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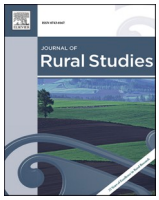

Using the right words or using the words right? Re-conceptualising living labs for systemic innovation in socio-ecological systems

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ABSTRACT

Mediterranean rural systems, understood as socio-ecological systems (SES), often face complex sustainability challenges arising from the structural coupling of ecological and socioeconomic processes, climatic pressures, and weak adaptive capacities. Living labs are gradually gaining ground as an approach to tackling complex sustainability challenges. However, the existing literature is urban-focused and little attention has been paid to the implementation of living labs in rural contexts. This study fills this gap by addressing whether the increasingly popular living lab approach is suitable for pursuing systemic innovation for sustainable development in rural SES. Through a systematic review of the existing literature, this paper offers a contemporary perspective on living labs as models to support systemic innovation and governance of rural SES, while also accounting for previous interpretations of the concept. The paper then moves to a critical discussion of the main constraints on living lab conceptualisation and operationalisation and provides several recommendations for more effective and transparent use of living labs in rural SES. We argue that it is paramount to recognise living labs not solely as laboratories to validate techno-scientific solutions, but also as living systems that can be designed as social learning spaces to improve situations of complexity and uncertainty. In this sense, the success of living labs is contingent upon the willingness and capacity of both stakeholders and researchers to remain actively engaged in social learning and co-creation processes.

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1. Introduction

In the quest for holistic, multi-stakeholder approaches to foster systemic innovation and the achievement of Sustainable Development Goals, living labs, defined as open innovation ecosystems to co-create knowledge and test alternative solutions in real-life environments (ENoLL, 2020), are currently receiving much attention and investment. Given its topicality, this study aims to contribute to the literature by addressing the following research question: is the increasingly popular

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living lab approach suitable for pursuing systemic innovation for sustainable development in rural socio-ecological systems (SES)?

To clarify this study's rationale, a terminological premise is necessary, particularly concerning the concepts of systemic innovation, SES, and rurality.

This study is situated in a broader theoretical discourse on systemic innovation (Chesbrough and Teece, 1996; Colvin et al., 2014; Lindhult et al., 2022; Takey and Carvalho, 2016). We adopt the definition by Colvin et al. (2014), which understand systemic innovation as "an emergent property of the changes in practices and understandings that are enacted in contexts of concern" (p.761).

The paper also intersects with research on SES, which are defined as systems "of biophysical and social factors that regularly interact in a resilient, sustained manner" (Redman et al., 2004, p. 163). Although the considerations made in the following sections can be extended to the wider debate on systemic innovation in SES, the focus of this study lies particularly on rural SES because of their relevance to wider sustainability challenges (Martínez-Fernández et al., 2023). This study was inspired by research activities conducted within two PRIMA-funded projects: Sustain-COAST, focused on governance innovation for sustainable groundwater management in Mediterranean coastal aquifers; and SALAM-MED, aimed at promoting sustainable land and water management in Mediterranean drylands. Empirical analyses of living labs to promote sustainable land and water management in rural Mediterranean agroecosystems will be the subject of future research.

Rurality has been defined in various ways (Johansen and Nielsen, 2012; Nelson et al., 2021; Phillips, 2016), and its conceptualisation has shifted from a dichotomy of non-urban towards more multifaceted definitions. For this study, we referred to the aspects of rurality that are structurally intertwined with the sustainable management of agroecosystems. Rural systems, understood as SES, often face complex sustainability challenges arising from the structural coupling of ecological and socioeconomic processes, climatic pressures, and weak adaptive capacities (Butler et al., 2014; IPCC et al., 2022). Such challenges are experienced as uncertain, complex, and multi-dimensional (Floyd et al., 2014; Ison et al., 2021; Medema et al., 2014) and are often framed as "wicked" (Rittel and Webber, 1973), to emphasise that no one-solution-fits-all is available, but rather a range of options are needed to manage complexity in an adaptive and sustainable way (Head and Alford, 2015; Ison et al., 2015).

Our research on living labs also draws insights from systemic innovation and sustainability transition studies. A consideration emerging from the literature is that effective sustainability transitions require adaptive, systemic, learning-based and participatory forms of governance (Huitema et al., 2009; Medema et al., 2014; Pahl-Wostl, 2006). It is argued that strategies for systemic innovation should not be limited to technical fixes deterministically designed to be applied across multiple contexts; instead, they should be theory-informed and context-specific, rooted in local socio-cultural contexts, and involve a wide range of stakeholders, including researchers, practitioners, technology developers, policymakers, and citizen-consumers (Colvin et al., 2014). Other recurring aspects that we find in the existing scientific literature include the need for transformations in the understanding and practice of those involved through social and transformational learning (Colvin et al., 2014; Dyball and Keen, 2005; Ison et al., 2007); the integration of top-down impact approaches with bottom-up capacity approaches (Linnér and Wibeck, 2021; Vermeulen et al., 2013; Wise et al., 2014); and the need for systemic, multi-stakeholder, and transdisciplinary approaches (Ison, 2010; Weber and Khademian, 2008; Reynolds et al., 2018).

In this respect, living labs are gaining momentum in research and policy arenas. In recent decades, EU funding efforts have spurred living lab activities to promote sustainable development. The advent of the European Network of Living Labs (ENoLL) in 2006 brought more than 480 recognised living labs worldwide under an umbrella association. Systematic reviews (Bronson et al., 2021; Dekker et al., 2020; Dutilleul et al., 2010; Følstad, 2008; Gascó, 2017; Greve et al., 2021; Hossain et al., 2019; Leminen et al., 2012; McGann et al., 2018; Tõnurist et al., 2017) and methodological guidelines (ENoLL, 2020) on living labs exist. However, while living lab experiences in urban contexts have been extensively documented (Bulkeley et al., 2016; Leminen et al., 2021; Wahl et al., 2021; Voytenko et al., 2016), rural contexts remain under-researched (Burbridge and Morrison 2021; Bronson et al., 2021). Moreover, the rapid diffusion of living labs, coupled with the fact that they are a broadly conceived and evolving phenomenon, may lead to semantic, conceptual, and methodological confusion among scholars and practitioners aiming to apply such an approach to rural SES. Tension arises between "using the right words", i.e. adopting the popular living lab expression as a panacea for all problems and a disguise for all forms of participation, and "using the words right", i.e. ensuring a more transparent and effective use of the living lab concept in rural SES.

