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Encouraging Agricultural Innovation: A Comprehensive Review

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ABSTRACT

Living Labs (LLs) has become a cutting-edge approach to research and innovation across several domains, including agriculture. Research on using novel techniques for agricultural development in practice is lacking. This knowledge deficit significantly hampers current research efforts. This study investigates the valuable functionality of agricultural LLs to alleviate the paucity of comprehensive research. A systematic literature review of 18 academic articles on LLs implemented in the agricultural sector was performed. Our findings demonstrate significant geographical distribution, thematic orientation and organizational structure variation across these LLs. Two essential elements compose the dimensions on which agricultural LLs are based: the innovation process and the actors concerned. Examining these elements allows for a deeper comprehension of the various methods used in agricultural LLs and provides a theoretical framework for contextualizing them within current research. The study concludes by disclosing promising directions for future research. It emphasizes the significance of examining the interdependent interactions among actors participating in LLs initiatives. Furthermore, it emphasizes the importance of employing flexible approaches that can accommodate the distinct features of every agricultural setting to facilitate a sustainable transition.

Keywords: Co-creation, Living labs, Open innovations, Stakeholders, Sustainability

1. Introduction

The study explores the pressing need to support agricultural innovation, especially in rural regions that are dealing with serious issues including depopulation, inadequate infrastructure, and environmental barriers made worse by the COVID-19 epidemic (Kalantaryan et al., 2021; Visagie and Turok, 2021). The importance of agriculture in rural development is emphasized throughout the study, since it is a vital sector in addressing these intricate problems. The review emphasizes the interrelated issues caused by climate change that impact food systems, ecosystems, and the need for adaptable organizational structures in agriculture, drawing on research by Sanchez-Zamora et al. (2014). The study emphasizes the significance of involving a variety of stakeholders, including farmers, technology developers, academics, lawmakers, and consumers, in order to successfully address these issues (McPhee et al., 2021). According to Timpanaro et al. (2023) and Fałkowski et al. (2017), an all-encompassing strategy calls for a strong agricultural knowledge and innovation system that is in line with ecological shifts. SŇumane et al. (2018) also emphasize the collaborative aspect of agricultural innovation and support methods that encourage involvement from several stakeholders. In order to promote systems-based methods and participatory techniques in agricultural research and innovation, the study recognizes the importance of ongoing interactions between farmers and academics (Toffolini et al., 2023) and Klerkx et al. (2012). The study revolves on the idea of Living Labs (LLs), which are acknowledged by European Union investors and policymakers for their ability to collaborate with stakeholders and co-develop solutions in an iterative manner to solve complex societal issues (Følstad, 2008; Kviselius, 2009). By encouraging collaborative problem-solving, LLs enable stakeholders (Dell'Era et al., 2019). This is especially important in agriculture to meet sustainability objectives (Ciaccia et al., 2021). Although LLs have been studied in a number of domains (Niitamo et al., 2006; Evans et al., 2015; Paskaleva, 2011), their potential for use in agriculture has not yet been fully realized. In order to close this gap, this study looks at how LLs could advance sustainable farming methods in the face of global issues like food poverty and climate change, as well as practical agricultural innovation that is suited to farmers' needs. This paper's main goal is to provide evidence-based insights that can guide agricultural policies and practices, opening the door for environmentally conscious and inclusive agriculture in the framework of the EU's ambitious Green Deal initiative, which may have implications for low-income nations like India.

Generalities on LLs according to Current Literature

The mission of Living Labs is to function as practice-based organizations that support and carry out open, creative, and collaborative practices. Furthermore, they seek to provide authentic environments in which open and user innovation processes may be investigated and evaluated concurrently (Balloon and Schuurman, 2015; Leminen and Westerlund, 2019). Professor William Mitchell of the Massachusetts Institute of Technology coined the term "Living Lab" in the early 2000s to describe a research methodology that puts an emphasis on user-centered techniques. The method seeks to find,

