Mai, Kes McCormick, and Yuliya Voytenko Palgan, 126–146. London: Routledge.

Delina, Laurence L. 2020. "A Rural Energy Collaboratory: Co-Production in Thailand's Community Energy Experiments." *Journal of Environmental Studies and Sciences* 10 (1): 83–90. http://doi.org/10.1007/s13412-019-00572-x.

Dell'Era, Claudio, Paolo Landoni, and Sara Jane Gonzalez. 2019. "Investigating the Innovation Impacts of User-Centred and Participatory Strategies Adopted by European Living Labs." *International Journal of Innovation Management* 23 (05): 1950048. https://doi.org/10.1142/S1363919619500488.

European Network of Living Labs. 2022. "What are Living Labs." April 27, 2022. https://enoll.org/about-us/what-are-living-labs/.

Evans, James, Ross Jones, Andrew Karvonen, Lucy Millard, and Jana Wendler. 2015. "Living Labs and Co-Production: University Campuses as Platforms for Sustainability Science." *Current Opinion in Environmental Sustainability* 16: 1–6. https://doi.org/10.1016/j.cosust.2015.06.005.

Fischer-Kowalski, Marina, and Jan Rotmans. 2009. "Conceptualizing, Observing, and Influencing Social–Ecological Transitions." *Ecology and Society* 14 (2): 3–21. https://doi.org/10.5751/ES-02857-140203.

Georges, A., D. Schuurman, and K. Vervoort. 2016. "Factors Affecting the Attrition of Test Users During Living Lab Field Trials." *Technology Innovation Management Review* 6 (1): 35–44. https://doi.org/10.22215/timreview/959.

Giboreau, Agnes. 2018. "Situational Factors and the Design of In Situ Evaluations." In *Methods in Consumer Research* 2, edited by Gastón Ares and Paula Varela, 109–116. Duxford: Woodhead Publishing.

Guzmán, Javier García, Alvaro Fernández del Carpio, Antonio De Amescua, and Manuel Velasco. 2013a. "A Process Reference Model for Managing Living Labs For ICT Innovation: A Proposal Based on ISO/IEC 15504." *Computer Standards & Interfaces* 36 (1): 33–41. https://doi.org/10.1016/j.csi.2013.07.004.

Guzmán, Javier, Alvaro García, Ricardo Fernández del Carpio, Manuel Colomo-Palacios, and Diego. Velasco de. 2013b. "Living Labs for User-Driven Innovation: A Process Reference Model." *Research-Technology Management* 56 (3): 29–39. https://doi.org/10.5437/08956308X5603087.

Guzmán, Javier Garcia, Hans Schaffers, Vilmos Bilicki, Christian Merz, and Monica Valenzuela. 2008. "Living Labs Fostering Open Innovation and Rural Development: Methodology and Results." Paper presented at the 2008 IEEE International Technology Management Conference (ICE), 1–8.

Hagy, Shea, Frida Bard, A. Sasic Kalagasidis, and Ena Sredanovic. 2017. "Next Generation Living Labs." *Comprehensive Report*, 11–18.

Hossain, Mokter, Seppo Leminen, and Mika Westerlund. 2019. "A Systematic Review of Living Lab Literature." *Journal of Cleaner Production* 213: 976–988. https://doi.org/10.1016/j.jclepro.2018.12.257.

Hyysalo, Sampsa, and Louna Hakkarainen. 2014. "What Difference Does a Living Lab Make? Comparing Two Health Technology Innovation Projects." *CoDesign* 10 (3-4): 191–208. https://doi.org/10.1080/15710882.2014.983936.

Kovács, Katalin. 2016. "Evaluation and Practice of Interactive Value Production in Living Labs." *Periodica Polytechnica Social and Management Sciences* 24 (1): 52–59. https://doi.org/10.3311/PPso.8336.