In answering the question of whether living labs are suitable for promoting systemic innovation for sustainable development in rural SES, this study contributes to the existing living lab literature in two main ways: first, by contextualising the living lab discourse within rural SES; and second, by offering a contemporary perspective on living labs as models for supporting systemic innovation and governance of rural SES, while also giving an account of previous interpretations of the concept and taking into consideration the abovementioned tension arising between "using the right words" and "using the words right".

We first systematically reviewed the existing literature focusing on four main themes: (i) emergence and evolution of the living lab concept, (ii) theoretical frameworks underpinning living labs, (iii) state-of-the-art living lab characteristics and typologies, (iv) emergence of rural living labs, with a focus on the main features and implementation challenges. Then, we discuss the potential and constraints of living labs to facilitate systemic innovation in rural SES. The discussion was informed by the outcomes of the literature review and was driven by a reflection on the following constraints associated with living lab conceptualisation and operationalisation in rural SES: (i) semantic stretch, (ii) conceptual (re-) framing as models of governance, (iii) role of researchers, (iv) time.

The paper is organised as follows. First, the review method and process are outlined and the results of the literature review are presented. Then, the potential and constraints of living labs to pursue systemic innovation for sustainable development in rural SES are discussed. We conclude by providing several recommendations for more transparent and effective use of the living lab concept and proposing future research avenues.

2. Methodology

A combination of bibliometric and inductive content analysis techniques was used to review the existing living lab literature, drawing from both general living lab literature and literature focused on rural living labs (Fig. 1). After an initial literature scan, we identified the following search terms to reflect our main interests: evolution of the general living lab model, emergence of rural living labs, and use of living labs to address sustainability challenges in rural contexts. The final search string used for the literature review was: "Living Lab*" AND "agriculture" OR "agroecosystem" OR "water management" OR "sustainability" OR "sustainable development" OR "review" OR "rural development". We used Scopus as database, which is recognised as one of the world's leading databases for multidisciplinary academic articles. We placed no restrictions on the publication year and only considered publications in English. From this initial search, 672 publications were identified, of which 326 were journal articles and reviews. After extracting the basic information (title, list of authors, name of the journal, publication year, abstract, and keywords) as a CSV file, publications were screened following a review of their titles, keywords, and abstracts to ensure that the focus was on living labs. Publications that did not meet at least one of these criteria were iteratively filtered out: publications on living labs to promote systemic innovation and/or to

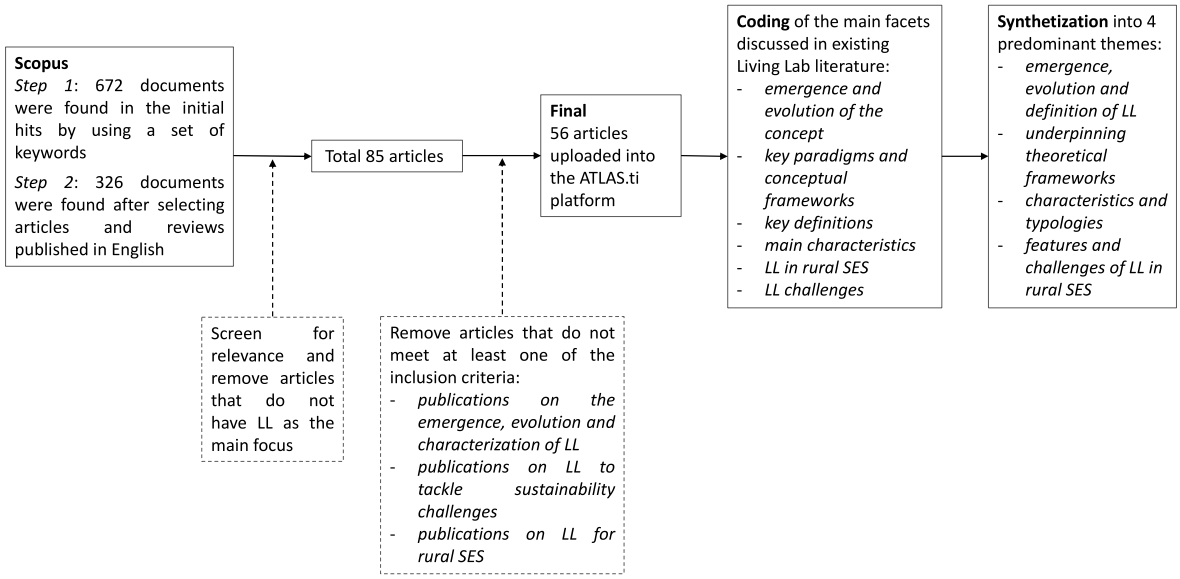

Fig. 1. Flowchart of methodology.

tackle sustainability challenges; publications on living labs' theoretical foundations, evolution and characterisation; publications on the application of the living lab approach to agroecosystems and/or rural contexts. An initial subset of 85 articles that met the relevance criteria was identified and read in full to ensure their suitability. A final selection of 56 publications was uploaded in PDF format into the ATLAS.ti platform, which is widely used for qualitative data analysis and literature reviews (Paulus et al., 2014; Smit, 2018; Wright, 2014). We acknowledge that the final number of publications included in the review is relatively small, but this reflects that the living lab concept is still only emerging within sustainability research and practice, particularly within rural SES. The analysis process encompassed an inductive approach, allowing flexibility in identifying emerging patterns and themes. Coding was performed iteratively. Initially, segments of interest were systematically gathered during first-stage coding (Silver and Lewins, 2014). In the second stage of the analysis, similar codes were grouped. After refinement based both on code frequency and thematic content, we identified 6 codes (second-stage coding) which were further merged into 4 higher-order categories (third-stage coding).

3. Results of the literature review on living labs

3.1. Trends and keyword analysis

The publication trend for living labs has been accelerating since 2011, notably surging between 2017 and 2022. This multi-disciplinary phenomenon encompasses several research domains. Studies on living labs have appeared in a broad range of journals and the dominant subject areas covered by publications, based on Scopus categories, were "social sciences", "environmental sciences", "engineering", "business management" and "computer science". The scope of living lab literature has expanded considerably over time, only recently encompassing "agricultural and biological sciences", "arts and humanities", and "earth and planetary sciences".

Fig. 2. Word cloud of the keywords in the reviewed publications.

To identify the main research streams in living lab literature, an inductive approach was used based both on code frequency and thematic content analysis.