recognize, and scale answers in contexts that are always changing and evolving (Van Geenhuizen, 2019). The establishment of the European Network of Living Labs (ENoLL) in 2006 marked a major advancement for the European concept of Living Labs. In order to address the economic crisis and social difficulties facing the continent, ENoLL brought a unique perspective to the European Union's policy framework (Ståhlbrost, 2013). National networks were established in a number of countries, including Belgium, the Netherlands, Spain, Portugal, Slovenia, the United Kingdom, and Italy. The precise definition of LLs is still unknown after more than 20 years of research. According to the European Network of Living Labs (ENoLL), LLs are innovation environments designed to meet consumer needs. These ecosystems are constructed by a systematic, collaborative process that combines artistic and scientific methods with physical communities and environments. They serve as go-betweens, facilitating value co-creation, rapid prototyping, and validation between individuals, communities, research institutions, businesses, and regions. They also speed up innovation and business growth. Leminen et al. (2012) claim that in real-world scenarios, LLs collaborate to produce, analyze, and validate novel inventions, commodities, services, and systems. They are classified as either virtual environments or actual places. Public-private partnerships include stakeholders such as businesses, governmental agencies, universities, institutions, and users. According to Bergvall-Kåreborn et al. (2009), LLs are a cutting-edge user-centered setting. With a strategy that encourages user participation in open and distributed innovation processes including all major partners in real-world scenarios, the environment is based on research and everyday experience. This "milieu" or "context environment"'s primary goal is to provide long-term benefit. Although definitions of LLs vary, they have several fundamental characteristics, the primary being innovation (Almirall et al., 2012; Schuurman et al., 2011). According to Hossain et al. (2019), LLs are a productive instrument for innovation development and a growing open innovation. Available networks are collaborations between various stakeholders to value customers and clients while also developing creatively (Westerlund and Nystrom, 2014; Westerlund et al., 2018). According to Mastelic et al. (2015), cooperation is essential between academics, businesses, consumers, representatives of civic society, and politicians. In essence, by including diverse audiences, LLs aim to enhance co-creation (Franz, 2015; Ståhlbrost, 2012). It is essential that stakeholders actively participate in all stages of the innovation process in order to sustain their interest throughout time (Brankaert et al., 2015). Using an innovation and co-creation paradigm increases the likelihood of coming up with fresh ideas that might effectively address today's socioeconomic and environmental issues (Zavratnik et al., 2019).

2. Methodology

A review seeks to provide novel and comprehensive understandings grounded on reliable and rigorous evidence (Palmatier et al., 2018; Peterson et al., 2017). Systematic literature evaluations emphasize three essential features:

- In order to guarantee inclusivity and relevance, the data collection process necessitates a thorough examination of relevant scientific publications from a variety of sources;
- A clear protocol for the methodical gathering of scientific evidence must be established in order to guarantee its validity. This guide should give clear guidance for the review approach, leaving no space for ambiguity or doubt;
- The selection process should concentrate on gathering empirical data and follow a rigorous strategy to guarantee transparency and replication of results (Pakseresht *et al.*, 2022). This review follows PRISMA standards (Page *et al.*, 2021). It gives a critical and thorough literature study on adopting Living Labs in agriculture. A comprehensive evaluation of current literature entails identifying relevant publications and summarizing their essential concepts (Sutton *et al.*, 2019; Grant and Booth, 2009).

Data Collection

A precise set of keywords was picked to begin a search query for related articles. The resultant search term was filtered to 'living lab*' to accommodate for changes in the definition and identification of Living Labs. This was attempted to prevent redundant consequences that may develop using identical words for the topic. The research was restricted to Living Labs techniques in agriculture, establishing a standard. Consequently, the terms "agr*" and "rural" were added in the study process. Other keywords were used in the search query to eliminate clinical laboratories, medical practices and research infrastructures. To enhance and reinforce the selection procedure, 'AND NOT' search criteria were used to exclude "clinical*," "animal*," "labor*," "labor*," and "label*." Articles were acquired using Scopus and Web of Science (WoS) scientific databases. Tawfik *et al.* (2019) acknowledged these databases as two main archives for transdisciplinary scientific literature. The search was done on 22nd March 2023 to permit a wide-ranging inquiry across several disciplines. The time period was established between 2000 and 2023, reflecting that LLs research has acquired substantial importance and advancement in the recent 15 years. The absence of non-peer-reviewed findings, editorials and reviews assured objectivity. Books were not included to ensure accessibility. The resultant collection of articles is exact, dependable and free from duplication and wrong data. The next steps of the review process were represented by tables including the abstracts of each article. The outcome of this first step was a preliminary sample of 350 articles. The selection was influenced by exclusion criteria pertaining to the engagement in the agriculture sector (Table 1). These criteria were utilized to ensure methodological coherence with the purpose, *i.e.*, employing LLs in agricultural settings as the topic of research.

Table 1: Completed review matrix

Author	Year	Country	Title	Source	Thematic area	Approach
Alamanos ***et al.***	2022	Greece	Water for Tomorrow: A Living Lab on the Creation of the	Water (Switzerland), 14 (18), 2879	Environmental Sustainability	Case study

			Science-Policy-Stakeholder Interface			
Beaudoin *et al.*	2022	Canada	A research agenda for evaluating living labs as an open innovation model for environmental and agricultural sustainability	Environmental Challenges, 7, 100505.	Policy	Conceptual
Hebrard *et al.*	2022	Multi-national	Towards Innovation-Driven and Smart Solutions in Short Food Supply Chains	International Journal of Food Studies, 11, 129-137	Innovation - agricultural practices	Case study
Hvitsand *et al.*	2022	Norway	Establishing an Agri-food living lab for sustainability transitions: Methodological insight from a case of strengthening the niche of organic vegetables in the Vestfold region in Norway	Agricultural Systems, 199, 103403.	Environmental Sustainability	Case study
McPhee *et al.*	2021	Canada	The Defining Characteristics of Agroecosystem Living Labs	Sustainability (Switzerland), 13(4), 1718.	Policy	Conceptual
Metta *et al.*	2022	Multi-national	An integrated socio-cyber-physical system framework to assess responsible in agriculture: A first application with Living Labs in Europe	Agricultural Systems, 203, 103533.	Innovation - digitization	Case study

