



Systematic Literature Review: Inter-Relatedness of Innovation, Resilience and Sustainability - Major, Emerging Themes and Future Research Directions

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Abstract

Rationale Research has been using resilience, sustainability and innovation interchangeably, but there is a lack of research that would provide an insight into how they are related to each other. This systematic literature review thus investigates research on sustainability, innovation and resilience, how they are related to each other, and also identifies major, emerging themes and future research directions on these topics.

Procedure We used Bibliometrix software to visually describe articles with the highest number of citations, to present the thematic evolution of the field and present a historical map. The triangulation and thematic groups were identified and compared by two independent researchers.

Results Resilience is involved in processes, sustainability is concerned with the outcomes, while innovation represents a pathway to achieving both resilience and sustainability. Resilience can ensure the provision of the system functions in the face of shocks and stresses and sustainability can ensure the adequate performance of the system in general. Three major themes were identified, ‘socio-ecological systems’, ‘transformational innovation’ and ‘political governance’, as well as three emerging themes, ‘food security and agriculture’, ‘businesses and finance’ and ‘interconnected systems’. There is a need for longitudinal, multi-scale and interdisciplinary research that would explore various aspects of integrating these concepts.

Conclusion There is a great overlap between the concepts of resilience, sustainability and innovation. Future research could study these concepts in relation to each other.

Keywords Sustainability · Innovation · Resilience · Systems · Future

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Introduction

Countries and societies face issues as a result of climate change, such as excessive or insufficient precipitation, rising sea levels, extreme temperature changes, storms, droughts, floods and other climate hazards that are only going to increase in the future [72, 100], thus making it ever more important to prepare for [40]. Resilience enables adaptivity to an unknown future [75], and sustainability, as defined by the United Nations Brundtland Commission [92], is concerned about meeting the needs of the present without compromising the ability of the future generations to meet their own needs. Resilience is important in overcoming the inevitable problems that arise when faced with unpredicted shocks and stressors [75]. The two concepts can be regarded as vital if humanity is to successfully face the major changes that may occur in the near future [70]. However, the distinguishment among both is still debated and differently approached by the authors [70, 76]. On the other hand, the underlying concept that could help societies to achieve both resilience and sustainability can be found in innovation. Leach et al. [40] define innovation as new ways of doing things, both in science and technology, but also associated with institutions and social practices.

Innovative approaches are needed to deal with large-scale changes [22, 97], steer away from potential Earth system thresholds [77] and to build the resilience of social-ecological systems, so they are better able to deal with changes as opportunities [97, 98]. Innovation has so far often occurred without reference to the issue of ecological integrity, even though it is essential to consider this before implementation as many innovations can have considerable ecological and societal risks (Olsson et al. [70]). However, we must also consider technological advances that have the potential to combat climate change. What was once considered as science fiction is now slowly moving into the centre of international climate change discussions, research and politics [21]. Such innovations can be closely linked with the concepts of sustainability and resilience. In fact, the overlap between resilience and sustainability is considerable, as can also be seen by Lebel et al. [41], suggesting that the critical factors for sustainability are resilience, the capacity to cope and adapt, and the conservation of sources of innovation and renewal. Therefore, one could argue that we are talking about very similar concepts, which are inter-related. In this study, we systematically review the academic literature and examine the empirical examples of how sustainability, resilience and innovation have been applied simultaneously to understand the interrelations among the concepts and their application in diverse settings. While much research has been performed to study sustainability, resilience and innovation, there is a significant lack of research that would assess the relations among them in a systematic way. Our study thus aims to overcome this gap and to identify how the concepts are interlinked and to provide a framework to study these concepts in practice.

- RQ1: How are the concepts of sustainability, resilience and innovation related?

Many authors suggest that an interdisciplinary approach is needed to study sustainability, resilience and innovation [13, 14], with a multitude of stakeholders involved in the process [12]. For future research studies that aim to integrate these three concepts, it is therefore necessary to understand how they have been studied empirically and where gaps in the literature may occur. The implementation of sustainability, resilience and

innovation requires a multi-scale and multi-stakeholder approach [40]. We are therefore interested to understand what research methods were used and at what scales were they studied at. In this context, Lebel et al. ([41], pp.1) furthermore argue that we should ask not only *The resilience of what, to what?* but also *For whom?* Continued involvement from a variety of stakeholders is integral to effective decision-making and institutionalisation of programmes in the long run [6]. In further research or in applying these concepts in practice, researchers may also need to better understand the variety of stakeholders involved in the process, the research methods used to study such concepts empirically and at what scales are they are referred to.

- RQ2: What research methods are used by the researchers to study resilience, innovation and sustainability?
- RQ3: What scales authors referred to in the study of innovation, resilience and sustainability?
- RQ4: Who are the stakeholders involved in the study of resilience, sustainability and innovation?

Our paper provides a review of the most influential publications, as well as newly published articles, to identify the major trends within this research and what the most promising directions are for new research studies. We use a systematic literature review, which has a high level of evidence, as represented by the evidence-based pyramid [85]. A bibliographic mapping was used for a visual interpretation of the connections between groups. Most articles reviewed were published in journals such as *Ecosystems*, *Ecology*, *International Journal of Agricultural Sustainability*, *Journal of Environmental Planning and Management*, *Local Environment*, *Ecology and Systems*, *AMBIO*, *PNAS*, *Climate Risk Management* and *Global Environmental*. Two independent researchers triangulated the themes to identify major and emerging themes among the highly cited and newly published articles. The related research has adequately addressed all three concepts, and our review of the literature found 269 articles that refer to resilience, sustainability and innovation simultaneously. However, no research was found that would address all three concepts in a systematic way. Our review of the literature identifies major and emerging themes of research, which can provide guidelines for future research directions in the field of sustainability, resilience and innovation.

