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Review

A Systematic Review of Living Labs in the Context of Sustainable Development with a Focus on Bioeconomy

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Abstract: The living lab (LL) concept has a significant potential to drive sustainable development, particularly in the bioeconomy sector, by assisting communities in improving their quality of life whilst also considering the environmental impact. In this context, the main research question was the following: is there any specific mechanism through which living labs operate under the sustainable development concept? We reviewed 120 papers addressing this topic and performed a bibliometric analysis on the linkage between sustainability and living labs by applying the methodology of a systematic review. We concluded that living labs can drive innovation and experimentation in sustainability, which can be transposed into tangible solutions to economic, environmental, and social problems. The role of living labs in the transition to a bioeconomy is discussed and further research directions are presented.

Keywords: living labs; sustainability; bioeconomy; urban living labs

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1. Introduction

Across the globe, humankind is constantly seeking new resources at a rapidly growing pace. As a result, a tremendous amount of strain is put on the climate, ecosystems, and biodiversity. The notion of sustainable development was proposed in the late 1980s in the Brundtland Report on Environmental Protection and Nuclear Safety, also known as the Brundtland Report, as "development that meets the needs of the present without jeopardizing future generations' ability to meet their own needs" [1]. Since then, the notion of sustainable development has grown in popularity, becoming the focus of numerous papers. The implementation of the Global Framework and the 17 Sustainable Development Goals has resulted in a shift away from an economic model based on linear growth, which has been sustained by a change in national strategies to achieve this transition [2]. On the other side, understanding the social, economic, and political environments remains an ongoing challenge for researchers. Many drivers of sustainable development have been identified so far, such as technology readiness, multi-actor collaborations, and science-based policies [3].

In this article, the living lab (LL) concept is depicted as one strong driver of sustainable development, particularly in the bioeconomy sector, with the main role of assisting communities in identifying and implementing ways to enhance the quality of life in different aspects, whilst also considering the environmental impact. Also, in the context of

this paper, we refer to living labs as an open innovation ecosystem that is user focused, and grounded on a methodical approach to user co-creation that integrates research and innovation processes in realistic settings and communities [4].

During the past 20 years, the LL concept has been used and researched in various fields, including public health sciences, environmental engineering, and urban planning [5,6]. The idea has influenced peri-urban, urban, and rural environments as well. Specifically, living labs, embedded in the territorial structure, boost the possibilities for technological advancements and the propagation of a digital culture by bringing together stakeholders from many facets of the community [7].

Moreover, living labs proved to be effective in encouraging inclusive community development, including all stakeholders, in addition to technology benefits through group learning, innovative co-creation, and information sharing [8]. However, the specific mechanisms through which living labs can spur sustainable development remain under-explored, although there is evident synergy between these two concepts. Therefore, the objectives of this article are as it follows:

- To systematically review the literature addressing the linkage between living labs and sustainability;
- To analyze to what extent LLs have been a basis for innovation;
- To perform a bibliometric analysis on the link between living labs and sustainability;
- To synthesize living labs contributions to sustainability with a particular focus on the bioeconomy sector.

1.1. Sustainability and Bioeconomy—Two Synergic Concepts

Sustainability is defined as "a characteristic or state in which current needs can be met without jeopardizing future generations' or populations' ability to meet their own needs" [9]. As efforts to harness biodiversity continue, a variety of economic models have been proposed to increase and improve sustainability. Some of these economic models are represented by the bioeconomy and the circular economy, which have become in recent years important means to improve sustainability. A growing number of governments, businesses, non-governmental organizations (NGOs), and civil society organizations (CSOs) are incorporating them into their operations. They all have the same goal of increasing access to resources while reducing greenhouse gas emissions.

A bioeconomy is considered to be a subsection of economics that is based on biology and bioscience, with activities in the environmental, social, political, and economic spheres [10–19]. Some authors, however, argue that the bioeconomy does not separate technological progress from societal progress [20]. Bugge, Hansen, and Klitkou's approach proposed three dimensions of bioeconomy: (i) biotechnology—highlighting the role of biotechnology in several economic sectors; (ii) bioresources—emphasizing the processing and valorization of raw materials; and last, (iii) bioecology—emphasizing environmental sustainability, biodiversity promotion, and environmental protection [17,21–24]

The core of the bioeconomy is the idea that economic activities must be based on renewable resources. This means that the products and services of the economy should be produced from renewable resources, in a manner that does not harm the environment. This contradicts the traditional economy, which relies on the exploitation of finite resources that cause pollution and harm to the environment. The ultimate goal of bioeconomy is to create a more sustainable, efficient, and responsible way of producing and providing goods and services with minimal environmental harm [25–30].

The implementation of the bioeconomy requires an effective legal framework, as well as financial incentives to support the transition to the new system. The European Commission's Circular Bio-Economy Action Plan [31] outlines a set of policy-related instruments that can be adopted to incentivize the transition to a circular bioeconomy. This includes measures for creating a more vibrant market for bio-based products, such as creating regulatory and fiscal incentives for the production and use of bio-based products, reducing administrative burdens and improving market access, as well as raising public awareness

and driving public–private collaboration. The European Commission is also committed to enhancing its collaboration with Member States to unlock the potential of the circular bioeconomy. This includes developing common strategies for biomass production and processing, as well as investing in research and innovation [31]. Additionally, a shift in public attitudes and behaviors towards more sustainable practices is needed to facilitate a successful transition to the bioeconomy.

1.2. The Living Lab Concept

When living labs made their appearance in Europe in the early 2000s, it was visible that the European living lab concept, which was built on earlier experiences with participatory design, significantly reinterpreted the US-originated home labs. The user began to be studied in his or her usual environment, rather than in a laboratory setting, which was a significant difference [32], that employed delivering the testing facilities to the users [33]. Recently, a new concept (the "agro living labs" or ALLs) emerged, due to climate change, war conflicts in Europe, and the COVID-19 health crisis [34].

A living lab is a real-world environment for innovative co-creation concerning knowledge, products, or services, where the term "user" implies those living in the lab, if any, but also the stakeholders from business, society, and academia [35]. The user-centric approach used by the LL methodology, which involves all relevant actors and end users, is a key component. All the actors can be categorized using the quadruple helix Model, an extension of the conventional Public–Private Partnership, even though the specific actors will vary depending on the LL emphasis, objective, and context [36,37].

Participants in the quadruple helix model include individuals from every sector of society. Universities or research institutes are two examples of academia stakeholders. The public sector might include regional and local governments, as well as the public sector in general (such as formal health care providers in some countries). Industry may also include organizations and clusters of businesses of all sizes. Citizens and civil society, which encompass all end users like customers and their associations, are the fourth actor in the quadruple helix [19]. As a general principle, users who are willing to participate in the innovation processes should be easily accessible in a living lab setting. Table 1 summarizes the essential principles of a usual living laboratory.

Table 1. Key principles of living labs.

Principle	Description
Representativeness	Participants in the quadruple helix model include individuals from every sector of society.
High-end technology	Any LL should also have access to multiple contexts, top-tier infrastructure, and technology that can enable user involvement, as well as technology development and testing processes.
Context-dependent methodologies	Every LL setting also requires organization and procedures appropriate to its particular conditions.
Stakeholder access	Finally, an LL requires access to a variety of partners with diverse areas of knowledge who can add to the ongoing operations.
Pragmatism	Innovation should be conducted in settings that are as similar to real-world situations as possible.
Added value	Providing value for all stakeholders along the value chain.

1.3. Living Labs as Catalysts for Sustainable Development

The living lab concept is used all over the world to drive innovation that is suitable for and based on real-world issues and situations [38]. Despite the LL approach's potential

for tackling difficult problems, like socio-ecological transformation, there are questions that remain regarding its contribution to sustainable development [39].