First, keywords were mapped by their relative frequency, as shown in the word cloud (Fig. 2); the larger the size, the higher the frequency with which a word was listed among the keywords of the reviewed articles. Besides "living labs" (34 times), the most frequent keywords were "innovation" (13 times), "co-creation" (8 times) and "open innovation" (7 times). The keywords "sustainability" and "sustainable development", "sustainability transition", and "social sustainability" appeared 14 times, reflecting that the living lab concept is gradually gaining ground as an approach to tackle complex sustainability challenges. Notably, "agricultural sustainability", "sustainable agriculture", and "rural development" appeared only 4 times, revealing that the implementation of living labs to tackle sustainability challenges in rural contexts is still an under-researched area in the literature.

After keyword mapping, articles were reviewed extensively and the coding process was conducted iteratively. 120 codes were identified during first-stage coding, following an inductive approach. Through refinement based on code frequency and thematic analysis, similar codes were merged into higher-order categories, revealing overarching themes. The results of the review were synthesised based on the following predominant themes:

1. The emergence and evolution of the living lab concept, paying particular attention to how the definition changed over time.
2. Theoretical frameworks underpinning the living lab phenomenon.
3. Living lab key characteristics and typologies.
4. The emergence of rural living labs, with a focus on the main features and implementation challenges.

3.2. The emergence and evolution of the living lab concept

Recent studies have attempted to provide a historical account of the living lab phenomenon (Compagnucci et al., 2021; Cuomo, 2022; Leminen and Westerlund, 2019; Paskaleva and Cooper, 2021). Seeking to contribute to the discourse, we analysed the emergence and evolution of living labs, identifying three perspectives that shaped their conceptualisation across time (Fig. 3):

1 Research perspective

Initially, living lab studies were dominated by American researchers. This term was first used at the Massachusetts Institute of Technology in the early 2000s to describe a user-centric research methodology for prototyping and validating solutions in real-life situations (Eriksson et al., 2005; Van Geenhuizen, 2019). Nevertheless, Leminen and Westerlund (2019) argued that the concept's origins predate this period, with its initial mention in academic discussions by Tarricone (1990), Lasher et al. (1991), and Bajgier et al. (1991).

2 Business model perspective

In the early 2000s, living labs made a breakthrough from the US research context to corporate environments and then to Europe. Initially considered extensions of test beds for experimenting with ICT services in real-life settings, living labs were then referred to as co-creation spaces, with users regarded as partners for innovation rather than mere targets of experiments (Følstad, 2008; Leminen and Westerlund, 2019; Rits et al., 2015; Schaffers et al., 2008). The creation of the ENoLL in 2006 played a pivotal role in the formalisation of living labs and in promoting a set of standardised tools for living lab activities (Leminen and Westerlund, 2019). ENoLL was founded in 2006 under the Finnish presidency of the Council of the European Union to enhance European competitiveness by fostering best-practice exchanges and facilitating user involvement in ICT-based innovations.

3 Policy perspective

More recently, the living lab concept has been mainstreamed into EU policies and research frameworks to address innovation and sustainability challenges (Zavratnik et al., 2019). Notably, the Horizon Europe mission "A Soil Deal for Europe" aims to establish 100 living labs and lighthouses for sustainable soil and land management by 2030 (Bouma et al., 2022; Löbmann et al., 2022).

The living lab is a rapidly evolving phenomenon whose definition has evolved accordingly. Depending on the dominant perspective (research, business model or policy), living labs have been referred to as collaborative innovation methodologies, learning spaces, innovation

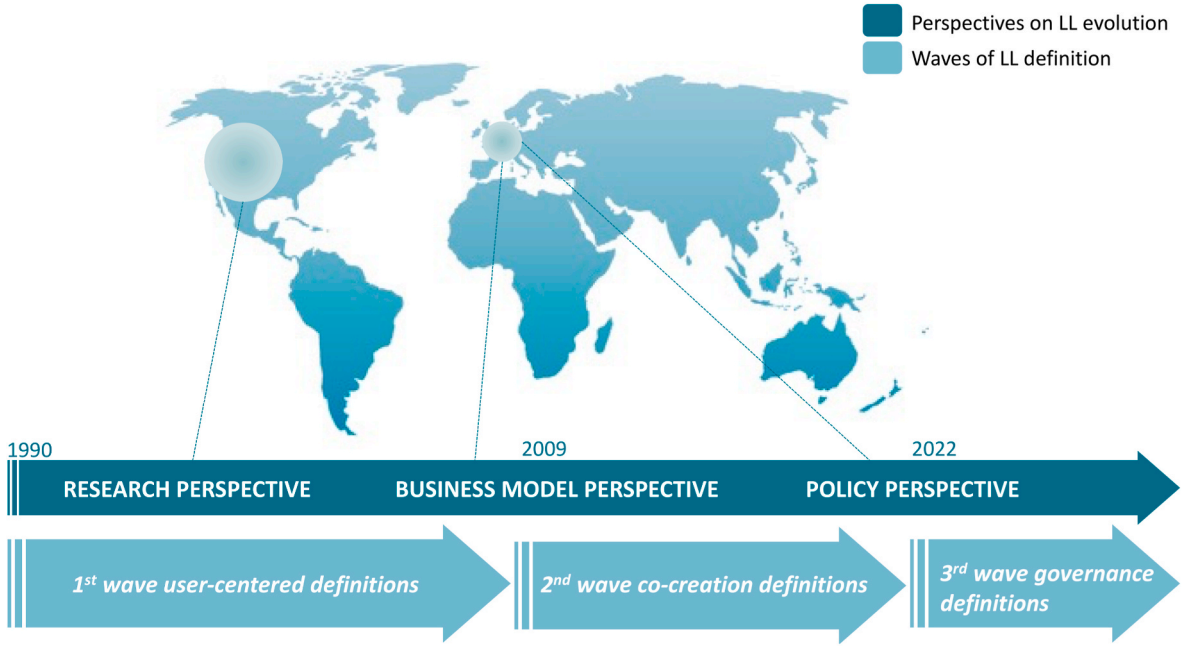

Fig. 3. Three perspectives on the emergence and evolution of living labs.

ecosystems, and collective governance approaches. Table 1 provides a list, albeit not exhaustive, of the main living lab definitions proposed in the European research and policy arenas overtime. In line with the proposed perspectives, we also identified three waves of living lab definitions (Fig. 3). To a certain extent, the three definitions proposed over the years by ENoLL, which acted as a point of reference for living lab matters, epitomise this evolution.

First-wave "user-centred" definitions referred to living labs as a user-centred methodology to promote innovation and were ICT-focused (Ballon et al., 2005; Dell'Era and Landoni, 2014; Eriksson et al., 2005; Følstad, 2008; Schaffers and Kulkki, 2007). This is in line with ENoLL's initial purpose of enhancing European competitiveness by facilitating user involvement and contributions to innovation processes.