- RQ5: What are the major and emerging themes within the field of sustainability, resilience and innovation?
- RQ6: What are the future research directions on innovation, resilience and sustainability?

Our systematic review of literature maps out the data from Thomson Reuters' Web of Science, where we searched for all the articles referring to resilience, sustainability and innovation simultaneously. The rest of this article proceeds as follows: In '[Research Methodology](#)', we discuss the methodology used in developing the article; '[Results](#)' presents the results, using descriptive statistics to map out the authors with the highest number of citations and a historical mapping approach to identify and discuss the three major themes referring to 'political governance', 'socio-ecological systems' and 'transformational innovation'. In the second part of '[Results](#)', we identify the emerging themes of 'food security and agriculture', 'business and finance' and 'interconnected systems'. In '[Discussion](#)', we present a discussion of the findings of our research, give an overview of the inter-relatedness among the fields of sustainability, resilience and innovation and provide a framework to study these concepts

in practice. We then provide a critical overview of the major and emerging themes. Based on our findings, we provide new research directions in ‘[Future Research Directions](#)’. ‘[Conclusion](#)’ then concludes the article and sets an agenda for further research on sustainability, resilience and innovation.

Research Methodology

Method

Our study used a method of systematic literature review. Systematic literature reviews differ from traditional narrative reviews since they enable researchers to adopt replicable, scientific and transparent processes of analysing research. By using technology to carry out a systematic literature review, we were able to overcome some of the normal bias in literature searches [49]. The methodology includes a set of applied procedures and techniques, which provide an insight into information about the specific topic of research, which supports the overall scientific credibility of the study. To visually describe the articles included in the review, we have used the Bibiloshiny package [11] within the Bibliometrix command in R, which allowed us to import from the bibliographic database in the Web of Science. The bibliographic mapping approach is commonly used to systematically review a field of research and its influential publications. The result of this method is a bibliographic map that enables researchers to visually describe the structure of the literature in a chronological manner, providing information on the most cited works and the relationships among them [49]. We used this approach as it enabled us to develop an objective assessment of the topics of interest [45, 48].

Data Collection and Data Cleaning

The study was pre-registered on the OSF platform [106]. Our article follows the steps in data collection, as outlined by Janssen et al. [29], Janssen [28], Linnenluecke et al. [48], and Linnenluecke et al. [46]. In the Thomson Reuters Web of Science platform, we searched for articles referring to ‘sustainability’, ‘resilience’ and ‘innovation’. Studies referring to all three concepts were included in our review. The initial search included 376 records. Following the example of previous researchers Linnenluecke et al. [49], Janssen et al. [29], Janssen [28] and Linnenluecke et al. [46], the records were manually cleaned by two reviewers that checked the title, abstract and keywords for each record. For each article, we retrieved the following information: name(s) of the author(s), title of the article, name of the journal, citation details (volume, issue and page numbers), as well as abstract and keywords. After the initial review, articles referring to urban planning, peace engineering, cultural heritage and historical development were excluded from further review. The final literature review included 269 articles. We have included studies in the review that have the largest number of citations for major themes, which were listed on the historical map. Finally, we review all the studies that were published up to one year before the review took place.

Data Analysis and Synthesis

We visually represented the descriptive analysis of the most influential articles by using a thematic evolution technique and a historical bibliographic mapping approach. Two

researchers independently assessed and identified major themes based on the bibliographic map and then triangulated the research topics by reading the abstracts or articles in detail, if necessary. The researchers independently triangulated research studies into groups and then compared the results. Based on discussions, they agreed on the major themes of research. A similar procedure was followed to identify emerging themes, just without the visual representation. The researchers looked through those articles published up to one year before the data was collected to identify emerging themes. They then independently classified them into groups based on the similarities of research topics. Both times, two independent researchers classified the research into groups independently and then, after discussions, decided on the major and emerging themes. When the groups were identified, the analysis of the research groups followed. Based on the major and emerging themes, new directions for future work were identified for each of these.

Results

Descriptive Statistics

The author with the most citations in the review was Olsson, followed by Folke, Galaz and Thompson. We followed the example of Linnenluecke [47] in using a cut-off score set at the point where the local citation score (LCS) was levelling off, which happened to be at 6 or more citations, which showed 36 authors among those with the most local citations (Fig. 1).

Thematic Evolution

Looking at the thematic evolution, we can see how research evolved over time (Fig. 2). The general trend shows the fragmentation of research into sub-topics from 1999–2018 to 2019–2021. In 1999–2018, we see corporate social responsibility, management, dynamics, resilience and knowledge as the major themes of research. In 2019–2021, we see the main topics of have become systems, transition, sustainability, impact, adaptation, knowledge, policy, vulnerability and agriculture. Resilience was the largest field of research by far from 1999 to 2018 and then fragmented into various sub-topics referring to sustainability, impact, adaptation, knowledge, policy and vulnerability. What is interesting is that resilience is not a topic of such interest in the later years, from 2019 to 2021, while sustainability only starts to become the topic of interest from 2019 to 2021, when the highest number of articles were published on the sustainability domain. The theme referring to management has in recent years transitioned towards systems, sustainability and impact, while the theme referring to science has fragmented to more specific topics, such as sustainability, adaptation and knowledge. Knowledge is a much smaller topic of interest in 2019–2021 than in 1999–2018, and it has fragmented into agriculture, policy and knowledge.