Until now, LLs have been used to develop new insights and tools in a variety of industries such as urban planning, application design, or information management and technology. Moreover, specific living lab studies have utilized the approach to climate change mitigation and sustainable natural resource management in terms of environmental and agricultural sustainability [34,40–42].

Considering the features discussed in the previous section, living labs have the potential to be a strategic research tool for science in sustainability and bioeconomy. This can enable the generation of competitive advantages by bringing together sustainable requirements and contributions. A living lab may also serve as a platform to test newly developed product–service systems, as well as to support the research agendas by analyzing processes of current production and consumption patterns [16,43]. A particular kind of living lab that emerges frequently when sustainability issues are discussed in the literature is the urban living lab (ULL) [44].

Both concepts have many similarities and we presume that the usual features of LLs, as well as the guidelines for their design and operation, apply the majority of the time to urban living labs, as well.

Nonetheless, the main distinction between these two concepts is the specific focus on developing solutions to improve sustainability in urban settings. Urban living labs have a particular aspect that is frequently referred to as the "urban" component by researchers of urban living labs: the inclusion of this clear goal of promoting urban sustainability in a living lab's problem and goal statement [45–47]. To conclude, living labs are rooted in sustainability and span many fields of study and interests. These include the advancement of intelligent network technologies that are applicable to smart urban environments [48,49], investigations of local settings that reveal best practices in sustainable development in real time [50], and research on ways to improve social and material conditions whilst ensuring agency and resource efficiency [51]. This article is structured into five main chapters, where Section 2 outlines the methodology for the systematic review and bibliometric analysis, Section 3 presents the results, including key performance and thematic findings, and Sections 4 and 5 offer a discussion on the role of living labs in sustainable development and conclude with implications, key insights, and future research directions.

2. Materials and Methods

Generally, bibliometric analysis is termed as the application of mathematical and statistical techniques to any written means of communication [52]. Bibliometric analysis enables the examination of the literature on different research subjects in order to investigate the conceptual structure and trends of research topics [53]. Science maps are often used in conjunction with bibliometric methods to obtain a visualization of the structure of a research topic's theoretical foundation [54]. Bibliometric techniques include co-citation analysis, bibliographic coupling, co-authorship analysis, and co-word analysis [55]. To ensure a comprehensive and rigorous analysis of the link between living labs and sustainable development, this study followed a three-phase methodology that combines bibliometric analysis with a systematic literature review. In the first phase, an extensive search was conducted in the Web of Science database to identify relevant publications using specific keywords related to sustainability and living labs. Following the data collection, a careful screening phase was conducted to exclude publications that did not meet the predetermined inclusion criteria. Finally, the selected documents were analyzed using Biblioshiny software 4.1.2 to generate a detailed picture of trends, collaborations, and the global impact of research in this field. This systematic approach allowed for an objective and replicable assessment of how living labs contribute to innovation in sustainability, with a particular focus on the bioeconomy.

Phase 1. Data collection

To begin with, we selected Web of Science, one of the most prestigious scientific databases, to collect data that integrates the state-of-the-art literature on living labs, sustainable development, and bioeconomy. Next, by taking into account the review of the literature, we identified the search phrases and confirmed them with domain professionals. The abstract, title, and keywords were encompassed in the string ("sustainability" OR "sustainable development" AND "living labs"). This study looked at publications that came out before February 2024. The preliminary search yielded 1704 results.

Among those 1704 results, only 1606 were published between 2012 and 2023. Additionally, only articles that were written in English were considered for the review process; reviews and conference proceedings were excluded. After applying the second and the third search criteria, a total of 1274 documents were identified. The last criteria used was the exclusion–inclusion one: only subjects that were directly related to the keywords that we utilized were included, such as environmental science, economics, earth and planetary sciences, green sustainable science technology, and multidisciplinary sciences. Finally, a number of 818 articles complied with the mentioned criteria. In order to reduce the possibility of bias, determined by the continuous update of the WoS database, the process of retrieving the relevant papers was performed once only.

Phase 2. Data Screening

All publication titles and abstracts were carefully reviewed for their relevance to sustainable development and living lab concepts. Publications unrelated to this topic, as well as duplicates, were excluded from the sample. Next, the papers were manually evaluated for validity, which means that a quality control analysis of the publications was performed through abstract analysis, to ascertain if the selected keywords were contextually relevant.

A total of 120 articles were found to be satisfactory. Appendix A provides a short description of all the papers analyzed.

Phase 3. Bibliometric analysis

The documents were then imported into Biblioshiny software, the virtual interface of Bibliometrix. This study used bibliometric analysis to create an overall picture of the existing knowledge on LLs and sustainability.

One of the primary applications of bibliometric analysis is performance analysis—the evaluation of publication information of authors and institutions, such as annual production, citations, author ranks, countries, journals, and disciplines.

Furthermore, science mapping, another important application of bibliometric analysis, creates structural images of scientific fields using bibliographic data.

In contrast to the narrative literature review, which is susceptible to the researcher's subjective bias and is frequently less rigorous, bibliometric analysis can improve the quality and objectivity of a review by introducing a systematic and reproducible review process [56].

3. Results

3.1. Performance Analysis

This section analyzes the contribution of research constituents to a specific field (countries and journals in this case). The results show the distribution of the 132 publications indexed in Scopus related to LLs and starting from 2012. The trend that characterizes the annual scientific production is ascendant, starting with 1 article in 2012 and 28 articles in 2022. Table 2 presents the details on the number of articles published every year.

Table 2. Number of articles published.

Year	Articles
2022	28
2021	34
2020	21
2019	18
2018	15
2017	11
2016	3
2015	1
2014	0
2013	0
2012	1

In terms of country production, the territories with the most intense blue tones are responsible for the highest publication records. In Figure 1, the world's scientific production on living labs and the sustainability linkage is depicted. In this map, all author nationalities, who make up the collection, are considered.

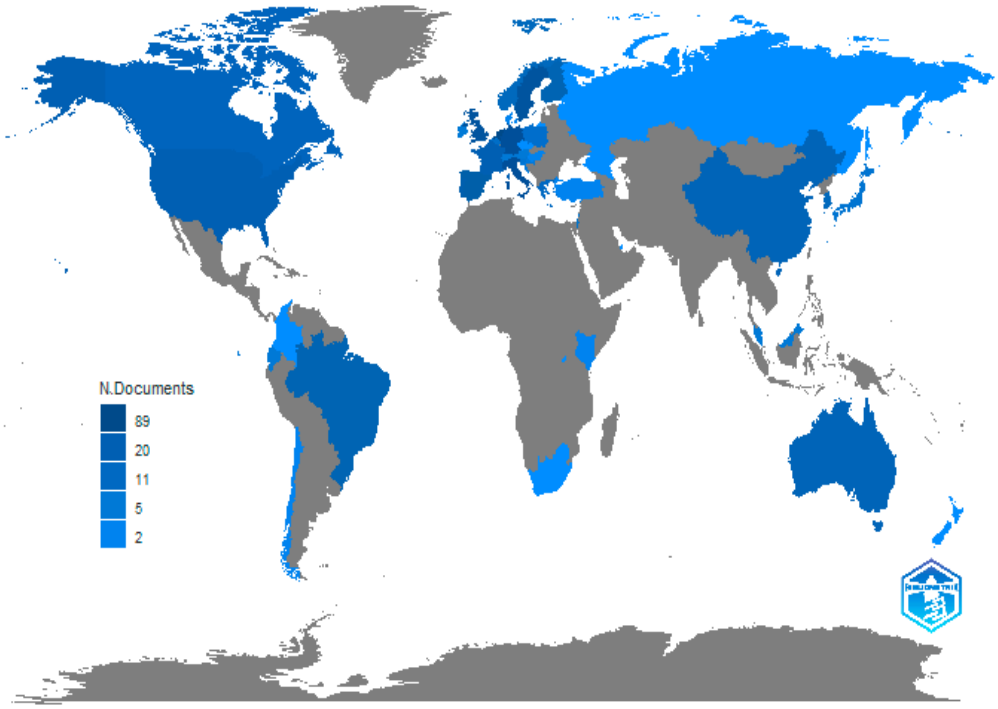

Figure 1. Scientific production by country.