Second-wave "co-creation" definitions were pillared on the co-creation paradigm, recognising the importance of wider stakeholder collaboration (Almirall and Wareham, 2010; Bronson et al., 2021; Gascó, 2017; Zavratnik et al., 2019). Second-wave living lab definitions reflect a broader understanding of living labs, expanding from ICT to a wider array of fields. The expected outputs of living labs have also widened from ICT-based innovations to encompass new knowledge, services, and societal infrastructure (Bergvall-Kåreborn and Stahlbrost, 2009; Westerlund et al., 2018; Westerlund and Leminen, 2011).

Third-wave "governance" definitions regard living labs as a policy tool (Cuomo, 2022) and a collective governance approach to tackle sustainability challenges (ENoLL, 2020; Voytenko et al., 2016). Third-wave definitions are more impact-oriented than previous ones, recognising living labs as innovation ecosystems driving socio-technical and governance innovation through participative and transdisciplinary

Table 1
Three waves of living labs definitions in the research and policy arena.

	Definition	Keywords
1st wave "user-centered" definitions	"Both a methodology for User Driven Innovation and the organisations that primarily use it" (ENoLL, as reported in Dell'Era & Landoni, 2014, p. 4)	User-centred methodology ICT-focused Experimentation and validation environment Real-life settings
	"experimentation environment in which technology is given shape in real-life contexts and in which (end) users are considered co-producers" (Ballon et al., 2005, p.3)	
	"user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real-life contexts" (Eriksson et al., 2005, p.4)	
	"Experimentation and validation environments characterized by early involvement of user communities, closely working together with developers and other stakeholders, and driving rapid cycles of ICT-based innovations" (Schaffers and Kulkki, 2007, p. 31)	
	"human-centric research and development approach in which ICT innovations are co-created, tested, and evaluated in open, collaborative, multi-contextual real-world settings" (Ståhlbröst, 2008, p. 4)	
	"environments for innovation and development where users are exposed to new ICT solutions in (semi) realistic contexts, as part of medium or long-term studies targeting evaluation of new ICT solutions and discovery of innovation opportunities" (Følstad, 2008, p. 116)	
2nd wave "co-creation" definitions	"open innovation environment in real-life settings in which user-driven innovation is the co-creation process for new services, products and societal infrastructures" (ENoLL, as reported in Bergvall-Kåreborn & Ståhlbröst, 2009, p. 357)	Co-creation paradigm Open innovation Real-life settings Participative and multi-disciplinary research
	"Living Labs are also intermediaries and perform roles as facilitators of user involvement, and in some cases, orchestrators of the whole innovation process" (Almirall and Wareham, 2011, p. 234)	
	"physical regions or virtual realities where stakeholders form public-private-people partnerships (4Ps) of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products and systems in real-life contexts" (Westerlund and Leminen, 2011, p. 20)	
	"design research methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting" (Dell'Era & Landoni, 2014, p. 5)	
	"settings or environments for open innovation, which offer a collaborative platform for research, development, and experimentation in real-life contexts, based on specific methodologies and tools, and implemented through specific innovation projects and community-building activities" (Gascó, 2017, p. 91)	
	"Sociotechnical platform with shared resources, a collaboration framework, and real-life context, which organizes its stakeholders into an innovation ecosystem that relies on representative governance, open standards, and diverse activities and methods to gather, create, communicate, and deliver new knowledge, validated solutions, professional development and social impact" (Westerlund et al., 2018, p. 56-57)	
	"spaces for innovative and participative research, development and activities that use multidisciplinary approaches and promote the co-creation paradigm" (Zavratnik et al., 2019, p. 1)	
	"mechanism or approach that brings a diversity of stakeholders together to arrive at user-centric solutions and innovations and thus they could present a viable method for solving complex issues." (Bronson et al., 2021, p. 1)	
3rd wave **"governance"** definitions	"open innovation ecosystems in real-life environments using iterative feedback processes throughout a lifecycle approach of an innovation to create sustainable impact" (ENoLL, https://enoll.org/about-us/ , accessed October 26, 2022)	Collective governance Sustainable impact Transdisciplinary research Innovation ecosystem
	"a form of collective urban governance and experimentation to address the sustainability challenges and opportunities created by urbanisation" (Voytenko et al., 2016, p. 2).	
	"user-centered, place-based and transdisciplinary research and innovation ecosystems. They are understood as collaborative initiatives between multiple partners to co-create, test, monitor and evaluate solutions to a common problem" (EC, 2022)	
	"policy tools [...] for addressing complex problems in real-life contexts" (Cuomo, 2022, p. 5)	

research (European Commission, 2022).

3.3. Theoretical frameworks underpinning living labs

Our results show that the theoretical foundations of living labs remain largely unexplored. Of the reviewed papers, only 16 attempted to shed light on Living Labs' theoretical roots, whereas in most publications (32), theoretical frameworks were merely cited, and eight did not refer to conceptual frameworks.

User-centred design and participatory design appear to be central theoretical frameworks in early living lab literature (Bergvall-Kåreborn and Stahlbrost, 2009; Dell'Era and Landoni, 2014), and in most recent publications, the co-creation paradigm appears to be the most frequently cited (Beaudoin et al., 2022; Hossain et al., 2019; Lehmann et al., 2015). Living labs are also often associated with open and user innovation paradigms (Følstad, 2008; Hossain et al., 2019). Another, albeit limited, stream of living lab literature refers to systems and design thinking. For instance, Yasuoka et al. (2018) examined how the Urban Design Thinking approach is applied in a sustainable living lab context, while Luján Soto et al. (2021) reviewed the living lab methodology from a systems approach perspective. More recently, Potters et al. (2022) referred to design thinking, systems thinking, and reflexive monitoring as living lab theoretical foundations. Less prominent and emergent frameworks for conceptualising living labs are also related to theories of learning, particularly social learning (Mastelic et al., 2015; Luján Soto et al., 2021; Schäpke et al., 2018b) and action-based learning (Song et al., 2015). Finally, Schaffers and Kulkki (2007) proposed applying the action research paradigm (Baskerville, 1999) to achieve effective and active participation of a wide range of stakeholders in living labs.

3.4. Living labs defining characteristics and typologies

Another stream of the reviewed literature focuses on identifying the key characteristics that are common to all living labs in an attempt to develop a prototype.

In line with early interpretations of living labs, living lab characteristics were initially very ICT-focused and emphasised testing and replication.