Analysis of Papers

After analyzing the abstracts, 47 articles were chosen for a thorough assessment. All of the papers were thoroughly read and the various subjects were systematically coded. An inductive method was used for data analysis, allowing for the identification of patterns and emerging themes. The coding process was carried out in two main stages. In the first stage, interest parts were systematically collected. This process facilitated the identification of fundamental concepts and recurring motifs. Afterwards, similar attributes were categorized into broader analytical categories. This method facilitated the identification of more profound connections between the emerging concepts, allowing for a systematic understanding of the data. This study incorporates findings from previous literature reviews on Living Labs. During the coding process, it was observed that compared to other sectors, agricultural LLs tend to specify fewer detailed details. This conclusion motivated our inquiry to detect abnormalities and gaps in agricultural LLs compared to other situations. The categories intend to collect information on the discourses around the laboratories in agricultural settings and general descriptive data relevant for aggregative results (Table 2). To ensure robustness and reliability, the coding approach was performed individually by many researchers, lowering the possibility of biased interpretations and each step of the study was documented in full, allowing the method to be repeated and transparent. Finally, 29 articles were rejected during the analysis method. Eighteen articles, encompassing three ideas and 15 case studies of agriculture-oriented LLs, were judged appropriate for complete examination. The review's modest sample size of papers implies that the LL notion is still in its infancy as it applies to agricultural practice and research.

Table 2: The categories used for the article analysis.

Categories	**Category description**	**Sub-categories**
Descriptive information	Generally recognisable data related to the lab case	Location of the first author's lab (country and university), Present condition of the laboratory, Case study/Idea Topical and thematic emphasis, An explanation of a particular lab
Process information	Techniques and essential actions for putting agricultural living labs into practice	Identification of Methods Approaches Structurally: The Effect of Methodologies
Actors	Type of actors involved relations	phases in the Living Lab, Type of collaboration in the Living Lab, Variety of actors involved in the Living Lab activities

information	between them and nature of the partnership within the Living Lab	Representativeness and inclusiveness of the actors Involvement of researchers in the Living Lab Involvement of the public sector in the Living Lab

3. Discussion

The conclusions of the review were divided into three distinct tiers. Section 3.1 offers a descriptive summary of the agricultural Living Labs studied in the sample. In section 3.2, the essential ideas that describe agricultural LLs are addressed via the examination of conceptual papers. Section 3.3 highlights the major aspects within agricultural LLs.

3.1. Descriptive Overview

This section's results include a range of topics. 1) The articles' division according to the year of publication; 2) The writings' focus on a certain nation; 3) The articles' topic or theme; and 4) The articles' distribution both physically and geographically. A total of eighteen publications detailing the use of Living Labs in agriculture were found (see Appendix A for a summary of the articles and their descriptions). Examining the number of articles published on agricultural LLs year by year reveals a growing trend in recent years, which was expected considering the rising importance that governments have placed on these tools for dispersing innovation. There were three papers released on this topic in 2019, however there was a slight decrease in 2020, with just one item published. Nonetheless, there were four publications on LLs in agriculture in 2021, and seven papers were published in 2022—a significant increase. In conceptual articles, the original author's country was taken into account. Europe accounts for the majority of LLs, with eight publications in total. The other contributors to this collection are three from France and one each from Italy, Spain, Portugal, Norway, Poland, Greece, Belgium, and Latvia. With two publications from Canada, Nigeria is the only country in Africa to make the list of non-European countries. Furthermore, three papers that addressed several LLs located in distinct nations were found and classified as "Multinational." The distribution of LLs in many agricultural theme groups is shown by the analytical results. 22% of the examined LLs were centered on environmental sustainability, 39% on agricultural policy, and the remaining LLs were centered on agricultural innovation. This second group was further subdivided based on the LLs' desire to support and encourage digital advances (11%) or innovative agricultural practices (28%). The levels refer to the stated goals of the LLs in terms of geographic extent. The results show clear relationships between the estimated geographic scales at which the LLs are expected to operate and their placement. All case study articles fall under this category, with the exception of the three conceptual pieces, which don't mention any specific location. Geographically speaking, the majority of LLs (6) aspired to be at the regional level, and the remaining (5) were at the local, (2) at the international, or (2) at the national levels. The LLs display themselves in a variety of ways at each of these levels. The analysis found that 7 (46%) of the LLs had no identifiable physical location. They lack explicit geographic objectives but are centered on laboratories, seminars, or specific processes. Furthermore, only two LLs identified specific physical locations as their places of employment; these locations were inside agribusinesses. Three LLs used a mixed approach, rotating between in-person lectures and online tools to encourage participation. In the end, only two LLs were completed entirely online.