The color intensity increases directly proportional to the number of publish papers. It appears that the topic is widespread around the world, with particular importance in The Netherlands (89), Germany (27), Italy (56), and the United Kingdom (41), which are considered the most productive countries in the sampled base.

With respect to the corresponding authors' countries, Figure 2 depicts two important indicators: the SCP (single country publications) indicating, for all countries, the number of papers that have at least one co-author affiliated in a different country) and the MCP (multi country collaboration) measuring the extent of the international collaboration of a country.

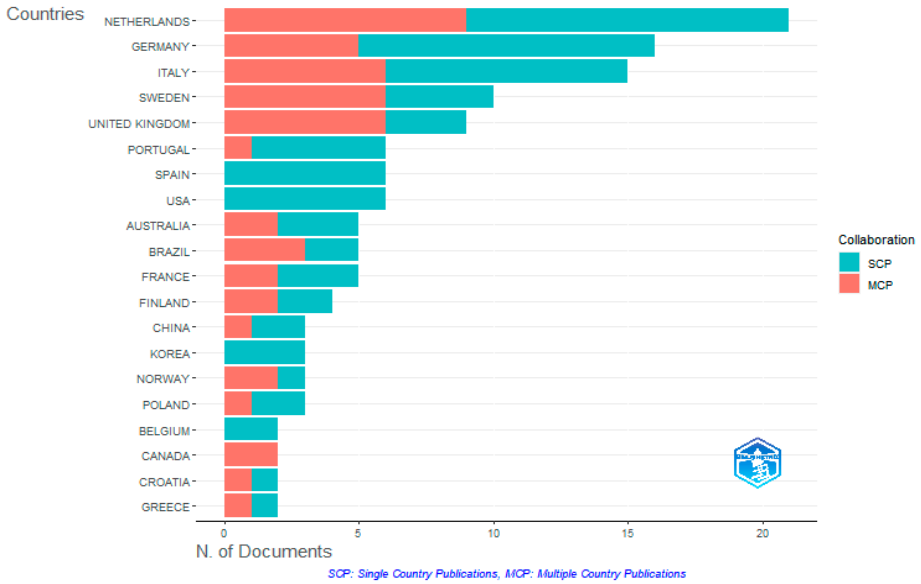

Figure 2. Corresponding authors' countries.

Table 3 bellow contains detailed statistics on single country publications and multiple country publication. A high international collaboration can be observed in the case of The Netherlands, Italy, Sweeden, and the United Kingdom, while the lowest is present in countries such as Spain or Korea.

Table 3. Statistics on country collaboration.

Country	Articles	SCP	MCP	Freq	MCP_Ratio
The Netherlands	21	12	9	0.15	0.42857143
Germany	16	11	5	0.11428571	0.3125
Italy	15	9	6	0.10714286	0.4
Sweden	10	4	6	0.07142857	0.6
United Kingdom	9	3	6	0.06428571	0.66666667
Portugal	6	5	1	0.04285714	0.16666667
Spain	6	6	0	0.04285714	0
USA	6	6	0	0.04285714	0
Australia	5	3	2	0.03571429	0.4
Brazil	5	2	3	0.03571429	0.6
France	5	3	2	0.03571429	0.4
Finland	4	2	2	0.02857143	0.5
China	3	2	1	0.02142857	0.33333333
Korea	3	3	0	0.02142857	0
Norway	3	1	2	0.02142857	0.66666667
Poland	3	2	1	0.02142857	0.33333333
Belgium	2	2	0	0.01428571	0
Canada	2	0	2	0.01428571	1
Croatia	2	1	1	0.01428571	0.5
Greece	2	1	1	0.01428571	0.5

3.2. Source Analysis

Generally, the "source" concept refers to a journal, book, conference proceedings series, etc., which published one or more documents included in our database. Figure 3 presents the first 10 most relevant sources from the study sample we examined. It can be observed that *Sustainability* is the most relevant source, representing 20 papers from the sample.

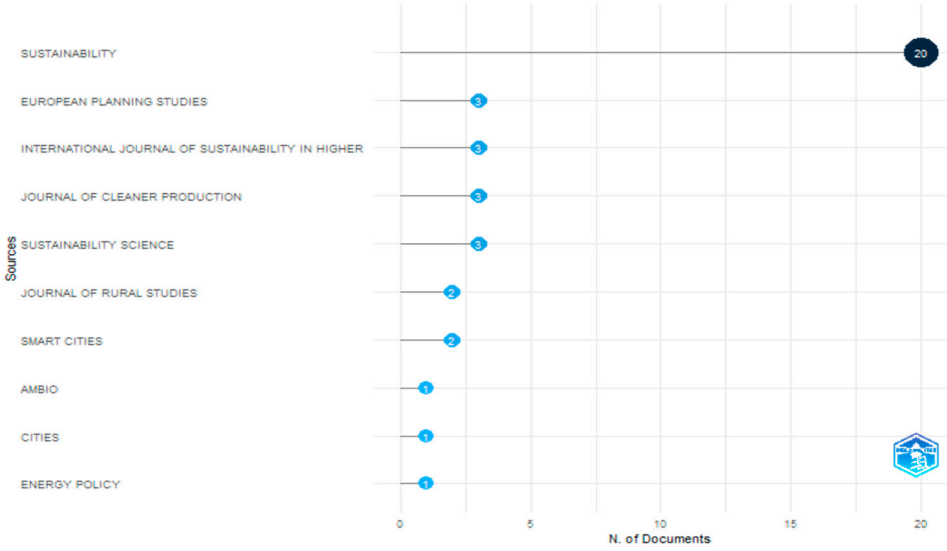

Figure 3. Most relevant sources.

Moreover, we used the Bradford law of scattering to determine the most influential journals. This law is particularly useful for quantifying the correlation between scientifical journals and the number of articles published.

It argues that a small number of major journals will produce the majority of articles on a specific topic, presenting a sizable portion (one-third) of publications, followed by a second, larger group of journals, whilst the remaining third depicts a much broader group.

The first zone is considered to be the nucleus of journals particularly devoted to the given subject. The nucleus zone (zone 1) is represented in the case by the journal "Sustainability", comprising 55% of the articles analyzed. The following two journals are the main contributors to the middle zone (zone 2). See Table 4 below.

Table 4. Most relevant journals.

Source	Rank	Freq	Cum Freq	Zone
Sustainability	1	55	55	Zone 1
International Journal of Sustainability in Higher Education	2	7	62	Zone 2
Journal of Cleaner Production	3	7	69	Zone 2
European Planning Studies	4	5	74	Zone 2
Technology Innovation Management Review	5	4	78	Zone 2
Frontiers in Sustainable Cities	6	3	81	Zone 2
Urban Planning	7	3	84	Zone 2
Current Opinion in Environmental Sustainability	8	2	86	Zone 2
Energy Research and Social Science	9	2	88	Zone 2
Environmental Innovation and Societal Transitions	10	2	90	Zone 2
Gaia-Ecological Perspectives for Science and Society	11	2	92	Zone 2

3.3. Global Citations

Global citations quantify the number of citations obtained by all the documents forming the sample. These data are provided by WoS and are included in the meta-data record. For most documents, a significant part of global citations could come from other disciplines (Figure 4).