As the meaning of living labs evolved, so did their defining characteristics. Emphasis was no longer solely on testing and replication, but also on user empowerment through learning and co-creation (Voytenko et al., 2016; Yasuoka et al., 2018). As ENoLL grew, the five characteristics proposed by the organisation (co-creation, real-life setting, active user involvement, multi-stakeholder participation, and multi-method approach) were considered the gold standard and are now among the most widely accepted in academic and policy discourse (ENoLL, 2020).

Another prominent theme analysed in the reviewed literature focused on categorising living labs into different typologies. Various dimensions have been utilised to put forth different living lab typologies: the types of actors driving activities (Leminen et al., 2012), different living lab interpretations (Schuurman et al., 2013), the innovation process and tools (Leminen and Westerlund, 2017), sectors and contexts of application. For instance, ENoLL categorises its living labs based on sectors of application: artificial intelligence, agriculture and food, culture and creativity, energy, environment, health and wellbeing, social inclusion and innovation, education, industries and manufacturing, and media. Moreover, a distinction was made between urban and rural living labs (McPhee et al., 2021). However, as also noted by McLoughlin et al. (2018) in their bibliometric analysis, the literature on urban living labs is prolific (Cuomo, 2022; Leminen et al., 2021; Steen and Van Bueren, 2017; Voytenko et al., 2016; Wahl et al., 2021), whereas studies on the application of the living lab concept to rural contexts are limited.

3.5. Living labs for rural socio-ecological systems

Living labs have only recently gained ground in policy discourse as potential approaches to tackling sustainability challenges in rural SES. The International Agroecosystems Living Laboratories working group, which was formed at the 2018 G20 Meeting of Agricultural Chief Scientists, defines agroecosystem living labs as "Transdisciplinary approaches which involve farmers, scientists and other interested partners in the co-design, monitoring and evaluation of new and existing agricultural practices and technologies on working landscapes to improve their effectiveness and early adoption" (International Agroecosystem Living Laboratories Working Group, 2019, p. 4). The European Commission defines soil living labs as innovation ecosystems to accelerate the adoption of sustainable and tailored solutions for healthy soils (European Commission, 2022)

This recent political push has given rise to the nascent literature on the use of living labs in rural SES. Zavratnik et al. (2019) define rural living labs as "a concept for establishing a holistic ecosystem that enables synergies among various stakeholders in rural areas: inhabitants, entrepreneurs, decision and policymakers, educators, farmers and aspiring (young) leaders, and builds upon the values of circular economy" (p.12).

Distinguishing features of rural living labs have been explored, with Zavratnik et al. (2019) highlighting a strong focus on sustainability and revealing a broader systems-oriented perspective compared with general living labs. Scholars have documented the experience of living labs for environmental and agricultural sustainability (Beaudoin et al., 2022), rural development (Schaffers and Kulkki, 2007; Zavratnik et al., 2019), sustainable agri-food systems (Gamache et al., 2020; Hvitsand et al., 2022; Wieliczko and Floriańczyk, 2021), soil health and sustainable land management (Bouma et al., 2022; Löbmann et al., 2022), and social innovation in rural areas (Galardi et al., 2022).

McPhee et al. (2021) identified commonalities between urban and rural living labs in terms of sustainability focus, complexity, and place-based nature. Nonetheless, the authors also identified the following peculiar characteristics: higher levels of scientific research; longer innovation cycles with high uncertainty due to exogenous factors; and a higher number and diversity of stakeholders involved, requiring complex governance schemes. Table 2 summarises the defining

Table 2
Defining characteristics of general and rural living labs. Adapted from Steen and van Bueren (2017) and McPhee et al. (2021).

Dimension	Characteristics	
Aims	General living labs	Innovation
		Formal learning for replication
	Specific for rural living labs	Explicit focus on environmental and agricultural sustainability, rural development, sustainable agri-food systems, soil health and sustainable land management, and social innovation in rural areas
		Knowledge production and generation of knowledge networks
Activities	General living labs	Co-development, co-production and co-creation
		Iteration
	Specific for rural living labs	High levels of scientific research, with interdisciplinary and transdisciplinary skills required
		Long innovation cycles with high uncertainty due to external factors
		Scaling up and scaling out
Participants	General living labs	Public actors, private actors, users, and knowledge institutes
	Specific for rural living labs	Often driven by the public sector or academic institutions
		High diversity and number of partners, interests, and values requiring complex governance schemes
Context	General living labs	Real-life context
	Specific for rural living labs	Place-based nature; embeddedness in a rural community or agroecosystems

characteristics of general and rural living labs based on an adaptation of Steen and van Bueren's (2017) framework.

Living lab literature also focuses on the difficulties encountered when implementing living labs. Hossain et al. (2019) identified the following commonly faced challenges: complex governance establishment; difficult user recruitment due to low interest and motivation; temporality mismatch between the addressed issues and living lab duration; constraints in sustainability and scalability; efficiency, which is strongly dependent on the quality of the learning process and environment; unpredictable outcomes.

With reference to agroecosystems, Potters et al. (2022) identified four main challenges for effective living lab implementation. First, living labs are most appropriate for addressing situations that are experienced as complex and contested but also as pressing and urgent. Second, before establishing a living lab, enabling conditions should be identified, including appropriate funding mechanisms, inclusive learning spaces, and institutional backing. Third, proficient facilitation is fundamental, rather than rigid management. Lastly, the capacity and willingness of stakeholders to actively participate are vital for designing processes that foster social learning and co-creation.

Evaluating living lab impacts and processes has also been identified as a challenge. Many scholars (Ballon et al., 2018; Beaudoin et al., 2022; McPhee et al., 2021) have claimed that assessing the impact and effectiveness of living labs is essential to inform future improvements. However, evaluation frameworks in living lab literature are notably scarce, particularly impact-oriented ones (Bronson et al., 2021). Potters et al. (2022) proposed four conditions and fifteen corresponding assessment criteria for successful living labs, including context-related factors that are oftentimes overlooked. Fig. 4 summarises the endogenous and exogenous factors contributing to successful living lab implementation, drawing from the general living lab literature and literature focused on rural living labs.

4. Discussion: living labs for systemic innovation and sustainability in rural socio-ecological systems

After reviewing the literature, we identified the following gaps:

- Living labs are a broadly conceived and still-evolving phenomenon, which may generate semantic, conceptual, and methodological ambiguity for researchers interested in adapting living labs to a wide range of contexts.
- Living lab scientific literature is urban-focused, with the concept only recently gaining ground in rural contexts.
- Open innovation and co-creation appear to be central theoretical frameworks in living lab literature, although less prominent frameworks for (re-)conceptualising living labs are emerging, suggesting a promising area for future research.
- The literature focuses on multi-stakeholder engagement as a condition for the successful implementation of living labs, while little attention is paid to researchers' ability and willingness to actively engage in co-creation processes.
- Existing living lab literature is predominantly descriptive, while empirical studies on the effectiveness and limitations of living labs are rare, partly due to the lack of widely accepted frameworks to evaluate the impacts of living labs.