Historical Mapping and Major Themes of Research

Historical mapping was used to identify the major thematic groups. Even though the historical mapping does not include every possible article included in this review, it has

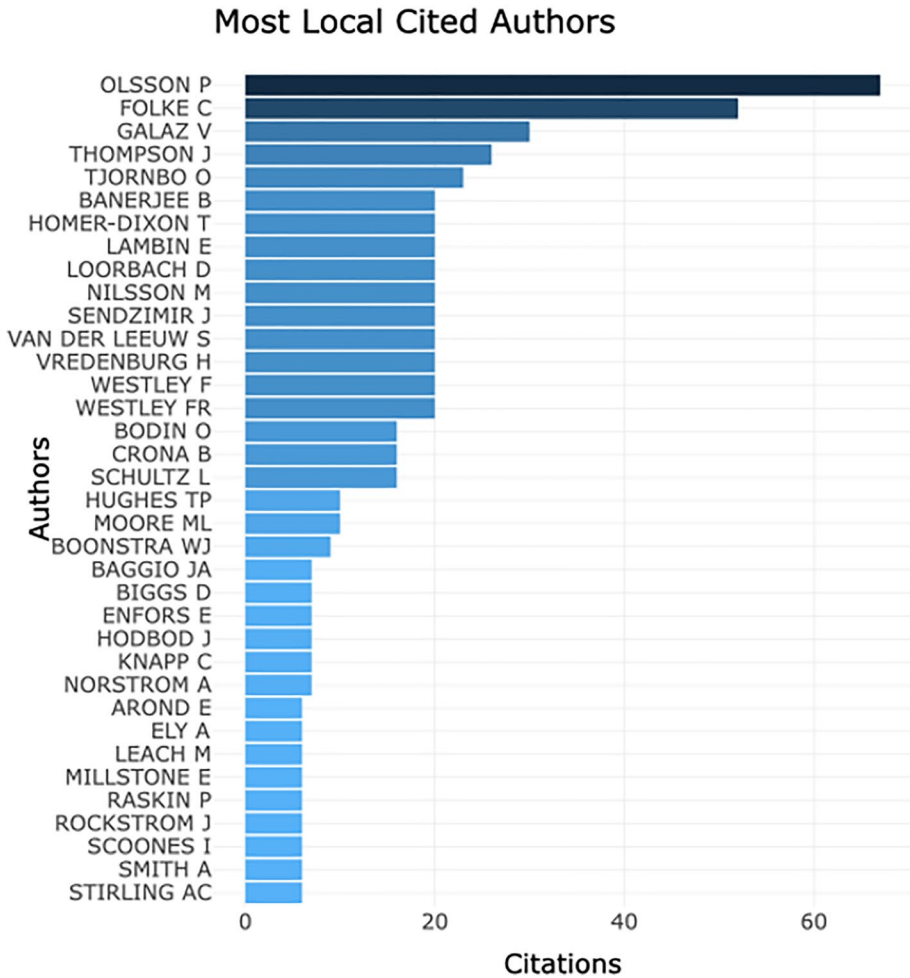


Fig. 1 Number of citations per leading authors

enabled us to arrive at a classification of major research streams, which were identified by manually looking through the articles and categorising them into their research groups. In Table 1, top publications are listed with a local citation score (LCS), which is the number of citations by authors included in the study, and a global citation score (GCS), which is the number of citations that the publication has received in total. Most articles with the highest number of citations were published in 2014, although several were published in later years (Fig. 3). The predominant approaches among the highly cited articles were a literature review (nine out of 19 articles), six case studies and three example reviews, one used a qualitative method and one a global quantitative study. Three major thematic groups of articles were identified, encompassing social-ecological systems, transformational innovation and political governance.