3.2. Key Concepts

The theoretical foundations of agricultural Living Labs will be covered in this section. Outlining the theoretical perspective, the research will focus on how these ideas provide the conceptual framework for comprehending the role and effectiveness of LLs in the agricultural setting. Sustainability, complexity, and context-based localization are the three fundamental ideas that distinguish agricultural LLs from urban and rural LLs, according to McPhee et al. (2021). Their incorporation and functioning within agri-food systems, however, provide an alternative perspective for efficient implementation and administration (e.g., seasonal cycles, amount and diversity of parties participating). The evaluation of LLs is one of the main topics covered. Since current iterations of evaluation frameworks are still limited, it is imperative to create sufficient ones (Beaudoin et al., 2022). This method offers a thorough and accurate evaluation of the effectiveness and impact of LLs (Bouwma et al., 2022). Every area and agricultural system has unique characteristics, thus adaptable LL strategies are required to meet local needs. A special focus on co-creation and active participation from all parties involved—farmers, researchers, institutions, and locals—is required for this (McPhee et al., 2021). The data demonstrate the need of advocating for a comprehensive approach that takes into account environmental, non-human, and human factors (Beaudoin et al., 2022; Gamache et al., 2020). Using initiatives like shared Living Labs (CLL) or citizen-centered Living Labs (CLL), which aim to create, manage, and share resources, might support such an all-encompassing strategy (Gamache et al., 2020).

3.3. Key Dimensions of Living Labs Case Studies

This section examines the distribution of Living Labs at the continental, national, and local levels, presents the major research questions, and then focuses on the labs' operations. Two key characteristics appear in the special context of agriculture, which has traditionally been less inclined than other sectors to value LLs as a form of shared development: process and players. Our study distinguishes the sector specialization from other literature reviews on LLs in broader contexts by emphasizing the aspects differently. This research highlights the need for a new perspective on agricultural dynamics by highlighting the potential value of process and actor characteristics as a major source of future advancements. Although earlier studies of the literature

have often discovered additional characteristics, there seems to be an emphasis in the agricultural setting on examining these two particular dimensions. This implies that in terms of complexity and multifaceted methods, future advancements could more closely resemble those in other areas.

3.3.1. Process

This section examined the many tools and methodical approaches used to accomplish the goals of Living Labs as well as the potential impact that these decisions may have on the overall effectiveness of these farming projects. Among the noteworthy methods found in the field of agricultural LiLs is the use of theoretical frameworks to LL methodology. This approach covers techniques for overseeing and integrating roles inside LLs, guaranteeing complete participation from stakeholders, and producing outstanding results. One instance is the Systems Innovation Approach (SIA) used at the Greek Living Lab, which enabled the organization of player interaction and the coordination of activities (Alamanos et al., 2022). Greater participation and a better understanding of the issues and possibilities for agricultural LLs may be achieved by a methodical approach that includes a review of existing practices and processes as well as the presentation and communication of stakeholder initiatives. Participatory Action Research (PAR) is an additional methodology that was used at the AgroforSyLL Living Lab in Metaponto (Ciaccia et al., 2021). In this case, extensive collaboration with local communities was established in order to properly understand the roles, resources, and competencies of researchers and other stakeholders involved in the process of defining LL. Better explanations of the LL, higher engagement, and improved communication and action were the outcomes of the creation of the Actor Platform (AP) and the Research Platform (RP). In the Polish setting, a multi-pronged approach including backcasting, the Analytical Hierarchy Process (AHP), and Cumulative Voting (CV) was used (Wieliczko and Florianczyk, 2022). Workshops are the main method used by agricultural LLs to include significant stakeholders in the decision-making and co-creation processes. Agricultural LLs use workshop methods to include important stakeholders in co-creation and decision-making procedures. The conducting of needs assessment workshops, when farm representatives and other influential persons convene to deliberate on sector-specific challenges and opportunities, is a customary feature of many LLs (Campos et al., 2019; García-Llorente et al., 2019). Through active player recruitment, those workshops might learn about real-world reactions and areas for development. Some LLs have embraced an approach to co-creation and collaboration that is more methodical and iterative. For instance, the Teaser Lab in France (Fleche et al., 2021) used facilitation concepts and the creation of a common ground among the stakeholders to build a more sustainable and healthful agri-food system. The LL by Plaisier et al. (2019), which examined the problem of post-harvest losses in Nigeria's tomato sector, is another such. The "World Cafe" was used to encourage debate and assessment of the knowledge gained, investigation of workable alternatives, and creative approach development. Using participatory approaches, an agricultural LL in Norway (Hvitsand et al., 2022) demonstrated a more cooperative and co-creative approach. In order to conduct work sessions using participatory and co-creative methodologies, participants were divided into mixed groups. People may brainstorm freely, design a possible future, explore ideas, and choose specific actions for change with the help of this approach. Agricultural LLs make an effort to encourage farmer, stakeholder, and community engagement despite methodological differences. There are notable parallels and differences between the two global agricultural LLs being investigated and the methods used. The use of multi-actor workshops is among the characteristics shared by the LLs under examination. Hebrard et al. (2022) emphasize the use of workshops involving communities, experts, and farmers. These organizations have similar goals for farming in the future: streamlining the procedure to meet consumer demands. Similar to this, Metta et al. (2022) integrate users, key informants, and stakeholders via interactive workshops that promote widespread participation and the exchange of ideas. However, LLs vary in the strategies they use throughout the sessions. In order to enhance decision-making, Hebrard et al. (2022) emphasize the need of evaluating vital success components (CSFs). In addition, a SWOT analysis is performed to look at the possibilities, threats, weaknesses, and strengths of the use cases. On the other hand, Metta et al. (2022) investigate the impact of digitalization on the agricultural industry using the concept of a physical socio-cybernetic system (SCPS). Both LLs encourage active stakeholder participation and co-creation of innovative agricultural solutions, despite differences in methodology. Multiple perspectives and expertise are included into this inclusive approach, which promotes more sector flexibility and better-informed decision-making (Bjorgvinsson et al., 2010). Toffolini et al. (2021) examined the dynamics of agricultural LLs and assessed the creation and redistribution of roles among individuals in such creative environments. Limited groups of performers participated in semi-structured interviews during which data, including frame notes and pastime ratings, were assessed. The methods used were meant to investigate the strategies and transformational processes of the LL player community. A long-term participatory observation approach was used in the context of the LL under evaluation, and the researcher actively participated in several meetings and activities. In conclusion, research on procedures in agricultural LLs has shown a variety of methods, from the use of theoretical frameworks to strategies derived from workshops involving several stakeholders. This variety serves as an example of the need of looking at success variables in specific situations and the crucial role that LLs play in removing obstacles to innovation. The LL approach, particularly via user-centered innovation, stands out as a crucial accelerator for getting beyond early opposition in the context of innovation-related barriers. In the context of agricultural LLs, user-centered innovation becomes a tool to make innovation acceptable and accessible. Useful examples and approachable fixes might help get beyond initial obstacles, fostering a more optimistic outlook and increasing the likelihood of broader adoption. This strategy, when combined with a focus on workshops as a key tool, offers excellent opportunities for producing real solutions that accurately reflect user needs.