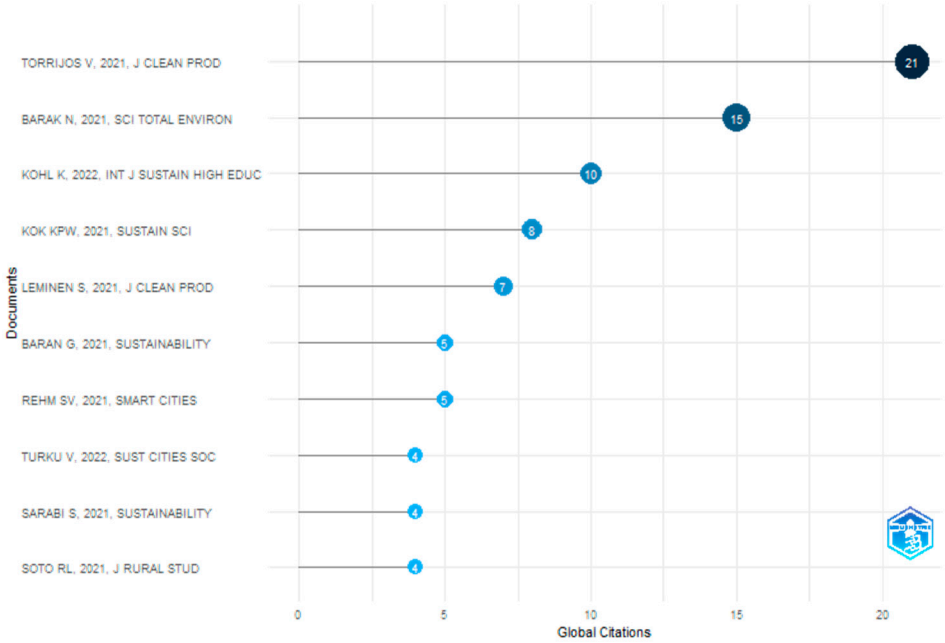

Figure 4. Most globally cited documents [24,26,56–63].

From Table 5, it can be observed that the paper elaborated on by Torrijos and collaborators [56] is the most globally cited document from the analyzed sample. The research focuses, among other issues, on integrating composting systems in bio-technological living labs for educational purposes.

Table 5. Statistics on most globally cited documents.

Paper	Total Citations	TC per Year	TC Normalized
Torrijos V, 2021, *J Clean Prod* [56]	21	7	4.586
Barak N, 2021, *Sci Total Environ* [62]	15	5	3.275
Kohl K, 2022, *Int J Sustain High Educ* [61]	10	5	8.484
Kok Kpw, 2021, *Sustain Sci* [24]	8	2.666	1.747
Leminen S, 2021, *J Clean Prod* [59]	7	2.333	1.528
Baran G, 2021, *Sustainability* [26]	5	1.666	1.091
Rehm Sv, 2021, *Smart Cities* [63]	5	1.666	1.091
Turku V, 2022, *Sust Cities Soc* [57]	4	2	3.393
Sarabi S, 2021, *Sustainability* [58]	4	1.333	0.873
Soto Rl, 2021, *J Rural Stud* [60]	4	1.333	0.873

3.4. Thematic Analysis

The Biblioshiny software program can also conduct data mining and statistical analysis on the most encountered extracted keywords from research publications. Keywords associated with a word frequency greater than or equal to 10 are then illustrated under the shape of word cloud (see Figure 5).

Overall, the figure depicts a pictorial representation of the most popular themes in this research field. The basic themes comprising the clearly established research issues in this area are shown in the bottom-right corner of the figure. The main themes are living labs, technology, urban living labs, etc. The themes increasing in importance in the last years are illustrated in the upper-right part of Figure 5. They primarily consist of three research topics: cities governance, the co-creation approach, and sustainability design. Keyword analysis (Table 6) also demonstrates that significant research has been conducted in these research areas.

Figure 5. Keyword thematic map.

Table 6. Keyword analysis.

Words	Occurrence	Clusters	Btw_Centrality	Clos_Centrality	Page Rank
Sustainability	11	Sustainability	2386.66	0.003	0.025
Cities	10	Cities	1075.69	0.002	0.026
Governance	10	Cities	1313.54	0.002	0.025
Innovation	9	Cities	1942.40	0.003	0.026
Management	8	Cities	1468.89	0.002	0.020
City	7	Cities	1133.77	0.002	0.018
Design	7	Sustainability	1332.60	0.002	0.018
Living labs	5	Living labs	1581.72	0.002	0.014
Energy	4	Cities	855.52	0.002	0.013
Framework	4	Cities	606.85	0.002	0.013

4. Discussion

4.1. Living Labs as Catalysts for Sustainable Development

As a general remark, we conclude that sustainable patterns cannot be realized exclusively via technological efficiency improvements. Many innovations in products and services with a great potential for sustainability fail because consumers reject them or because they have undesirable knock-on effects [64,65]. Unexpected user behavior and the improper usage of sustainable efficient technologies are additional critical factors [66].

Living labs tackle exactly these issues and enforce sustainable development by implementing a user-centric innovation environment, grounded in daily practice and research. This enables user and stakeholder influence in innovation processes, engaging stakeholders in real-life contexts with the aim of developing sustainable values [16,67].

With respect to the proposed objectives, particularly the analysis of the living labs contribution to sustainability, from the sample of analyzed studies we concluded that LLs can assist with the following issues on the implementation of the sustainable development agenda: (1) finding common ground with several actors who have various approaches and objectives concerning bioeconomy and sustainability; (2) assessing, evaluating, and adopting useful solutions from people who are difficult to reach out to; and (3) prevail over the lack of trust among stakeholders. Therefore, living laboratories support the resolution of complex issues that cannot be addressed by a single stakeholder, using a systematic method. Living labs can assist in both the rapid scaling up of bioeconomy innovations and

the better attainment of broad social acceptance, by involving people and end users from the very beginning. These findings are useful for practitioners and researchers, but they are the most useful for policy makers. If the first two categories are usually well informed when it comes to a subject of interest, the latter are more likely to make decisions based on political conjecture. The only way for research results to reach the political sphere would be through actions to popularize science, such as information campaigns and conferences in which political representatives are invited.

Moreover, living labs can also help assist in achieving the SDGs by addressing issues such as circular economy, sustainable urban planning, or sustainable consumption and production [68]. Climate change is also one of the targets that may be pursued through a living lab methodology by approaching both adaptation and mitigation solutions [49]. Regarding the specific contribution to the bioeconomy implementation, based on the analyzed sample of articles, we point out two important aspects.

First, bioeconomy innovation seeks to contribute to the transformation of production and consumption systems towards sustainability. This involves a gradual structural shift in business models and value chains, which can only be developed through collaboration, given the diversity of engaged stakeholders. The context of LLs is ideal for planning this transition. Hence, accordingly, the innovation processes in LLs should be focused on creating innovations that entail a low-resource consumption–production loop [69].

Second, only by involving system-relevant stakeholders in the process of innovation will this transition be successful. Consumers and policy makers are relevant in addition to science and business representatives. In practice, they should be integrated into living labs for a bioeconomy towards sustainability. In light of these arguments, creating living labs to aid in implementing the SDGs can be a useful instrument. Living labs might serve as the link between open innovation and the users of these technologies, in a sustainability setting, in addition to driving better interaction and cooperation among the many actors involved [70,71].

4.2. Further Research Directions

However, for being able to measure a specific contribution of living labs to sustainable development, a proper methodology for evaluation, a reliable database, and a relevant indicator set are required and should be taken into account during the innovation process and constantly be updated.

The research on sustainability illustrates the need for a comprehensive approach that considers the production–consumption system. The potential for achieving resource efficiency and improved life quality lies in the research areas of individual decision making, merged with organizational learning processes. Living labs provides the chance to analyze the production–consumption system interaction using a technical and socially flexible framework [72].