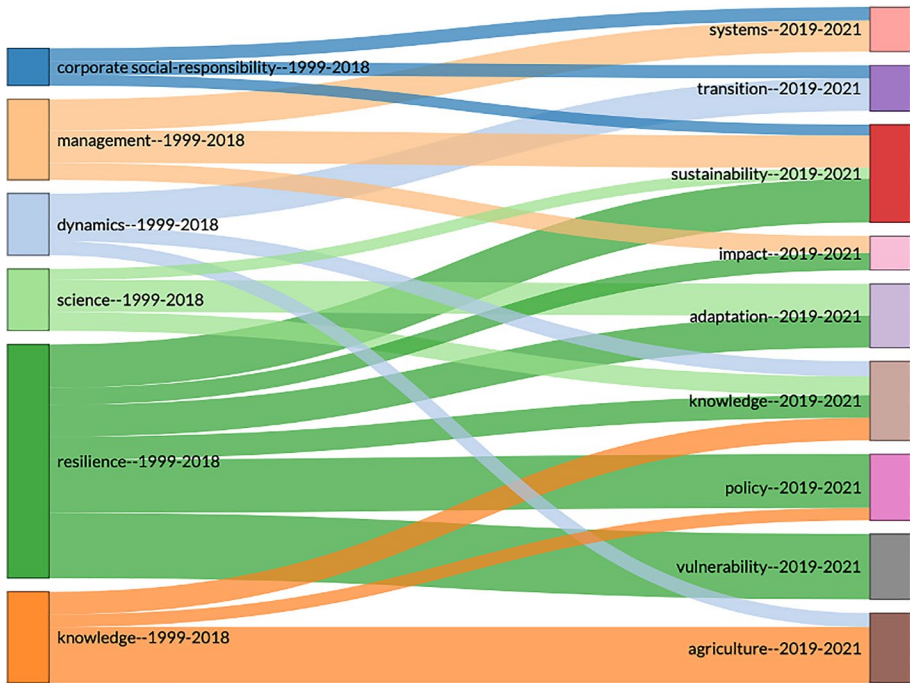


Fig. 2 Thematic evolution

Transformational Innovation

The first group of research works was concerned with how transformational innovation can be reached at the level of systems or society and how it can contribute towards achieving resilience and sustainability. Olsson et al. [70, 71] and Westley et al. [98] highlighted the importance of linking innovation to ecological integrity, with the main issue being how innovation is used [98]. Innovation within research has represented a tool to ensure resilience and achieve sustainability [60, 62, 69, 98]. Furthermore, innovation represents a tool for the transformation of socio-ecological systems [63, 70, 71, 97]. Olsson et al. [70] argue that scholars should make a distinction between adaptation and transformation when referring to resilience. Transformation must necessarily be included when looking at resilience in relation to the concept of sustainability [63]. Two types of innovation are identified as those that have transformative capacities to achieve a large-scale transformation: social and technological innovation. In the domain of technological innovation, Olsson et al. [70] referred to information and communication technology, nano- and biotechnology, synthetic biology, new energy systems and geo-engineering techniques. Within social innovation, they referred to new modes of governance, business models, microcredits and crowd sourcing. Social innovation is a more frequent theme in contributing to resilience and sustainability [57, 60, 62, 63, 70, 97, 98] than technological innovation [70, 98]. Two case studies were identified that studied how the processes of social innovation can have effects on ecosystem-based land-use planning, namely Oak Ridges Moraine [57] and Great Barrier Reef Marine Park [69].

Table 1 Highly cited articles in the citation network

Authors	Title	Journal	Year	LCS	GCS	Methods	Scales used	Inter-relatedness of sustainability, resilience and innovation	Stakeholders
a. Transformational innovation									
4	Moore et al. [62]	Ecology and Society	2018	1	22	Case study	Cross-scale	Innovation represents a tool for the promotion of place-based sustainable development	Social, economic and state actors
5	Olsson et al. [69]	PNAS	2008	6	203	Case study	Large	Innovation contributes towards resilience and sustainability	Park authority, scientific and policy agencies, community
6	Moore et al. [63]	Ecology and Society	2014	9	125	Literature review	Territorial scale (local vs. global) Single, multiple and cross-scale	Resilience fosters sustainability. Social innovation can create a transformational change towards improved social and ecological outcomes	Individuals, collectives
7	Westley et al. [98]	AMBIO	2011	20	345	Literature review	Spatial	Innovation represents the means to achieve resilience and sustainability	Private sector firms, NGOs, government
8	Westley et al. [97]	Ecology and Society	2013	19	266	Literature review	Organisational, jurisdictional and geographic Spatial scale (large vs. small)	Resilience represents a pathway for achieving sustainability. Innovation crucial in achieving the transformation of socio-ecological systems	Individuals, institutions
9	McCarthy et al. [57]	Ecology and Society	2014	1	11	Case study	Spatial	Social innovation represents an initiative, product, process or programme that profoundly changes the basic routines, resource and authority flows or beliefs of any social system. Social innovation within socio-ecological systems links research on resilience to social theory	Individuals, groups, organisations, agencies

Table 1 (continued)

Authors	Title	Journal	Year	LCS	GCS	Methods	Scales used	Inter-relatedness of sustainability, resilience and innovation	Stakeholders
10 Olsson et al. [70]	Sustainability transitions: a resilience perspective	Ecology and Society	2014	12	202	Literature review	Cross-scale Small vs. large	Resilience theory is useful for addressing sustainability transformations when the distinction between adaptability and transformation is made and reinforces a certain trajectory from one to another. Innovation can help the system towards having positive social and ecological impacts	Individuals, organisations, governmental institutions
11 Olsson et al. [71]	The concept of the Anthropocene as a game-changer: a new context for social innovation and transformations to sustainability	Ecology and Society	2017	3	53	Literature review	Spatial scale (large vs. small)	The Anthropocene requires us to consider that any innovation has both a social and ecological element, which represents a pathway to sustainability and resilience	Entrepreneurs, consumers, state government and multinational organisations
b. Political governance									
12 Butler et al. [6]	Framing the application of adaptation pathways for rural livelihoods and global change in Eastern Indonesian islands	Global Environmental Change	2014	1	74	Example review	Spatial scale (large vs. small)	Resilience of the system to retain overall function, which can be achieved through adaptive co-management. Innovation can help the system to maintain a social-ecological system within its current state, or to transform it	Individual, organisational, governmental
13 Butler et al. [7]	Priming adaptation pathways through adaptive co-management: design and evaluation for developing countries	Climate Risk Management	2016	2	36	Example review	Multi-scale and cross-scale	Resilience represents a part of an adaptive-co-management system	Individuals, institutions, governmental
14 Leach et al. [40]	Transforming innovation for sustainability	Ecology and Society	2012	9	202	Example review	Territorial scale (local vs. global) Multi-scale Large vs. small	Innovation can foster sustainable development	Governmental, business, civil society, farmers and consumers
15 Feola and Nunes [18, 19]	Success and failure of grassroots innovations for addressing climate change: the case of the transition movement	Global Environmental Change	2014	5	120	Case study	Spatial vs. temporal	Grassroots innovation can achieve sustainable development and resilience	NGO