3.3.2. Actors

Having stakeholders is essential to Living Labs. A few key players in the invention process must cooperate and communicate with one another for this innovation strategy to work. From outlining the problem to developing and implementing the solution, participants contribute at every stage. Co-generation of alternative ideas and engagement in decision-making are made possible by active involvement. Depending on their goals and objectives, each stakeholder's involvement in the agricultural and agri-food system differs. Diverse agricultural LLs, where partners with distinct interests and values contribute to a range of end-user experiences, are a good example of this variation. Within the studied literature on stakeholder participation in agricultural LLs, there were many areas of convergence. Most authors agree that it is important to include stakeholders at every stage of the agricultural innovation

process, from describing the problem to designing and implementing a solution. Academics, researchers, and farmers have all continuously had a variety of roles in agricultural LLs. In order to address complex agri-food system issues, several LLs make an effort to establish transdisciplinary or even multidisciplinary networks, drawing in scholars from many sectors. Agricultural LLs provide partners, standards, and divergent interests; thus, a particular kind of governance is required to effectively handle these concerns. Because of this, the public sector has always dominated LL administration, acting as a middleman between the many stakeholders, beliefs, and interests. Alamanos et al. (2022) emphasize the need of incorporating many stakeholders such as government officials, regional authorities, farmer organizations, professionals, and scientific and technical specialists. It also emphasizes the value of knowledgeable moderators, particularly locals who play important roles in the community, as facilitators in the agricultural innovation process (Ciaccia et al., 2021). Furthermore, the studies highlight the participation of often marginalized or underrepresented actors in community-based agri-food initiatives, including organic farmers and neighborhood associations (Fleche et al., 2021). According to García-Llorente et al. (2019), farmers, local government agencies, and rural development organizations should all be involved as agroecological trainers. An effort to bring together various stakeholders is described in another study (Hebrard et al., 2022). These stakeholders include universities, agri-food firms, farmers, representative groups, nonprofit organizations, and technological centers. It is emphasized that LLs has shifted from concentrating on specific digital technologies to addressing broader social technology concerns. As a result, groups who would otherwise go unnoticed or unappreciated may now participate. Considering the representativeness of the involved parties is essential for ensuring inclusive decision-making and effective governance (Wieliczko and Florianczyk, 2022). This necessitates that NGOs, farmers, and other important stakeholders be properly represented (Toffolini et al., 2021; Amon et al., 2022). In order to identify discrepancies, overlaps, and obstacles in resource management and multi-actor process coordination, it is also important to map actors participating in LLs (Majore and Majors, 2022). According to one study, active participation in the development and application of solutions by value chain participants may reduce post-harvest losses and increase adoption of suggested improvements (Plaisier et al., 2019). The examples analyzed highlight the importance of using local pilots and trials to evaluate potential changes. To do this, stakeholders must be directly involved in the implementation of interventions in order for them to evaluate the suggested innovations and provide feedback for future development (Fleche et al., 2021; Petry et al., 2018). It has been emphasized how important it is to look at the infrastructures and contextual elements of the LL, such as information management, group experimentation, and farmer-consultant relationships. In LLs, role redistribution is a dynamic process that is marked by collaborative effort and is governed by unpredictability and uncertainty. The analysis of agricultural LL stakeholders has shown important trends. Stakeholders' collaborative and interactive involvement throughout the innovation process is a crucial component. This tactic encourages the collaborative production of alternative concepts and is a great way to get over obstacles to creativity, including mistrust. The diversity of interests and values seen among various LLs emphasizes the need of equitable and inclusive representation in decision-making. Effective management of transdisciplinary networks often requires unified governance, facilitated by the public sector acting as a middleman between many stakeholders. Incorporating underrepresented players and doing thorough stakeholder mapping are essential steps towards attaining effective and comprehensive governance.