5. Conclusions

Living labs, with a focus on sustainability, can drive innovation that can be transposed into tangible measures for tackling economic, environmental, and social problems [73,74]. They can be effective instruments for encouraging knowledge integration for issues addressing sustainability, since social behavior is based on environmental and cultural contexts [75,76]. Also, besides the widespread use of the notion, interest in living labs as a resource for achieving the Sustainable Development Goals has grown steadily over time. The most recent research has been on how living labs may support urban entrepreneurship that encourages social and economic development, sustainability, and local business growth [49,77]. The living lab may also support rural areas. In this respect, the agro living lab, also known as the “agroecosystem living lab”, ”agroecology living lab”, or the “agri-food living lab”, emerged as a response to the environmental, economic, and social challenges.

From a policy framework standpoint, when implementing the transition to a bioeconomy, it is crucial to take into account both economic development and environmental

sustainability. Although it is frequently assumed that the advancement of biotechnology and the capitalization of bioresources will result in both economic growth and favorable environmental effects, it is crucial to assess and take into account the potential climate changes and other environmental effects of this transition. To make sure that the transition to a bioeconomy is actually sustainable, policy makers should pay close attention to the sustainability issue, but also to horizontal and vertical policy integration [41,78,79]. Since the stakeholders' interest might be competing, some elements must be taken into account in this process: there has to be a "problem owner", trust, and organizational structure [41]. The possible effects of bioeconomy policies on the environment, social equity, and economic development must be carefully assessed and carefully considered, in order to achieve this. The bioeconomy may not achieve its potential to aid in long-term sustainable development without an emphasis on sustainability [80,81].

To maximize the potential of living labs in driving sustainable development, it is essential to establish clear frameworks for collaboration across sectors and to engage stakeholders from the earliest stages of the innovation process. Policy makers should recognize the strategic value of living labs as platforms for co-creation and inclusive development, integrating them into broader sustainability agendas. Furthermore, it is recommended that future initiatives focus on developing robust evaluation methodologies to track the long-term impact of living labs, particularly in areas such as the circular economy, urban sustainability, and bioeconomy. By fostering stronger connections between research, industry, and policy, living labs can play a pivotal role in addressing complex sustainability challenges on a global scale.

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Appendix A

Table A1. Papers included in the analyzed sample.