Table 1 (continued)

Authors	Title	Journal	Year	LCS	GCS	Methods	Scales used	Inter-relatedness of sustainability, resilience and innovation	Stakeholders
16	Chapin et al. [12] Policy strategies to address sustainability of Alaskan Boreal forests in response to a directionally changing climate	PNAS	2006	4	101	Case study	Temporal territorial scale (local vs. global) Large	Adaptability and resilience are crucial in the implementation of policy strategies towards sustainability. Adaptability can be enhanced through policies that promote learning and innovation	Resource-harvesting institutions, resource-conservation institutions, hazard-reduction institutions, ecological-externality-producing institutions
17	Galaz (21) Geo-engineering, governance, and social-ecological systems: critical issues and joint research needs	Ecology and Society	2012	1	31	Literature review	Spatial (large), territorial (global)	Innovation should address socio-ecological feedback and support stewardship of ecosystem services	Governmental institutions
c. Socio-ecological systems management									
1	Cumming et al. [13] An exploratory framework for the empirical measurement of resilience	Ecosystems	2005	5	297	Case study	Spatial, temporal	Progress towards sustainability depends on understanding socio-ecological systems. Obtaining resilience is based on interdisciplinary synthesis, while innovation is fundamental to understanding resilience	State agencies, universities, NGOs and communities
2	Darnhofer et al. [14] Assessing a farm's sustainability: insights from resilience thinking	International Journal of Agricultural Sustainability	2010	1	161	Literature review	Spatial, temporal	Resilience theory applied to farming can lead towards achieving sustainability. Innovation represents a pathway to achieving resilience	Farmers, local farmer groups associations, community
3	Baker and Mehmood [1] Social innovation and the governance of sustainable places	Local Environment	2015	5	69	Literature review	Spatial, temporal and functional	Social innovation creates changes in collaborative forms of governance towards sustainability and resilience	Public, private and civil society actors

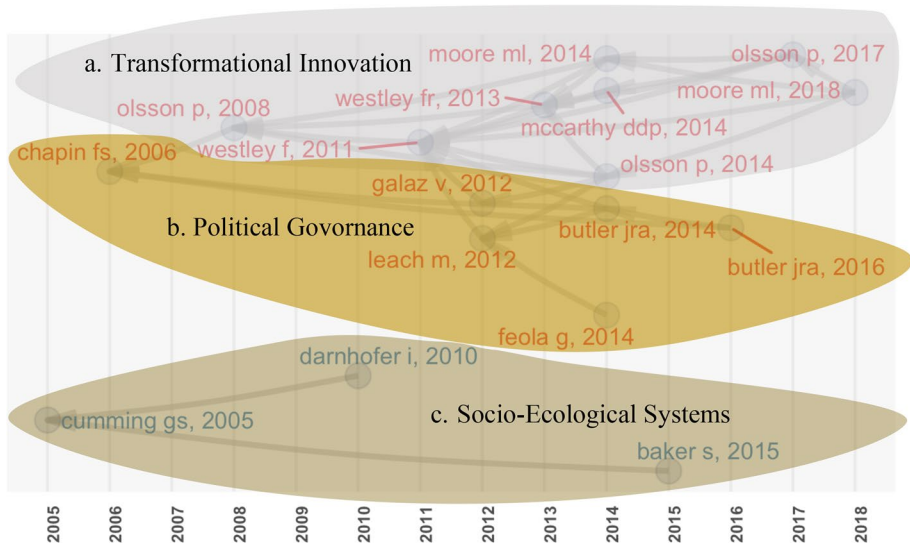


Fig. 3 Major themes of research among highly cited articles

Both top-down and bottom-up approaches can be considered as sources of innovation [98]. Moore et al. [60, 62] studied social innovation through a global fellowship programme and showed that introducing the insights of individual fellows included in the programme into new complex system dynamics can contribute towards transformational innovation. However, Moore et al. [63] argued that while social movements create conditions towards transformability, they are not the transformation itself. Disruption only creates opportunities for change to occur within the system. Individuals can interpret the problem and mobilise others to self-organise around a new idea or practice that addresses the issue [63]. Transformational innovations often require altering the dominant power structures and embedding the newly reconfigured social-ecological elements and feedback within institutions. The new trajectory itself then gains power, which is why a multi-stakeholder approach is necessary to adequately address transformational innovation [60, 62]. Research regarding innovation should encompass both the related power structures and various stakeholders when implementing resilience [70]. Frameworks to study the implementation of transformational innovation have been provided by many authors (Hölscher et al. 2019, [60, 62, 63, 97, 98]) while two groups of researchers used the adaptive cycle as a theory of how systems can implement innovation to ensure resilience [57, 97].