Discussion and Identification of Some Areas for Further Research

1. Areas of Operation and Thematic Areas of LLs

Over the last several years, there has been an increase in the number of research publications about the use of Living Labs in agriculture. The increase in publications indicates a growing recognition and curiosity in the significance of incorporating important stakeholders in agricultural innovation (Bronson et al., 2021). To determine if this expansion has significant real-world effects and whether LLs successfully translate progressive ideas into workable solutions that help rural areas, a careful analysis is necessary. One of the challenging circumstances that the statistics on the regional distribution of LLs highlighted. Despite the apparent diversity in the engagement of different countries worldwide, the majority of LLs are still found in Europe. To fully realize the potential for reciprocal learning and provide innovative solutions with a global impact, LLs must collaborate more internationally and share information more widely (Greve et al., 2020; Hossain et al., 2019). The thematic issues that LLs address are the subject of yet another important focus. The growing focus on agriculture governance and sustainable management is reflected in the sizable number of LLs with expertise in environmental sustainability and agricultural policy (McPhee et al., 2021). Nonetheless, it is essential to ensure that a wider range of concerns are addressed, such as the investigation of technological and digital advancements in agriculture (Keyson et al., 2013). This expansion would enable a more comprehensive strategy for addressing current and upcoming challenges in the agricultural industry and creating creative and long-lasting solutions (Guzman et al., 2013). One major issue is that the majority of LLs under investigation lack a fixed physical location. While this may suggest using flexible and creative running strategies, it also raises concerns about the interpersonal relationships and cooperation amongst the many stakeholders. It looked at the potential effects of not having a designated physical location on the effectiveness of co-creation, trust-building, and knowledge sharing (Radulescu et al., 2022; Lucchesi and Rutkowski, 2021). However, it should be acknowledged that online modalities may increase accessibility and engagement, especially for actors who are unable to participate in an LL because of physical limitations (Kovacs, 2016). However, to fully realize the promise of LLs as spaces for innovation and co-introduction, consistency across offline and online modalities is required.

2. Sustainability and Value of LLs in Rural Area Development

Our research on Living Labs in agriculture yields a number of conceptual elements that both strengthen the construct with new perspectives and confirm old ideas. First, the study emphasizes how important farmers are to the process of developing solutions within LLs. In contrast to popular belief, it encourages farmers to actively participate in agricultural innovation, turning them into real protagonists. The need of incorporating farmers' knowledge into the development of solutions is emphasized, acknowledging the breadth of their practical competence. Using a multidisciplinary approach inside agricultural LLs yields a significant benefit. According to the study, innovation is fueled by the synergistic integration of several disciplines, including technology, social sciences, and agriculture, which results in new perspectives. This integrated strategy has a significant impact by amplifying the objective and generating more flexible solutions. The importance of LLs as crucial vehicles for promoting the shift to more resilient and sustainable

farming practices is one of the main points made. These open innovation frameworks are predicated on broad stakeholder participation and collaboration at every stage of the innovation process, from problem identification to solution creation and implementation. In this method, active stakeholder involvement facilitates shared and participatory decision making as well as the cooperative production of innovative solutions. The need of tailoring LLs to different environments is emphasized in theoretical works. Every place and agricultural system has unique characteristics, hence localized LL strategies are necessary. All parties involved in the agricultural sector, including farmers, academic institutions, and local communities, must really cooperate and actively participate in this. Increased effect and efficacy of LLs in agriculture need such collaboration. A natural area may become a dynamic, digitally connected, and geographically localized innovation hub with the implementation of an LL (Scuderi et al., 2023). This transformation might provide significant development opportunities and revitalize the whole area. It is possible to intentionally design an agricultural LL to serve as a central hub for innovation that brings together all the key parties and improves the food chain. Establishing an agriculture LL facilitates the sharing of ideas and information by bringing together a multitude of stakeholders. This collaboration takes place in a transparent environment that provides the means to generate creative ideas and transform them into novel procedures, products, and services. Given the experimental nature of agricultural LLs, defining appropriate evaluation criteria is an important area for future research. Given the complexity and diversity of interactions that characterize these types of collaborative settings, this feature becomes even more crucial. Including interdisciplinary perspectives might be essential to developing evaluation standards that capture the multifaceted nature of LLs. To accurately measure the impact and effectiveness of LLs in agriculture, evaluations should take into account a variety of methodological, operational, social, and environmental factors. To address issues related to food distribution that are technical, economic, social, and environmental, a complete strategy must be adopted. To produce operational, democratic, and academic knowledge in the complex circumstances of Language Learning Organizations (LLs), a combination of evidence-based and participatory methodologies is required (Dekker et al., 2021). To effectively overcome these obstacles, it is important to assess the non-human factors, human features, and surrounding environment (Compagnucci et al., 2021; McCrory et al., 2020).