Considering this, in the following sections we will further explore the extent to which living labs within rural SES differ from the general living lab model, and we will return to the research question of whether the increasingly popular living lab approach is suitable for pursuing systemic innovation in rural SES. In answering this question, we offer a contemporary perspective on living labs and discuss four main methodological challenges that deserve attention:

- Avoiding semantic stretch to prevent conceptual and methodological ambiguity for researchers interested in adapting living labs to a wide range of contexts, particularly rural SES.
- Reconceptualising living labs from user-centric approaches of formal learning to models of collective governance, drawing on insights from systems thinking and theories of learning, particularly social learning.
- Identifying and reducing the factors that constrain researchers' willingness and capacity to remain actively engaged in social learning and co-creation processes.

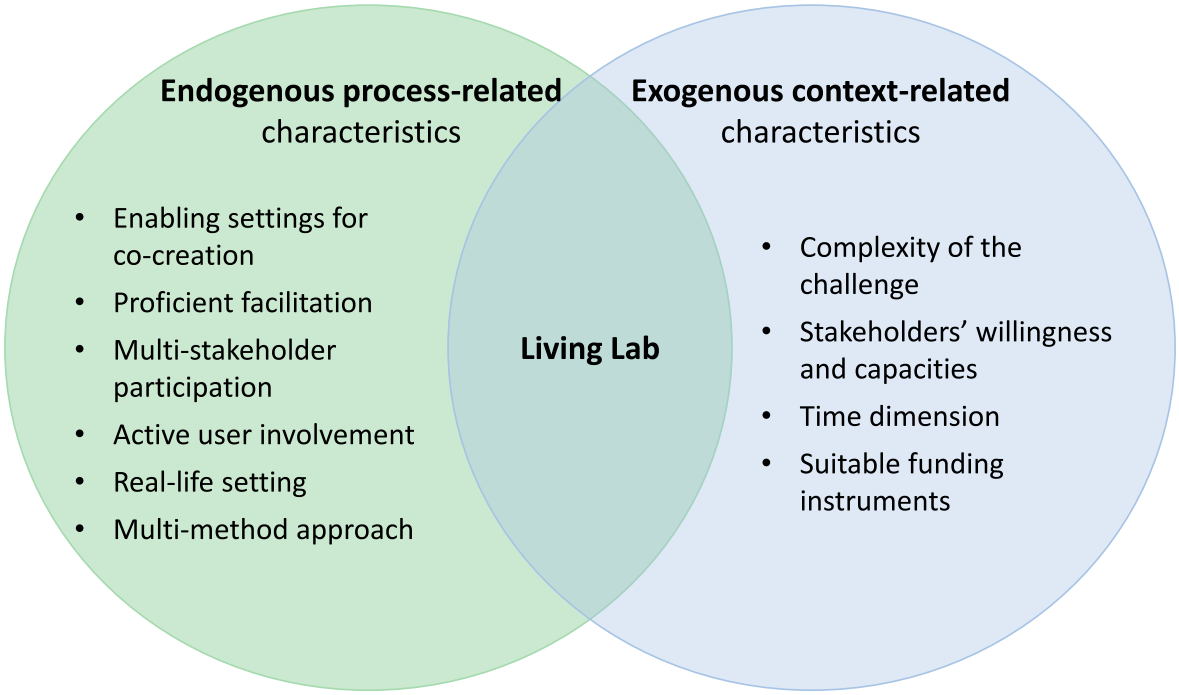

Fig. 4. Endogenous and exogenous factors for the successful implementation of living labs. Adapted from Potters et al. (2022).

- Identifying and addressing the consequences that arise from the discrepancy between the short-term project-based timeframes imposed when implementing living labs and the long-term nature of the socio-ecological processes of concern.

4.1. Emergence and evolution of living labs: from user-centric approaches to learning-based governance

While most of the existing literature has focused on urban living labs, a nascent strand contextualises the approach to rural systems. This may be partly due to the recent political drive to use living labs to tackle complex sustainability challenges in rural contexts and agroecosystems (International Agroecosystem Living Laboratories Working Group, 2019; European Commission, 2022). As the literature on rural living labs develops, understanding the distinctions and similarities between rural and other living labs is crucial. The emerging literature highlights several distinctive characteristics of rural living labs, including the co-creation of knowledge networks (McPhee et al., 2021), as opposed to formal learning (Steen and van Bueren, 2017); higher levels of scientific research and inter-/transdisciplinary skills; greater uncertainty due to external factors; and a more diverse array of stakeholders (McPhee et al., 2021; Zavratnik et al., 2019). In addition, we argue that rural living labs differ from other living labs in another critical aspect: time. The activities of rural living labs are intertwined with dynamic socio-cultural systems and long-term ecological processes, which often translate into more extended timelines for innovation and learning compared to other living labs.

Furthermore, after reviewing the literature (Section 3.2), we identified three waves of living lab definitions: user-centred, co-creation, and governance. The broad conceptualisation of living labs offers versatility for application across various subject areas and contexts. However, this broad understanding is a double-edged sword and carries the risk of semantic stretch, where the term "living lab" can be overused or misused, leading to conceptual and methodological confusion (Marradi, 1987). Considering the peculiarities of rural living labs, we advocate an evolved understanding of living labs as models of collective governance and spaces for social learning, promoting systemic innovation for sustainable development. This interpretation aligns with the literature on social learning, which is defined as both a process of knowledge co-creation and a governance approach suitable for wicked situations (Collins and Ison, 2009; Colvin et al., 2014; Ison et al., 2021). Although co-creation and open innovation are central theoretical frameworks in general living lab literature, emerging literature proposes alternative frameworks for (re-)conceptualising living labs. We endorse the incorporation of learning theories (Mastelic et al., 2015; Schäpke et al., 2018a), design thinking, and systems thinking (Luján Soto et al., 2021; Potters et al., 2022) into the design and implementation of rural living labs. This aligns with critiques of positivist research approaches, which rely on rationality and technical fixes to address uncertainty and complexity, while dismissing individuals' experiences and values as non-objective and therefore unimportant. Moreover, it recognises that systemic innovation does not solely occur through formal learning and replication within a laboratory context, but rather through social learning (Colvin et al., 2014) and the co-creation of hybrid knowledge integrating scientific and lay knowledge (Curry and Kirwan, 2014; Nguyen et al., 2014).