Change demands innovation across multiple scales [98], as a transformation can occur on a single scale and lead to change on multiple scales [63, 70]. Researchers who consider the issue of transformability within that of resilience note that the scale dimension is necessary, as this will indicate whether factors should be considered in contrast or even conflict [70]. Westley et al. [98] consider macro-, meso- and micro-scales as those that need to be considered if transformational innovation can achieve long-term change. At a macro-scale, authors refer to the political, economic, cultural and legal institutions that should be transformed away from what favours environmental destruction. At the meso-scale, authors refer to the problem or domain scale, which represents the opportunities that need to be incorporated to promote novelty and innovation. Finally, the micro-scale refers to individuals and small groups where invention originates and where the early sources of disruptive

or catalytic innovation can be found. Various authors [69, 70, 97] often refer to the size of the transformation on a scale dimension (large vs. small scale). However, while Olsson et al. [69] focus on large-scale innovation in order to achieve a large-scale change, small niche innovations have also shown the capacity to scale up and transform institutions [63, 97, 98].

Research has considered a wide variety of stakeholders when referring to resilience, sustainability and innovation, ranging from social, economic and state actors [60, 62, 70, 71, 98] to environmental organisations such as park authorities, scientific and policy agencies, as well as the broader community. Moore et al. [63] were less specific in identifying stakeholders, as they consider either individuals or collectives. According to Olsson et al. [71], individual stakeholders included in their study were entrepreneurs and consumers. Westley et al. [97] refer to individuals or institutions. Besides individuals, McCarthy et al. [57] delineate collectives onto groups, organisations and agencies. Westley et al. [98] also consider NGOs and private sector firms as stakeholders.

Political Governance

Within the major theme of political governance, researchers have provided specific frameworks to understand how political decision-making can be guided to achieve adaptive co-management [6, 7] and sustainability [40]. Butler et al. [6], Butler et al. [7] applied resilience theory to adaptation pathways, which can provide a decision-making framework whose aim is to push societies towards a more sustainable future by considering complex systems, uncertainty and multiple stakeholders. The use of an adaptive pathways approach, however, showed limited evidence for institutional change to existing processes [7].

Chapin et al. ([12], pp. 16,641) define resilience as the ‘capacity of social-ecological system to absorb shocks or perturbations and still retain fundamental function, structure, identity and feedbacks due to changing conditions’. Climate change works in interaction with population growth and ecosystem loss, which reduces land, water and food supply. Bad resilience may occur as a trap, which means that self-reinforcing social and ecological feedback can make moving to new trajectories extremely difficult. Poverty can remain due to corruption, traditional institutions and fatalism. Transformation is required when the system is trapped in an undesired state. Resilience can be improved by addressing the negative feedback that prevents systems from changing, thus fostering ecological, cultural, institutional and economic diversity, as well as adaptability [12]. Innovation can help the system to stay in its current state or to transform it [6], and it can foster sustainable development and resilience [40]. Adaptability can be enhanced through policies that promote learning and innovation [12]. A case study by Chapin et al. [12] of Alaskan boreal forests provided researchers with broad policy strategies that can be widely applicable in other settings. Socially innovative initiatives at the community level can, through the co-ordinating role of the state, be scaled up and act as a pressure for more participatory forms of governance when implementing grass-roots innovation [1]. Grassroots innovations, in this way, emerge as networks generating innovative solutions for climate change adaptation and mitigation and therefore work as strategies towards achieving sustainability and resilience [18, 19].

Feola and Nunes’ [18, 19] study is the only study on the major themes which acknowledged both local and global contextual factors in a case study of transition movements. Grassroots innovations support the process of local niche innovation creation and the incubation of socio-technical innovation. Less successful transition

initiatives underestimate the importance of contextual factors and material resources in influencing success [18, 19]. Sustainable development goals enable major transformations to take place, not only in policies and technologies but also in modes of innovation too. Leach et al. [40] examine examples from East Africa and Latin America and proposed a 3-D framework where the policymakers evaluate their decision-making based on direction, diversity and distribution when implementing innovation in moving towards sustainable development. Political governance can play an important role in designing, implementing as well as regulating an innovation. An innovation should address socio-ecological feedback and support the stewardship of ecosystem services [21]. Galaz [21] argue that geo-engineering and Earth stewardship are not necessarily in conflict, but rather can be viewed as complementary, which is why it is important to have institutional settings and regulations that are strong enough to prevent ecological risk while allowing for novelty, fail-safe experimentation and continuous learning.

When studying the diverse nature of political governance, we need to understand it within the cross-scale and multi-scale contexts [6, 7, 40]. Researchers have thus used various scales of reference, with the one referring to the spatial (large vs. small scale) being the predominant frame of reference [6, 7, 12, 21, 40] followed by a territorial scale that considers local vs. global level of initiatives [6, 12, 18, 19, 40]. Some authors also consider related issues using a temporal scale and the notion of time [18, 19, 12]. Research in the major theme of political governance refers to a diverse set of stakeholders, with most of the studies including governmental institutions. Butler et al. [6, 7] classified stakeholders into individuals, institutions and governmental organisations. Leach et al. [40] referred to stakeholders as farmers and consumers. Feola and Nunes [18, 19] have looked into how resilience, sustainability and innovation can be achieved from an NGO perspective, while Chapin et al. [12] are more specific and include resource harvesting, conservation, hazard reduction and ecological externality institutions as the topics of interest.