3. Organization, Approach, Actors and Governance of LLs

Creating networks of knowledge among all parties involved, both within and outside the job, is the aim of Living Labs. Furthermore, more quantitative and qualitative assessments are needed in agricultural LLs because of the extreme complexity of agricultural and agri-food systems. The large number of partners involved in these kinds of LLs highlights this complexity (McPhee et al., 2021). A wide range of qualitative approaches must be used if the Agricultural LLs are to be successful. The "mode" element of the lab exercise is essential to fully understanding the influence and effectiveness of these strategies. Adopting theoretical frameworks as guiding principles for the creation and implementation of LLs is one of the biggest problems. Theoretical frameworks are helpful because they provide a deep understanding of the constraints and patterns that define creative agricultural tactics. This broadens our understanding of the challenging conditions and strategies related to agricultural creativity. Employing a theoretical framework expedites the process of developing a shared vision and imagination, articulating goals, and determining appropriate research methods. But, it is important to understand that in order to guarantee the effectiveness of the strategies used, these frameworks must be adjusted to the unique surroundings of each LL. Complementary qualitative techniques are integrated into multi-approach approaches in agricultural LLs to provide a radical and nuanced view of problems, opportunities, and solutions in the agricultural sector. It is possible to collect a range of viewpoints from participants in agricultural LLs, including as farmers, professionals, community leaders, and other stakeholders, by using a variety of qualitative methods. Understanding these points of view is essential to understanding the unique requirements, opinions, and goals of the parties involved in the agricultural innovation system. The multi-method approach in agricultural LLs often incorporates qualitative techniques like as workshops, backcasting, interviews, the Analytical Hierarchy Process (AHP), and Cumulative Voting (CV). In agricultural lowlands (LLs), using a multi-method strategy helps get over constraints that come with using a single technique. For example, although interviews may provide a detailed account of actors' ideas and experiences, workshops allow for participant participation and collaboration. Concurrently, the use of backcasting and AHP facilitates the direction of decision-making towards viable and preferred future alternatives. Planning carefully and having a thorough understanding of the objectives of the study are necessary when integrating many approaches. The results of the analysis have shown the benefits and limitations of using workshops as the primary means of integrating important stakeholders in the selection and co-creation processes within agricultural LLs. The primary strategy used in agricultural LLs, workshops help to include key stakeholders, foster innovation, and provide long-lasting solutions.

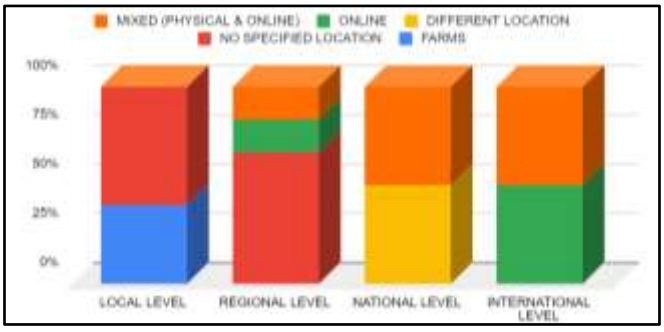

Figure 1: Quantification of Living Labs across different geographical levels and places

Involving stakeholders fosters collaborative networks and alliances, which is advantageous for marketing innovation. First and foremost, in order to avoid the marginalization or exclusion of certain viewpoints, an inclusive participation environment must be created (Bjorgvinsson et al., 2012). It is possible for stakeholders who lack money or representation to feel uneasy or hesitant to participate actively. According to Engels et al. (2019), effective workshop