4.2. Epistemological issues related to living labs in rural SES

We return to the research question that motivated this study: is the increasingly popular living lab approach suitable for pursuing systemic innovation in rural SES? We argue that it is, provided that living labs are understood not only as laboratories but also as living systems that can be designed as social learning spaces, where techno-scientific knowledge and processes are hybridised with tacit ones to promote changes in the understanding and practices of those involved (Colvin et al., 2014). Nonetheless, we warn against the uncritical use of living labs as a panacea for all situations and we identified at least four epistemological issues to be considered when applying the concept to rural SES: (1) semantic stretch, (2) conceptual (re-)framing as models of governance, (3) role of researchers, and (4) the time dimension.

1 Semantic stretch

The initial concern pertains to terminology. Can a powerful expression lose its power and meaning due to excessive and uncritical use? There is an observed tendency towards semantic stretch concerning the term "living lab", leading to excessive or inappropriate application. As mentioned in the introduction, the rapid spread of the living lab concept introduces a dilemma between "using the right words" and "using the words right". This, in turn, may weaken the intended meaning of the term and significantly limit the effectiveness of living labs in fostering systemic innovation for sustainable development. Researchers integrating living labs into their research practice should reflect on the risks associated with using "idolized expressions" that employ generic *passe par tout* words without context-specific clarification. Thus, it becomes imperative to question the link between "words" and "things" (Foucault, 1966) and the role of cognition in shaping the relationship between terms and real-life phenomena (Marradi, 2007, 2022). Establishing a shared language is essential for developing mutual understanding, especially in situations where researchers are perceived as outsiders unable to grasp the challenges local stakeholders face. The implication is that, to overcome the tension between "using the right words" and "using the words right", researchers should consider distinct characteristics defining living labs in rural SES, which include higher levels of scientific research and inter-/transdisciplinary skills, greater uncertainty due to external factors, more intricate governance, and extended innovation and learning timelines.

2 Learning-based governance of rural SES

The second concern is related to the conceptual understanding of living labs. The review highlighted three waves of living lab definition (Section 3.2). The evolution from user-centric approaches (1st wave) to models of collective governance (3rd wave) is even more significant when designing and implementing living labs in rural SES, where complex sustainability challenges and wicked situations are prevalent. This aligns with the existing literature, which advocates for alternative governance approaches in addressing wicked situations, moving away from deterministic and overly technocratic methods towards learning-based and participatory approaches (Huitema et al., 2009). Social learning has been recognised as a pivotal process to sustainable decision-making (Medema et al., 2014; Steyaert and Jiggins, 2007), and proposed as a systemic governance approach particularly suitable for wicked situations (Collins and Ison, 2009; Ison, 2010; Ison et al., 2015; Ison et al., 2021). Drawing from this body of literature, we argue that incorporating social learning theories in the design and implementation of living labs in rural SES would be beneficial. In this sense, living labs could serve as new arenas for social learning and models for learning-based, systemic and adaptive governance within rural SES.

While we acknowledge instances where living labs have been designed as social learning spaces, we also recognise the risk of conflating all forms of participation with social learning. As discussed in Section 3.5, one of the main challenges in implementing living labs is ensuring stakeholders' willingness and capacity to actively engage in the social learning process (Potters et al., 2022). Additionally, we argue that the inclusion of marginalised groups, such as women and youth, is fundamental not only to enhance the diversity of ideas and values shaping decision-making, but also to promote equity. Therefore, stakeholder mapping and analysis hold significant methodological importance in research concerning rapidly changing and complex rural SES.

Different stakeholder groups, characterised by different worldviews, perceptions or interests, may choose different pathways when addressing interconnected issues and sustainability challenges (Haasnoot et al., 2013). Exploring the behaviours, perceptions, relations, and influence of stakeholders is critical, as it enhances the overall understanding of the social, technical, and political feasibility of specific decisions, contributing to the co-creation of shared solutions for systemic innovation (Reed et al., 2009).

3 Role of researchers

The third concern relates to the role and responsibility of researchers. We argue that the effectiveness of living labs is contingent not only upon effective stakeholder engagement (Potters et al., 2022) but also upon the willingness and capacity of researchers to remain actively engaged in social learning and co-creation processes.

As mentioned in Section 3.3, living labs are predominantly associated with the co-creation paradigm (Bergvall-Kåreborn and Stahlbrost, 2009; Dell'Era and Landoni, 2014; Lehmann et al., 2015). This aligns with the current scholarly discourse advocating for a transition from linear to second-order modality of research practice (Paschen and Ison, 2014). The literature highlights the importance of researcher reflexivity, epistemological awareness, and adaptability in effectively addressing uncertain, multidimensional, and complex situations (Ison, 2018; Ison et al., 2021). From this standpoint, researchers are encouraged to adopt the role of collaborative learners rather than that of detached experts solely responsible for knowledge dissemination, thereby minimising researcher bias (Roux et al., 2006). Additionally, research should actively incorporate tacit and lay knowledge (Polanyi, 1958), engaging local stakeholders in discussions about change and future trajectories to prevent maladaptive responses (Paschen and Ison, 2014; Rickards and Howden, 2012).

However, co-creation raises methodological challenges about to the role we assume as researchers, and to whose knowledge is perceived as relevant when defining problems and suitable responses (Chambers and Howes, 1979). Ensuring active engagement of local stakeholders can raise the risk of over-identifying with the stakeholder groups and communities under study (Touraine, 1984). This methodological challenge, known as "going native", arises when researchers become deeply involved in the systems being investigated, potentially compromising research integrity (Monti, 1992; Tresch, 2001). Nonetheless, direct observation remains essential for exploring aspects of local tacit knowledge that elude easy formalisation and for understanding the sociocultural dimensions of change. Communities are deeply rooted in their cultural heritage, encompassing symbolic elements, traditions, and languages that may not be immediately apparent (Polanyi, 1966; Van Huylenbroeck and Durand, 2003). Cultural capital represents a shared social and historical memory (self-referential element for community identity recognition) while also facilitating participatory processes capable of influencing political, socio-economic, and ecosystem dynamics (participatory element shaping community interactions).