Socio-ecological Systems

The final group on major themes included articles concerned predominantly with the interactions among social-ecological systems. However, studying both the ecological as well as social dimensions has often been neglected by research studies [1]. Within this major theme, a substantial overlap can be found among the constructs of resilience, innovation and sustainability, while all concepts seem to be concerned about social and ecological interaction [1, 13, 14]. Cumming et al. [13] are the most influential authors within this theme. According to them, resilience is defined in terms of the system's ability to maintain an identity while being faced with internal changes and external shocks and disturbances. The two aspects of identity can refer to the ecosystem (e.g. amount of focal habitat) and social factors (e.g. cultural groups). The relationship component within the definition refers to how the components fit together, while the continuity component represents the variables that maintain a system's identity through space and time [14]. Resilience thinking in the integration of sustainability, resilience and innovation integrates both social and ecological aspects. Resilience focuses on the process of enhancing the likelihood that the system will be able to weather shocks or pass through inevitable adaptive cycles in an unproblematic manner, reduce serious vulnerabilities and move system states from an undesirable to a desirable state [13]. Cumming et al. [13] identified an exploratory framework for operationalisation and a measure of resilience which can be used for empirical studies across cases. This allows for

the socio-ecological system to be studied, as well as to make predictions about whether properties of interest are resilient.

Progress towards sustainability in this theme depends on our understanding of socio-ecological systems. Resilience in the domain of socio-ecological systems is based on the interdisciplinary synthesis, which when applied to farming can lead towards sustainability [14]. Innovation can represent a part of or a pathway to achieving resilience [13, 14]. Innovation in socio-ecological systems is more concerned with how variables that are related to novel solutions and responses to change can be shaped by biodiversity, cultural and livelihood diversity [13], as well as how learning and innovation can shape socio-ecological system interaction in fostering the resilience [14]. Darnhofer et al. [14] have shown that farming systems are too complex and variable over time and space for resilience models to give specific and closely predictive guidance to farmers. For a farm to achieve sustainability, it must take advantage of current opportunities while managing conditions that expand future possibilities, ensuring adaptability and transformability [14]. As such, sustainability considers the resilience of the system using both the short to the long term. Research work in socio-ecological systems builds on the idea of the adaptive cycles proposed by Holling [26], which consist of four phases: exploitation, conservation, release and reorganisation [13, 14].

Interest in socio-ecological system interactions has remained on the temporal and spatial scales [1, 14], with Baker and Mehmood [1] adding the functional scale. Each subsystem interacts with other subsystems at other spatial scales and other domains, which in turn are influenced by them. This is difficult to measure and thus make accurate predictions of how a system will respond, which gives rise to a need to address both the spatial and temporal mismatches that exist between a certain biophysical system and the governance system that is responsible for managing human–environment interactions. This mismatch may also occur when implementing social innovation, which can cause governance practices to fail with regard to promoting resilience on the social and ecological levels [1]. The research into socio-ecological systems looked at a diverse set of stakeholders ranging from public, private and civil society actors [1]. Stakeholders among them consider state agencies, universities, NGOs and communities [13], as well as farmers, local farmer groups associations and communities [14].

Emerging Research Trends

Bibliographic mapping investigates research that is well cited, and it does not consider newer research, which is why in the following section, we review the most recently published papers (up to a year before data collection started) and identify the most important themes in the most recent works. We review the papers that were published in one year before data collection. The results show that literature reviews [8, 16, 25, 35, 43, 51, 55, 67, 79, 91] and case studies [2, 4, 9, 17, 24, 30, 54, 61, 83, 88] are still the predominant research methods, although more sophisticated methods of research are starting to become adopted, though, such as systematic literature reviews [15], comparative analysis of the investment criteria and other reports [33], interviews [23, 81] and surveys [32, 50, 66, 90].

Food Security and Agriculture

The first emerging theme, on food security and agriculture, encompasses the largest set of articles ([2, 8, 16, 33, 55, 67, 76, 79, 81, 83, 91] which could be due to the rising need to consider food security within the frame of resilience, sustainability and innovation. The constraint of the natural resources should not exceed natural regenerative capacity, while the economic return should meet certain expectations to be considered sustainable [16]. Dong [16] argues that there is a paradigm shift occurring from efficiency-driven industrial agriculture to resilience-focused eco-friendly agriculture.

Sustainable systems require adequate performance across economic, social and environmental domains [76, 83]. On the other hand, Reidsma et al. ([76], pp. 19) define resilience as the ‘ability to ensure the provision of the system functions in the face of complex and accumulating economic, social, environmental and institutional shocks and stresses’. It can thus be argued that there is a substantial overlap between resilience and sustainability. Resilience can work as a catalyst in sustaining the sustainability of the system when faced with external pressures and shocks, while sustainability is the umbrella that requires adequate performance in general and is therefore a broader concept and less specific. Resilience considers adaptability – ‘the capacity to actively respond to shock and stresses without changing the systems structures and feedback mechanisms’ – resilience also encompasses transformability, the ‘system’s capacity to reorganise its structure and feedback mechanisms in response to shocks and stresses’. While Reidsma et al. ([76], pp. 19) add the robustness of the system, which refers to ‘the capacity to resist and endure shocks or stressors’ ([76 pp. 19). When looking into the definition of resilience, a distinction was made by Reidsma et al. [76] between specific resilience, which considers what, to what and for what purpose, and general resilience, which considers the system’s overall robustness, adaptability and transformability. Studying these from the farming systems perspective, it was found that the resilience of the focal systems was perceived as low to moderate, and robustness and adaptability were often greater than transformability. Liu et al. [50] investigate technological innovation as the key to improving productivity in food production and agriculture. The implementation of technological innovation is linked to financial prosperity. Even in the newer research on food security and agriculture, the theory of adaptive cycles continues to be applied [5], while a new theory of change is presented by Seghieri et al. [83].