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
1	Bernert, P., Wanner, M., Fischer, N., and Barth, M [81]	*Environment Development And Sustainability*	This study presents the framework underlying design concepts for transformational learning materials in postsecondary education.	X
2	Plassnig, S. N., Pettit, M., Reichborn-Kjennerud, K., and Säumel, I. [82]	*Frontiers In Sustainable Cities*	X	The study documents various scaling living lab practices and activities developed in collaboration with local actors in Andernach, Berlin, Havanna, Oslo, and Rotterdam.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
3	Bouwma, I., Wigboldus, S., Potters, J., Selnes, T., van Rooij, S., and Westerink, J. [83]	*Sustainability*	The study develops ways of assessing the activity of living laboratories and how they contribute to transitions towards sustainability.	X
4	Bradley, S., Mahmoud, I. H., and Arlati, A. [84]	*Sustainability*	X	This research is grounded on a comparative synthesis regarding various case studies, aimed at identifying complex integrated and collaborative governance frameworks.
5	Leal Filho, W., Ozuyar, P. G., Dinis, M. A. P., Azul, A. M., Alvarez, M. G., da Silva Neiva, S., . . . and Vasconcelos, C. R. [85]	*Sustainability Science*	This paper presents the results of a lengthy analysis into the strategies, techniques, and resources used by postsecondary institutions to develop living labs.	X
6	Oliveira, R. [86]	*Land*	X	This study describes how the food web creation procedure was carried out, as well as its main accomplishments in terms of a dedicated action plan, and provides the first baseline for the pursuit of a food strategy for city–region food planning.
7	Alexandrakis, J., Hein, J., and Kratzer, J. [87]	*Sustainability*	This study found that living lab programs had a significant impact on SMEs' ability to innovate sustainably and transfer knowledge.	X
8	Alamanos, A., Koundouri, P., Papadaki, L., Pliakou, T., and Toli, E [88]	*Water*	The results have important implications for comprehensive water resource management, including for international sustainability agendas.	X
9	Willems, J. J., Kuitert, L., and Van Buuren, A. [41]	*Environmental Policy And Governance*	The framework presented in this article is used to analyze how the urban living lab might support the integration of policies, and it is then applied to three case studies from Antwerp, Dordrecht, and Gothenburg.	X
10	Florez Ayala, D. H., Alberton, A., and Ersoy, A. [89]	*Sustainability*	X	From a circular economy overview, this paper examines how ULLs might develop into paths of sustainability and transition towards cutting-edge city systems.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
11	Amorim, E. E. R., Menezes, M., and Fernandes, K. V. G. [90]	*Sustainability*	The paper examines study cases with ULL projects, governmental innovation policies, and international knowledge transfer processes.	X
12	Xu, Y., Li, P., Pan, J., Zhang, Y., Dang, X., Cao, X., . . . and Yang, Z [91]	*Sustainability*	X	The study's conclusions suggest that in order to lessen human-ecological conflicts, topographic variables and human disturbance should be fully taken into account in future land-use and spatial development decisions.
13	Ness, B. and Wahl, D. [92]	*Ambio*	X	From the perspective of sustainability researchers, this paper offers reflections on transdisciplinary processes of knowledge co-production and experimentation.
14	Almeida-Silva, M., Monteiro, A., Carvalho, A. R., Teixeira, A. M., Moreira, J., Tavares, D., . . . and Manteigas, V. [93]	*International Journal Of Environmental Research And Public Health*	X	The SAVING project, whose goal was to create an active and sustainable aging program to support the shift to sustainable aging in senior housing structures, is examined in this study.
16	Salvatore, S., Magatti, G., Acciarri, M., Rossetti, M., da Costa, L. P., and Ribeiro, I. [94]	*Sustainability*	X	This research tackles the implementation of SWM projects in two European universities, Milan-Bicocca University and Instituto Superior Técnico from Portugal.
17	Eaton, E., Hunt, A., Di Leo, A., Black, D., Frost, G., and Hargreaves, S. [95]	*Sustainability*	X	This paper quantifies and evaluates the underlying impacts of household food waste before delving into the potential costs and benefits of changes in food waste behavior.
18	Moreira, F. D. A., Dalla Fontana, M., Sepe, P. M., Lopes, M. V., Moura, L. D. V., Medeiros, L. S., . . . and Di Giulio, G. M. [96]	*Sustainability Science*	X	The analyzed process is aimed at significantly improving usability by engaging users from the beginning, linking the nexus approach to prior knowledge and frameworks.
19	Koller, M., Eckert, K., Ferber, U., Gräbe, G., Verbücheln, M., and Wendler, K. [97]	*Sustainability*	This research provides the basis for a sustainable transformation of urban districts and proposes further research directions.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
20	Martek, I., Hosseini, M. R., Durdyev, S., Arashpour, M., and Edwards, D. J. [98]	*International Journal Of Sustainability In Higher Education*	The evolution of living labs is analyzed, with a focus on the university setting.	X
21	Bridi, M. E., Soliman-Junior, J., Granja, A. D., Tzortzopoulos, P., Gomes, V., and Kowaltowski, D. C. C. K. [99]	*Sustainability*	The paper discusses an integrative synthesis of the literature regarding housing retrofit developed in the context of living labs.	X
23	Turku, V., Jokinen, A., and Jokinen, P. [57]	*Sustainable Cities And Society*	X	This study investigates how multi-actor cooperation at the micro-scale ignites sustainability pathways in Tampere, Finland.
24	Galardi, M., Moruzzo, R., Riccioli, F., Granai, G., and Di Iacovo, F. [100]	*Sustainability*	X	This study presents how 16 small rural businesses located in Turin worked together to create innovative business models.
25	Brons, A., van Der Gaast, K., Awuh, H., Jansma, J. E., Segreto, C., and Wertheim-Heck, S. [101]	*Cities*	The paper investigates ULLs as an instrument for inclusive civic participation.	X
26	Eneqvist, E., Algehed, J., Jensen, C., and Karvonen, A. [102]	*European Planning Studies*	The emphasis on legitimacy reveals the fact that experimental governance has fragmented practices and it is used only as a way of obtaining short-term results, without long-term coherence. The governance has a lack of organizational ability. Both aspects could negatively affect its legitimacy, reducing trust and acceptance of the involved parties.	X
27	Burbridge, M. and Morrison, G. M. [103]	*Sustainability*	This study builds on the current top-down/bottom-up methodology for the construction of intermediaries of innovation and offers insights into partnership building at the university–industry–government nexus.	X
28	Maksymiuk, G., Pallares-Barbera, M., Arvanitidis, P., and Gawryszewska, B. J. [104]	*Sustainability*	X	In order to mobilize the community's effort towards social and economic development with less engagement from the state and market players, this study aims to explain how the UBH and its fringe function, as a facilitator of common identity.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
29	Sarabi, S., Han, Q., L. Romme, A. G., de Vries, B., Valkenburg, R., den Ouden, E., . . . and Wendling, L. [58]	*Sustainability*	The results of this study can assist cities in creating plans for overcoming the key obstacles in the adoption of ULL in the context of nature-based solutions.	X
30	Leminen, S., Rajahonka, M., Westerlund, M., and Hossain, M. [59]	*Journal Of Cleaner Production*	X	This study investigates 49 cases that focus on open innovation for sustainability, including Fab labs, participatory budgeting, and living labs.
31	Soto, R. L., de Vente, J., and Padilla, M. C. [60]	*Journal Of Rural Studies*	X	The study employs participatory action research with farmers and researchers to increase agricultural innovation and sustainability of the agroecosystem restoration.
32	Lasarte, N., Elguezabal, P., Sagarna, M., Leon, I., and Otaduy, J. P. [105]	*Sustainability*	The paper highlights how to identify, evaluate, and overcome significant renovation barriers using BIM and the possibilities of digitization.	X
33	Toffolini, Q., Capitaine, M., Hannachi, M., and Cerf, M. [106]	*Journal Of Rural Studies*	Based on relevant competencies and their distribution across actors, this study's findings make recommendations for establishing an agricultural LL inside an already-existing innovation system.	X
34	Kohl, K., Hopkins, C., Barth, M., Michelsen, G., Dlouhá, J., Razak, D. A., . . . and Toman, I. [61]	*International Journal Of Sustainability In Higher Education*	This paper focuses on UN developments and the lengthy history of university engagement in sustainability.	X
35	Rollin, P., Bamberg, S., Ketterl, C., and Weiland, S. [107]	*Journal Of Environmental Psychology*	This study focuses on assessing the outcomes of a ULL, which seeks to encourage a local mobility system sustainable transition by encouraging civic participation within a network involving multi-actor collaboration.	X
36	Tyl, B. and Allais, R. [108]	*Journal Of Cleaner Production*	This article questions how the living lab philosophy might incorporate the creation of networks for repair and reuse.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
37	Kok, K. P., Gjefsen, M. D., Regeer, B. J., and Broerse, J. E. [24]	*Sustainability Science*	The study argues that facilitators can better understand and manage the transdisciplinary challenges needed for change, if they consider "inclusion in practice" as a political action. This thing involves the clarification of the normative objectives specific to each context where inclusion is applied.	X
39	Nguyen, H. T., and Marques, P. [109]	*European Planning Studies*	X	The study findings challenge the usual perspective of the quadruple helix methodology and offers suggestions for managing future collaborations and evidence-based policy.
40	Homer, S. T. and Khor, K. S. [110]	*International Journal Of Sustainability In Higher Education*	This article attempts to present a multidimensional sustainability practice model that higher education institutions found useful and feasible for implementation.	X
41	Särkilahti, M., Åkerman, M., Jokinen, A., and Rintala, J. [111]	*European Planning Studies*	This research analyzes the links between a sanitation experiment and future urban development directions in the city of Tampere, Finland	X
42	van Waes, A., Nikolaeva, A., and Raven, R. [112]	*Technological Forecasting And Social Change*	The paper combines empirical data from a qualitative case study of four cycling innovation living labs, with theoretical insights from the literature on Strategic Niche Management, and insights from cross-disciplinary research on LLs.	X
43	Torrijos, V., Dopico, D. C., and Soto, M [56]	*Journal Of Cleaner Production*	The primary outcome of this project was the reduction in waste that did not have to be collected, transported, disposed of, or incinerated.	X
44	Kretschmer, S. and Dehm, S [113]	*Sustainability*	X	This study presents the case of a German University, the students, and other relevant stakeholders involved in a living lab.
45	Shafqat, O., Malakhtka, E., Chrobot, N., and Lundqvist, P. [114]	*Sustainability*	This paper presents a framework for end-use energy services that was created jointly with several stakeholders for a case study in a an LL setting.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
46	Barak, N., Sommer, U., and Mualam, N. [62]	*Science Of The Total Environment*	The papers discusses population density as a key driver for the dissemination of COVID-19 and the direct environmental consequences.	X
47	Baran, G. and Berkowicz, A [26]	*Sustainability*	The paper's main idea is to combine new search methods such as LLs with new technological opportunities for entrepreneurship.	X
48	Shvetsova, O. A. and Lee, S. K. [115]	*Sustainability*	X	This study was conducted to find out how South Korea's innovation landscape might be affected by living labs.
49	Ciaccia, C., Testani, E., Fiore, A., Iocola, I., Di Pierro, M., Mele, G., . . . and Diacono, M. [116]	*Sustainability*	A step-by-step process is analyzed through the definition of common objectives, highlighting the interest of local actors in sharing insights for the territory, in the process of completing the transition to sustainable food systems.	X
50	Koo, K. M., Han, K. H., Jun, K. S., Lee, G., and Yum, K. T. [117]	*Sustainability*	X	In this study, the development of SWG key constituent technologies—including intelligent water source management and distribution systems and the building of smart water distribution networks—is introduced.
51	Aquilué, I., Caicedo, A., Moreno, J., Estrada, M., and Pagès, L. [118]	*Sustainability*	This paper presents a framework to support the assessment of urban design projects through Urban Living Labs (ULLs).	X
52	Choi, C., Yang, S., Choi, S. H., and Jang, S. [119]	*Sustainability*	In order to provide the participants in LL with a theoretical foundation for problem solving, this study introduces the modelling and simulation (M&S) method.	X
53	Tolentino-Zondervan, F., Bogers, E., and van de Sande, L. [120]	*Sustainability*	This study examines the objectives of the parties involved in the Heijendaal living lab, a city logistics initiative that uses two hubs to bundle deliveries of commodities to The Netherlands' Heijendaal campus.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
54	Catulli, M., Sopjani, L., Reed, N., Tzilivakis, J., and Green, A. [121]	*Resources Conservation And Recycling*	X	In this work, a socio-technical experiment related to a sustainable innovation project that was conducted in a protected niche or a living lab is described, along with an evaluation of the experiment's capacity to drive learning and strategic vision.
55	Engez, A., Leminen, S., and Aarikka-Stenroos, L. [122]	*Sustainability*	The goal of this research is to analyze a ULL through an ecosystem approach in order to reveal the actor activities and flows between them, that enable sustainable development in urban settings.	X
56	Sahakian, M., Rau, H., Grealis, E., Godin, L., Wallenborn, G., Backhaus, J., . . . and Fahy, F. [123]	*Energy Research & Social Science*	X	This papers demonstrates the usefulness of practice-centered designs for project implementation.
57	Yusoff, S., Abu Bakar, A., Rahmat Fakri, M. F., and Ahmad, A. Z. [124]	*Environment Development And Sustainability*	X	The article provides data on the decrease in greenhouse gas emissions from on-campus activities and a living laboratory project carried out at the main campus of Malaysia University.
58	Malakhatka, E., Sopjani, L., and Lundqvist, P. [125]	*Sustainability*	X	This study aims to synthesize commonly held theories about co-creation from two major perspectives: co-creation as an innovation process and co-creation as a design process.
59	McPhee, C., Bancerz, M., Mambrini-Doudet, M., Chrétien, F., Huyghe, C., and Gracia-Garza, J. [126]	*Sustainability*	In order to improve the sustainability and resilience of agri-food systems, this study proposes a set of defining parameters for a newly emergent form of living lab.	
60	Save, P., Terim Cavka, B., and Froese, T. [127]	*Sustainability*	X	The purpose of this study was to examine the UBC CLL program, identify, and formalize its operations, retrieve significant transferable characteristics, and suggest reproducible processes that other academic institutions and local governments can use to scale up their sustainable practices in a similar manner.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
61	Compagnucci, L., Spigarelli, F., Coelho, J., and Duarte, C. [69]	*Journal Of Cleaner Production*	This study investigates the contribution of LLs in promoting innovation and sustainability.	X
62	Blezer, S. and Abujidi, N. [128]	*Technology Innovation Management Review*	This study supports and adds to existing theoretical positions on how to deal with the difficulty of maintaining a common ideology and examine the concepts of agency and power.	X
63	Della Valle, N., Gantioler, S., and Tomasi, S. [129]	*Frontiers In Sustainable Cities*	This work investigates how behavioral science results might influence ULL design to effectively encourage active participation in the urban energy transition.	X
64	Greve, K., Vita, R. D., Leminen, S., and Westerlund, M. [27]	*Sustainability*	The study discusses the conceptual basis of living labs research, examines recurring themes influencing the debate, and highlights their influence on other domains.	X
65	Lupp, G., Zingraff-Hamed, A., Huang, J. J., Oen, A., and Pauleit, S. [130]	*Sustainability*	This paper investigates how a LL methodology can be utilized for the design and application of nature-based solutions.	X
66	Mahmoud, I. H., Morello, E., Ludlow, D., and Salvia, G. [131]	*Frontiers In Sustainable Cities*	The authors of this study looked at three active European projects' co-creation paths and various shared governance approaches.	X
67	Matschoss, K., Fahy, F., Rau, H., Backhaus, J., Goggins, G., Grealis, E., ... and Vasseur, V. [132]	*Sustainability-Science Practice And Policy*	X	A change initiative is examined, designed to engage households in testing modalities to transform two common practices—heating and doing laundry.
68	Sharp, D. and Raven, R. [133]	*Urban Planning*	This article notices a rising trend toward precinct-scale experimentation and responds to a call for more research into relevant processes in urban experimentation.	X
69	Veeckman, C. and Temmerman, L. [134]	*Sustainability*	X	This article analyzes best practices in incorporating citizen science in ULLs based on the challenges in FloodCitiSense.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
70	Cerreta, M., Elefante, A., and La Rocca, L. [135]	*Sustainability*	X	The process's preliminary findings demonstrate how a co-exploration phase defined the living lab's cultural traits and how the potential reuse scenarios are oriented by the co-evaluation of individual activities.
71	Gamache, G., Anglade, J., Feche, R., Barataud, F., Mignolet, C., and Coquil, X. [6]	*Environmental Innovation And Societal Transitions*	In this work, the limits of LLs for analyzing and supporting the local transition of agri-food systems are explored.	X
72	Marcucci, E., Gatta, V., Le Pira, M., Hansson, L., and Bråthen, S. [136]	*Sustainability*	This paper explains how to properly conceptualize the Digital Twin (DT) idea in relation to developing urban planning and policy.	X
73	Marone, L., Onofrio, R., and Masella, C. [137]	*Sustainability*	The goal of this research is to determine the needs of the stakeholders in developing an LL in healthcare and to provide activities that will encourage innovation.	X
74	Mazutti, J., Londero Brandli, L., Lange Salvia, A., Fritzen Gomes, B. M., Damke, L. I., Tibola da Rocha, V., and Santos Rabello, R. D. [138]	*International Journal Of Sustainability In Higher Education*	X	This case study illustrated how air quality monitoring in an intelligent setting could emphasize and convey the effect of urban movement on air quality.
75	Korzer, T., Hübscher, M., Schade, K., and Ringel, J. [28]	*Proceedings Of The Institution Of Civil Engineers—Urban Design And Planning*	X	LLs are analyzed as a scientific approach, addressing the gap between theory and practice and providing additional evidence of how digitization occurs outside of first-tier cities.
76	Baedeker, C., Piwowar, J., Themann, P., Grinewitschus, V., Krisemendt, B., Lepper, K., . . . and von Geibler, J. [139]	*Sustainability*	X	This study's findings are presented, and a user-centered building management system (UC-BMS) is suggested as a prototype for office buildings.
77	Cuomo, F., Ravazzi, S., Savini, F., and Bertolini, L. [140]	*Sustainability*	X	This article contrasts the paths followed by two transformative urban lab experiments, one in The Netherlands and the other in Italy.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
78	Polderman, A., Haller, A., Viesi, D., Tabin, X., Sala, S., Giorgi, A., . . . and Bidault, Y. [141]	*Sustainability*	This paper informs about the novel approach developed within the project named "Smart Altitude", co-funded by the European Regional Development Fund.	X
79	Baran, G. and Berkowicz, A. [29]	*Sustainability*	The study's goal was to create an example of a sustainability living lab as a methodological approach to studying the cultural enablers of sustainable development based on the living lab concept and its capabilities.	X
80	Jiang, C., Xiao, Y., and Cao, H. [142]	*Sustainability*	X	In this article, two design-driven techniques are suggested: encouraging locals to become innovation activists and encouraging collaborative entrepreneurial clusters based on reorganizing local resources.
81	Delina, L. L. [143]	*Journal Of Environmental Studies And Sciences*	X	This research analyzes the co-development of a community-based energy transition in a rural setting as an LL.
82	Moore, T., Horne, R., and Doyon, A. [144]	*Urban Policy And Research*	X	This paper investigates the impact of a government-led demonstration project in Australia.
83	Thees, H., Pechlaner, H., Olbrich, N., and Schuhbert, A. [145]	*Sustainability*	The research gap in the integration of LL mechanisms and destination governance is addressed in this study.	X
84	Ersoy, A. and van Bueren, E. [10]	*Urban Planning*	X	Three innovation projects from a ULL in Amsterdam are compared in this article's comparative case study.
85	Rodrigues, M. and Franco, M. [146]	*Sustainable Development*	X	This study aims to review indicators measuring sustainable development in cities.
86	Purcell, W. M., Henriksen, H., and Spengler, J. D. [11]	*International Journal Of Sustainability In Higher Education*	X	This study analyzes different strategies to promote supstainability and reach Sustainable Development Objectives, using an approach based on many case studies.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
87	Bulkeley, H., Marvin, S., Palgan, Y. V., McCormick, K., Breitfuss-Loidl, M., Mai, L., . . . and Frantzeskaki, N. [147]	*European Urban And Regional Studies*	This paper focuses on the urban living laboratory and creates a framework for a comparative examination of 40 European ULLs.	X
88	Hirata, S. [148]	*Risus Journal On Innovation And Sustainability*	X	This study illustrates a model for co-designing service innovation in the context of enterprises and postsecondary institutions.
89	Pucihar, A., Zajc, I., Sernec, R., and Lenart, G. [149]	*Sustainability*	The article presents the AV living lab and offers details about a large-scale pilot testing of AV and further mobility solutions.	X
90	Van Geenhuizen, M. [150]	*Sustainability*	The purpose of this study is to produce a list of essential learnings on urban living labs using the Responsible Research and Innovation strategy.	X
91	Levenda, A. M. [151]	*Local Environment*	This paper investigates a ULL centered on smart grid research and demonstration in an Austin, Texas residential neighborhood.	X
92	Chronéer, D., Ståhlbröst, A., and Habibipour, A. [152]	*Technology Innovation Management Review*	The following seven important components of an urban living lab are identified and discussed in this article: governance and management structure; financing examples; urban environment; NBS solutions; partners and users approach; ICT and infrastructure.	X
93	Osorio, F., Dupont, L., Camargo, M., Palominos, P., Peña, J. I., and Alfaro, M. [153]	*Creativity And Innovation Management*	A new framework is developed as the foundation for a guidance instrument for researchers and practitioners looking to assess or adapt an existing project.	X
94	García-Llorente, M., Pérez-Ramírez, I., Sabán de la Portilla, C., Haro, C., and Benito, A. [12]	*Sustainability*	X	This study discusses a project contribution to new and integrated rural development methods, as well as the potential to encourage cooperative solutions that improve farming activities while simultaneously delivering ecosystem benefits.