Leminen, Seppo, and Mika Westerlund. 2019. "Living Labs: From Scattered Initiatives to A Global Movement." *Creativity and Innovation Management* 28 (2): 250–264. https://doi.org/10.1111/caim.12310.

Leonardi, Chiara, Nicola Doppio, Bruno Lepri, Massimo Zancanaro, Michele Caraviello, and Fabio Pianesi. 2014. "Exploring Long-Term Participation Within a Living Lab: Satisfaction, Motivations And Expectations." Paper presented at the Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, 927–930.

Ley, Benedikt, Corinna Ogonowski, Mu Mu, Jan Hess, Nicholas Race, David Randall, Mark Rouncefield, and Volker Wulf. 2015. "At Home with Users: A Comparative View of Living Labs." *Interacting with Computers* 27 (1): 21–35. https://doi.org/10.1093/iwc/iwu025.

Lidskog, Rolf, Adam Standring, and James M. White. 2022. "Environmental Expertise for Social Transformation: Roles and Responsibilities for Social Science." *Environmental Sociology*, 255–266. https://doi.org/10.1080/23251042.2022.2048237.

Luo, Kuo-Shu, Shiang-Shin Lin, Kuei Kai Shao, and Hui-Hua Lin. 2012. "Developing an Engineering Data Bank Service for the Precision Machinery Industry Cluster Using the Living Lab Concept." *International Journal of Automation and Smart Technology* 2 (3): 265–275. https://doi.org/10.5875/ausmt.v2i3.147.

Markard, Jochen, Rob Raven, and Bernhard Truffer. 2012. "Sustainability Transitions: An Emerging Field of Research and Its Prospects." *Research Policy* 41 (6): 955–967. https://doi.org/10.1016/j.respol.2012.02.013.

Mastelic, Joëlle, Marlyne Sahakian, and Riccardo Bonazzi. 2015. "How to Keep a Living Lab Alive?" *Info*, https://doi.org/10.1108/info-01-2015-0012.

McHugh, Mary L. 2012. "Interrater Reliability: The Kappa Statistic." *Biochemia Medica* 22 (3): 276–282. https://doi.org/10.11613/BM.2012.031.

McPhee, Chris, Margaret Bancerz, Muriel Mambrini-Doudet, François Chrétien, Christian Huyghe, and Javier Gracia-Garza. 2021. "The Defining Characteristics of Agroecosystem Living Labs." *Sustainability* 13 (4): 1718. https://doi.org/10.3390/su13041718.

Moore, Trivess, Ralph Horne, and Andréanne Doyon. 2020. "Housing Industry Transitions: An Urban Living Lab in Melbourne, Australia." *Urban Policy and Research* 38 (2): 118–131. https://doi.org/10.1080/08111146.2020.1730786.

Moro, Anna, and Emma Puerari. 2015. "Ecosystem Innovation as Trigger of New Paths and Practices for Urban Space" In Culture, Innovation and Entrepreneurship: Connecting the Knowledge Dots." Paper presented at the 10th International Forum on Knowledge Asset Dynamics November, 1887–1897.

Munn, Zachary, Micah D. J. Peters, Cindy Stern, Catalin Tufanaru, Alexa McArthur, and Edoardo Aromataris. 2018. "Systematic Review or Scoping Review? Guidance For Authors When Choosing Between a Systematic or Scoping Review Approach." *BMC Medical Research Methodology* 18 (1): 1–7. https://doi.org/10.1186/s12874-017-0458-6.

Nesti, Giorgia. 2018. "Co-Production for Innovation: The Urban Living Lab Experience." *Policy and Society* 37 (3): 310–325. https://doi.org/10.1080/14494035.2017.1374692.

Nguyen, Vivian M., Nathan Young, Jacob W. Brownscombe, and Steven J. Cooke. 2019. "Collaboration and Engagement Produce More Actionable Science: Quantitatively Analyzing Uptake of Fish Tracking Studies." *Ecological Applications* 29 (6): e01943. https://doi.org/10.1002/eap.1943.