facilitation should thus increase the participation of all stakeholders by making sure that everyone feels comfortable sharing their ideas and suggestions. A complex picture has emerged from the examination of methods and parties inside agricultural LLs. The variety of strategies used—including workshops, backcasting, and evaluation methodologies—indicates the complexity of the challenges faced by the agriculture industry. This variation, although advantageous, presents a significant uniformity challenge. Lack of established best practices might prevent widespread adoption. As a result, it's critical to balance the need for customization with the goal of developing broadly applicable methods to address common problems. One crucial thing to consider is the workshop's organization (Akasaka et al., 2022). Using facilitation techniques like brainstorming, lateral thinking, and multicriteria assessment may help provide precise answers by revealing new ideas and approaches. Simultaneously, it is important to guarantee that discussions remain centered on the stated objectives of the LL, thereby preventing attention from being drawn to other subjects. The effectiveness of collaborative evaluation processes may be greatly recognized in arriving at a collective evaluation of proposed solutions. These approaches include important stakeholders in the review process, allowing for a wide range of requirements and opinions to be taken into account. In order to ensure that these gatherings really contribute to the accomplishment of agricultural sustainability goals, it is essential to address issues related to participation, coordination, and assessment. The long-term viability of agricultural LLs is an important factor. Collaboration efforts may come to an end after these projects, which are often focused on research and innovation and have a limited duration, are completed. The agricultural industry may not fully adopt the suggested adjustments. It is essential to devise strategies for knowledge transformation and integrate these accomplishments into the broader agricultural and food zone structure to ensure the dissemination and uptake of innovative solutions. The predominant position of local communities in agricultural LLs is a subject of further study. Local groups play a crucial role in the agriculture sector's adoption of sustainable alternatives since they ultimately acquire innovations and maintain important local expertise. This necessitates an inclusive approach that goes beyond standard community engagement, including members in the formulation, creation, and assessment of objectives and outcomes (Huang and Thomas, 2021; Nystrom et al., 2014). It is critical to provide the skills and support systems—such as training, access to sufficient resources and technology, and recognition of local and traditional knowledge—that enable communities to actively participate in decision-making (Veeckman et al., 2013). An essential element of open innovation in agriculture and agri-food systems is the active participation of stakeholders in agricultural LLs (Verloop et al., 2009). The wide range of stakeholders engaged in agricultural LLs, each with unique values, interests, and roles within the agricultural system, is an important finding from the literature assessment. However, handling this variability well is a significant task. A special kind of governance that can take into account and balance the multiple complications present in LLs is necessary due to the active participation of stakeholders (Leminen, 2013). The involvement of participants who are often overlooked or underrepresented in agri-food initiatives—such as local organizations and farmers using alternative organic models—highlights the inclusive and participatory nature of include stakeholders in agricultural LLs. One of the main issues that has to be carefully considered is how intricately the actors are interacting with one another. Understanding the complexities of this innovative ecology requires a specific mapping of the interactions and dynamics between these entities. Strengths like excellent collaboration and synergy among players are made clear by this research. Additionally, it detects capacity issues, such as disagreements, misalignments, or inefficiencies in the coordination of multi-actor methods and resource management. The diversity of goals and interests among the relevant parties is a crucial initial factor to take into account. For instance, although consumers may prioritize environmental sustainability and the quality of the final product, farmers may be motivated by the need to increase agricultural practices and productivity. Divergent viewpoints may give rise to disparate concepts on innovation and evaluating accomplishments. Collaboration between stakeholders may also require the pooling of resources, including money, infrastructure, expertise, and evidence. Insufficient coordination might lead to mishaps, conflicting decisions, or even the abandonment of worthwhile endeavors. In order to address these issues, appropriate governance structures that promote participation, transparency, and consensus among stakeholders must be included. In order to ensure that every stakeholder's perspective is valued and heard throughout the decision-making process, governance must be established to support this engagement. One approach that shows promise for removing obstacles is user-centered innovation; nevertheless, its effectiveness depends on its ability to convert real-world examples into tangible outcomes that can be implemented widely. To overcome deeply ingrained resistance to the adoption of modern agricultural practices, a complete plan is required. In summary, although LLs provide an environment that is conducive to innovation, the main challenge is in handling complexities and translating local successes into broader outcomes. Both competent governance and a collaborative and participatory approach from stakeholders are essential to the efficacy and sustainability of these initiatives.

4. Conclusion

Through the use of a systematic review, the purpose of this study is to examine the characteristics of living laboratories, with a focus on their use in agriculture. The study's conclusions provide a foundation for current LL-based user-centered advances in agriculture. A variety of techniques have been revealed by the thorough examination of the methodology used in the LLs, highlighting the need of examining success factors in particular circumstances. The use of many qualitative approaches, including workshops, backcasting, and interviews, helped to overcome the particular limitations of each approach. The importance of the participative approach and the stakeholders' cooperative synergy were highlighted by the research of agricultural LL stakeholders. The diversity of interests highlights how important it is to have inclusive and equitable participation in decision-making. Unified governance, mediated by the public sector, has often been necessary for the effective management of transdisciplinary networks. LL approaches have been shown to be effective in promoting innovation access, reducing resistance, and promoting more acceptance of ideas that are put forward. The information gathered from this evaluation is expected to provide the foundation for informed strategic planning and decision-making within the framework of modern user-centered innovations in agriculture, all backed by the trustworthy LL methodology. Policymakers looking for solutions to the problems brought on by the COVID-19 pandemic and the Russia/Ukraine conflict, which have raised the cost of industrial supplies and raw resources, may find great value in the LLs model. It is critical to recognize the limits of the study. These are the limited quantity of documented cases that our study examined. Furthermore, comprehending potential conflicts between participants within LLs may be hampered by only looking at experimental methodologies from academic and technical publications. The underlying causes of these disputes may include power disparities, competing interests, and varying capacities for participating in group activities. Agricultural LLs were surveyed, and the results revealed several important research vantage points that might further this field of

study. The way actors engage in LLs may have a significant impact on how multi-actor processes are coordinated and resources are managed. Future research priorities seem to include the need to develop reputable evaluation frameworks and the adaption of LLs in certain situations. While keeping a close watch on environmental concerns and climate change that may have an impact on the landscape of agricultural LLs, collective creativity and inclusive engagement continue to be at the core of these problems.

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