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
95	Von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., and Coenen, L. [154]	*European Planning Studies*	This study contributes to an improved comprehension regarding the diffusion mechanisms and strategies used by ULL to deliver impacts.	X
96	Ondiek, M. A., and Moturi, C. [155]	*Innovation & Management Review*	X	This paper assesses the sustainability of several LLs in Kenya.
97	Plaisier, C., Sibomana, M., Van der Waal, J., Clercx, L., Van Wagenberg, C. P., and Dijkxhoorn, Y. [156]	*Sustainability*	X	The framework presented is grounded on participatory development and includes LLs and World Cafes.
98	Roggema, R. and Yan, W. [157]	*Urban Planning*	Based on urban design practice, this article depicts urban agriculture as an enabling factor of nexus thinking.	X
99	Bracco, S., Delfino, F., Laiolo, P., and Morini, A. [158]	*Sustainability*	X	The article focuses on the actions performed by the University of Genoa to implement the Living Lab Smart City.
100	Van Geenhuizen, M. [159]	*Environment And Planning C-Politics And Space*	This article presents a new framework for living labs evaluation.	X
101	Puerari, E., De Koning, J. I., Von Wirth, T., Karré, P. M., Mulder, I. J., and Loorbach, D. A [160]	*Sustainability*	X	This paper concentrates on co-creation dynamics in ULLs associated with knowledge generation, and contribution to urban sustainability transitions.
102	Rodrigues, M. and Franco, M. [161]	*Journal Of Cleaner Production*	X	The main objective of this study is to analyze the LLs contribution toward the promotion of urban entrepreneurship in urban settings and their sustainability.
103	Dias, A. and Salmelin, B. [13]	*Modeling Innovation Sustainability And Technologies: Economic And Policy Perspectives*	The article elaborates on the background thinking and path for the conceptual innovation model. Open Innovation 2.0. Its basis lies on theories of virtual enterprises, as well as the MIT living lab concept.	X
104	Evans, J., Bulkeley, H., Voytenko, Y., McCormick, K., and Curtis, S. [14]	*Routledge Handbook On Spaces Of Urban Politics*	This paper examines the production and circulation of urban experiments through urban living laboratories.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
105	Menny, M., Palgan, Y. V., and McCormick, K. [162]	*Gaia-Ecological Perspectives For Science And Society*	This article examines how ULLs engage in a participatory methodology that facilitates co-creation with users.	X
106	Scholl, C., de Kraker, J., Hoeflehner, T., Wlasak, P., Drage, T., and Eriksen, M. A. [15]	*Gaia-Ecological Perspectives For Science And Society*	A four-steps approach of LLs is analyzed: co-designing experiments, establishing clear learning objectives, reviewing what has been learned, and disseminating and integrating lessons learned	X
107	van Geenhuizen, M. and Guldemond, N. [163]	*Cities And Sustainable Technology Transitions: Leadership, Innovation And Adoption*	This research identifies critical factors in the performance of LLs based on complex case studies in The Netherlands, Denmark, and Canada.	X
108	Sharp, D. and Salter, R. [164]	*Sustainability*	X	This report assesses Livewell Yarra, a ULL in Australia that brought along academic scholars and community stakeholders to take part in low-carbon living experiments.
109	Jurietti, E., Mandelli, A., and Fudurić, M. [165]	*Corporate Social Responsibility And Environmental Management*	This study uses a case study about the Unilever Sustainable LL to test the virtual CSR dialogue methodology.	X
110	Rizzo, S., Cappellaro, F., Accorsi, M., Orsini, F., and Bonoli, A. [166]	*Environmental Engineering And Management Journal*	Various experimental green technologies for urban resilience were co-designed by students, researchers, and lecturers as an outcome of a living lab.	X
111	Cerreta, M. and Panaro, S [167]	*Sustainability*	X	This research proposes a multi-stakeholder spatial decision analysis that integrates multi-stakeholder decision analysis with GIS processing using a collaborative evaluative framework to enable the development of resilient landscape solutions.
112	Steen, K. and Van Bueren, E. [16]	*Technology Innovation Management Review*	This paper adds to theoretical background by creating an operationalized definition of ULLs, which was used to evaluate 90 sustainable urban innovation projects in Amsterdam.	X