The willingness and capacity of researchers to remain actively engaged in the co-creation process may also be hindered by the methodological challenges of multi-, inter-, and trans-disciplinary research (Ison, 2008; Deutsch et al., 2023) and the existing research assessment criteria. There is a widespread consensus within the research community regarding the need to reform research assessment practices and criteria. Recently, 566 organisations signed the Agreement on Reforming Research Assessment (CoARA, 2022), aiming to review and develop research assessment criteria that recognise diverse contributions to high-quality research. This includes acknowledging disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary research, as well as contributions to knowledge generation and impacts across scientific, technological, economic, cultural, and societal dimensions. This holds particular significance when designing and implementing living labs within rural SES, which require higher levels of scientific research and inter-/transdisciplinary skills than the general living lab model.

4 Time dimension

The results of the literature review highlighted that time is a major challenge in the design and implementation of living labs (Hossain et al., 2019). There is a mismatch between the long-term nature of the socio-ecological processes of concern and short-term project-based timeframes. This is particularly pronounced in living labs within rural SES, adding layers of complexity. First, the activities of rural living labs are intertwined with long-term and unpredictable ecological processes, necessitating extensive scientific research and longer innovation cycles than other living lab types (McPhee et al., 2021). Second, rural living labs have an explicit focus on sustainability (Table 2), requiring a broader systems-oriented perspective than general living labs. A significant analytical effort is required to comprehend both the biophysical and social systems at play, as well as their co-evolutionary dynamics (Ison, 2018; Ison et al., 2015). Overall, living labs within rural SES may require longer co-creation and social learning timelines than other living labs. Third, as revealed in the literature review, rural living labs may require complex governance schemes (McPhee et al., 2021). Recruiting living lab participants may be time-consuming and existing or latent conflicts may intensify or arise. This is especially true in situations with strong social control and stakeholders failing to recognise the existence of collaborative problem-solving opportunities. Therefore, as argued by Potters et al. (2022), proficient facilitation becomes fundamental when admitting multiple stakeholders to the debate about systemic innovation in rural SES. Similar to other forms of multi-stakeholder partnerships (Brouwer et al., 2016), effective living lab governance also requires avoiding unnecessary conflicts and recognising existing conflicts that might jeopardise the social learning and co-innovation process within the living lab (Potters et al., 2022). In some instances, the use of a mediating object or dialogical tool (Colvin et al., 2014) may be relevant for guiding discussions and encouraging stakeholders' active engagement in the social learning process.

Overall, we encourage researchers wishing to integrate living labs into their research practice to consider these aspects when adapting the approach to rural SES.

5. Conclusions and future research avenues

Given the growing use of living labs to address sustainability challenges and their recent application in rural settings, this study explored whether living labs are suitable for catalysing systemic innovation for sustainable development in rural SES. The study considers the dilemma between "using the right words" and "using the words right". We believe this work contributes to the scientific debate on the benefits and drawbacks of living labs, particularly in rural SES.

The paper outlined the evolution of the living lab concept and offered a contemporary perspective on living labs as social learning spaces and models for collective governance promoting systemic innovation for sustainable development in rural SES. The benefits of applying living labs within rural SES include the co-creation of hybrid knowledge, social learning, new forms of collaborative practices, socio-technical innovation, and empowerment. Furthermore, living labs offer versatility for application across various contexts. However, living labs are not a one-size-fits-all solution and should be designed with critical self-reflection, addressing several epistemological issues: semantic stretch, governance, role of researchers, and time (Section 4.2).

We now propose several recommendations for more transparent and effective living lab use. These recommendations have the dual aim of reducing semantic, conceptual, and methodological confusion among scholars and practitioners aiming to apply the living lab approach within rural SES, while also informing the development of research programs that increasingly promote, if not require, the implementation of living labs.

Firstly, we emphasise the need to avoid the semantic stretch of the term "living lab", which may limit their potential to facilitate systemic innovation for sustainable development in rural SES. Instead of improperly/excessively using the popular living lab label ("using the right words"), efforts should be made to design/operationalise living labs that are flexible, adaptive, context-specific, and guided by robust theoretical foundations ("using the words right"). We also argue that greater emphasis should be placed on adaptation, rather than replicability, of the living lab approach, by considering the specific features of rural living labs (Section 4.4). This perspective has implications for research and practice. On the one hand, it demands that researchers demonstrate epistemological awareness and carefully consider contextual factors. On the other hand, it urges caution regarding the potential distortions that may arise from the existing certification processes for living labs. While we acknowledge the value of ENoLL's rigorous labelling process in ensuring the quality of living labs, an excessive focus on standardisation could compromise the contextual and dynamic nature of living labs.

Secondly, we acknowledge the benefits of multi-stakeholder participation in terms of enriching the decision-making process with diverse ideas and values as well as promoting equity. However, it is essential to recognise that participation alone is not sufficient for effective living lab implementation. Special attention should be paid to including marginalised groups, such as women and youth, and ensuring that the social learning and co-creation processes within living labs remain free from co-option by stakeholders with significant influence and resistance to change. This is particularly important when designing living labs within rural SES facing depopulation and limited generational turnover. Lastly, considering the explicit focus of rural living labs on sustainability, we call on the responsibility of researchers to act as collaborative learners rather than detached experts, leveraging social capital and promoting multi-stakeholder, transdisciplinary collaborations. However, existing research assessment criteria constrain researchers' willingness to actively engage in living lab processes, which are resource-demanding and characterised by unpredictable outcomes. Key performance indicators and research assessment criteria should be reformed to acknowledge the diverse contributions of multidisciplinary, interdisciplinary, and transdisciplinary research, as well as contributions to knowledge generation and scientific, technological, economic, cultural, and societal impacts. This implies that success may be measured not only in terms of immediate practical results but also in terms of generating social infrastructure and fostering long-lasting social learning spaces.

Moving beyond mere dissemination, formal learning, and participation, the implementation of living labs in rural SES should prioritise the establishment of spaces for social learning and co-creation, a more ambitious goal. However, the lack of recognised evaluation frameworks, and a predominantly process-oriented focus, needs addressing. We advocate for researchers to document and evaluate not only the joint learning process involving stakeholders and researchers but also the diversity of impacts and outputs generated by living labs.

To conclude, we propose the following avenues for future research in this field.

Firstly, empirical analyses should be conducted to document the application of the living lab model in various contexts, validate its effectiveness and gain deeper insights into the benefits and limitations of this approach. Secondly, there is a need to develop a comprehensive framework for evaluating the impacts of living labs, taking into consideration the multifaceted outcomes and effects generated by living labs across different domains. Lastly, it is crucial to explore theoretical frameworks that can effectively (re-)conceptualise living labs in rural SES. These areas of research will contribute to a better understanding of the potential of living labs and enhance their application as a valuable approach for driving systemic innovation and sustainable development.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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