Ogonowski, Corinna, Benedikt Ley, Jan Hess, Lin Wan, and Volker Wulf. 2013. "Designing for the Living Room" Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1539–1548.

Osorio, Ferney, Laurent Dupont, Mauricio Camargo, Pedro Palominos, José Ismael Peña, and Miguel Alfaro. 2019. "Design and Management of Innovation Laboratories: Toward a Performance Assessment Tool." *Creativity and Innovation Management* 28 (1): 82–100. https://doi.org/10.1111/caim.12301.

Pigot, Hélène, and Sylvain Giroux. 2015. "Living Labs for Designing Assistive Technologies." Paper presented at the 2015 17th International Conference on E-Health Networking, Application & Services (HealthCom), 170–176. IEEE.

Salminen, Juho, Suvi Konsti-Laakso, Marc Pallot, Brigitte Trousse, and Bernard Senach. 2011. "Evaluating User Involvement Within Living Labs Through the Use Of A Domain Landscape." Paper presented at the 2011 17th International Conference on Concurrent Enterprising, 1–10. IEEE.

Schuurman, Dimitri, Bastiaan Baccarne, Fahim Kawsar, Constantijn Seys, Carina Veeckman, Lieven De Marez, and Pieter Ballon. 2013. "Living Labs As Quasi-Experiments: Results From The Flemish Leylab." Paper presented at the XXIV ISPIM Conference: Innovating in Global Markets: Challenges for Sustainable Growth.

Schuurman, Dimitri, Lieven De Marez, and Pieter Ballon. 2016. "The Impact of Living Lab Methodology on Open Innovation Contributions and Outcomes." *Technology Innovation Management Review* 1 (1): 7–16. https://doi.org/10.22215/timreview/956.

Smit, Danie, Marlien Herselman, J. H. P. Eloff, Ernest Ngassam, Elmarie Venter, Felix Ntawanga, Cheng-Hui Chuang, and Darelle Van Greunen. 2011. "Formalising Living Labs to Achieve Organisational Objectives in Emerging Economies." Paper presented at the 2011 IST-Africa Conference Proceedings, 1–7. IEEE.

Ståhlbröst, Anna, and Birgitta Bergvall-Kåreborn. 2011. "Exploring Users Motivation in Innovation Communities." *International Journal of Entrepreneurship and Innovation Management* 14 (4): 298–314. https://doi.org/10.1504/IJEIM.2011.043051.

Steen, Kris, and Ellen Van Bueren. 2017. "The Defining Characteristics of Urban Living Labs." *Technology Innovation Management Review* 7 (7): 21–33. https://doi.org/10.22215/timreview/1088.

Van Geenhuizen, Marina. 2018. "A Framework for the Evaluation of Living Labs as Boundary Spanners in Innovation." *Environment and Planning C: Politics and Space* 36 (7): 1280–1298. https://doi.org/10.1177/2399654417753623.

Veeckman, Carina, Dimitri Schuurman, Seppo Leminen, and Mika Westerlund. 2013. "Linking Living Lab Characteristics and Their Outcomes: Towards a Conceptual Framework." *Technology Innovation Management Review* 3 (12): 6–15. https://doi.org/10.22215/timreview/748.

Von Wirth, Timo, Lea Fuenfschilling, Niki Frantzeskaki, and Lars Coenen. 2019. "Impacts of Urban Living Labs on Sustainability Transitions: Mechanisms and Strategies for Systemic Change Through Experimentation." *European Planning Studies* 27 (2): 229–257. https://doi.org/10.1080/09654313.2018.1504895.

Voyant Tools. December 20, 2022. www.voyant-tools.org.

Voytenko, Y., K. McCormick, J. Evans, and G. Schliwa. 2016. "Urban Living Labs for Sustainability and Low Carbon Cities in Europe: Towards a Research Agenda." *Journal of Cleaner Production* 123: 45–54. doi:10.1016/j.jclepro.2015.08.053.