Table A1. *Cont.*

No.	Authors	Journal	Main Findings	
			Theoretical Studies	**Case Studies/Best Practices**
113	Canzler, W., Engels, F., Rogge, J. C., Simon, D., and Wentland, A. [168]	*Energy Research & Social Science*	This case demonstrates the evolution of interdependent interests and collaborations between different industries as well as between businesses and academic organizations.	
114	Caprotti, F. and Cowley, R. [169]	*Urban Geography*	This paper discusses urban experiments and the associated concepts regarding the LL typology.	X
115	Hansen, S. S. [170]	*Handbook Of Theory And Practice Of Sustainable Development In Higher Education, Vol 3*	This work examines the performance of one living laboratory case study at Macalester College in Minnesota.	X
116	Bulkeley, H., Coenen, L., Frantzeskaki, N., Hartmann, C., Kronsell, A., Mai, L., . . . and Palgan, Y. [50]	*Current Opinion In Environmental Sustainability*	This paper suggests that LLs may acquire useful knowledge from transition studies and the literature on urban governance.	X
117	Voytenko, Y., McCormick, K., Evans, J., and Schliwa, G. [72]	*Journal Of Cleaner Production*	The purpose of this article is to develop current understandings by examining how the ULL concept is being operationalized in contemporary urban governance for sustainability and low-carbon cities.	X
118	Schliwa, G. and McCormick, K. [171]	*Experimental City*	This research examines how the living lab approach was adapted from the private to the public sectors, emerging as a research infrastructure and governance instrument for urban transitions.	X
119	Evans, J., Jones, R., Karvonen, A., Millard, L., and Wendler, J. [18]	*Current Opinion In Environmental Sustainability*	The article examines how living laboratories could offer a comprehensive and iterative framework for the co-production of knowledge.	X
120	Liedtke, C., Jolanta Welfens, M., Rohn, H., and Nordmann, J. [65]	*International Journal Of Sustainability In Higher Education*	The purpose of this paper is to analyze the results from the LIVING LAB design study, an initiative related to the Framework Programme created by the European Union.	X

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