There is a need to define agroecological or sustainable innovations in the context of people [83]. Consumers have become a topic of interest. Sustainable agriculture can deliver benefits for human health, as well as prevent environmental sustainability from being compromised. However, each consumer is only a limited agent of change, which is why broader perspectives need to be considered within the farming and agriculture domain [81]. Researchers consider both the social domain regarding using the agriculture to reduce hunger and the related impacts on the ecological aspects of food system security, as the race to meet sustainable development goals to achieve zero hunger by 2030 increases the need to intensify agricultural production, which raises concerns for the related environmental footprint. The deployment of new and improved technologies, especially advanced biotechnology, can help reach the targets set [67].

In terms of food security and agriculture, the stakeholders involved in research on sustainability, resilience and innovation were farm owners and farming communities. However, different stakeholders were also involved in the agricultural value chain, such as governments, scientific communities, the public [16], non-governmental organisations and

academic experts [81]. Research in this domain also acknowledges environmental parks [55], and primary forest owners [79] as those where resilience, sustainability and innovation play an important role. A broad array of stakeholders can be classified into public, civil and private stakeholders [83]. Benitez et al. [2] investigated how more specifically how females as stakeholders through participation and leadership contribute to positive economic, ecological and sociocultural changes in farming households and communities. Researchers looked at different scales, such as various spatial scales (small, medium vs. large) and territorial scale (municipal, provincial and national vs. local, national and international) [8, 16, 33, 67, 76, 79, 81], and individual vs. household scale [2], or at the level of the forest, farm, community and territory ([79, 83, 91]. The related technologies have the potential to play a role in improving the sustainability and resilience of food systems, at cell, plant, field and farm scales [8]. The notion of a temporal scale in terms of time has also been introduced into the discussion on food security and agriculture [81, 91].

Business and Finance

The idea of a win-win strategy emerges in the business and finance domain. Organisations act as a catalyst for the sustainable development of society, while at the same time need to develop in a sustainable way to realise their potential. The concept of organisational resilience is complex, and methods of effectively modelling resilient organisations are still developing. Nyaupane et al. [66] performed a study at the Bureau of Land Management, the largest public land management agency in the USA, which investigated organisational resilience. The employee-organisation relationship (E-O-R) framework was developed to understand the relationship between employees' skillsets, organisational traits and organisational resilience. It is possible to have employees whose skillset is adaptive, but it can occur that at the organisational level, such adaptability can be low, and thus, there are low resilience levels [66]. On the other hand, a survey of 455 organisations showed that long-term organisational resilience enables sustainable competitiveness through fostering dynamic capabilities [32]. Therefore, the concepts of resilience and sustainability are also interlinked in the business and finance domain.

Del Giudice et al. [15] further link the business model innovation theory and resilience theory within their research. Including socio-ecological systems, resilience theory and socio-technical transitions, the concept of transformational adaptation has been introduced to the study of climate change. Kasdan et al. [33] consider how transformational adaptation has influenced the funding priorities and financing of projects. They performed an analysis of investment criteria, board meetings, minutes, documents and reports under the convention of United Nations Framework Convention on Climate Change. Transformative potential guides funding decisions; however, it is important to consider whether transformational change is achievable and desirable at all times. Research also investigated how industry 4.0 adoption contributes towards sustainable business practice, and how digital technologies can improve resilience aftershocks [43], as well as how technology can be implemented towards achieving sustainability and resilience in the tourism sector [9, 51, 96, 102], sea-ports [15], and barriers to implementing the innovation for pottery businesses in Iran [23]. During the COVID-19 pandemic, the resilience of global logistics has become an important topic in global supply chain management [3, 24, 90]). Information sharing, logistics, networking and transportation are the most powerful factors that impact sustainable business and supply chain performance, while the need to move from corporate social responsibility towards also sustainability arises in this context [90]. Technological advances could

help through the use of new technologies and the adoption of advanced analytics such as blockchain [3]. Research also investigates how innovation presents an important factor in implementing a circular economy [9, 61].

Carraresi and Broring [9] argue that while research can often focus on innovation in a company's business, an innovative solution does not lie only in a particular object or process, but in a frame of mind. Therefore, the behavioural aspects are starting to be considered as success factors in the implementation of innovations in business settings. The multilevel nature of an innovation is considered in business research, where the innovative output of nations is impacted at the local and organisational levels [23]. Stakeholders represent organisations [32], employees [66], customers [9] and governmental organisations [23]. Most researchers within the domain of business and finance do not refer to the scale used, only Moore et al. [61] refer to the national scale and Trivellas et al. [90] to the small scale.

Interconnected Systems

We can only understand the concepts of sustainability, resilience and innovation when we understand the complexity of the system we are considering. Kok et al. [35] acknowledge the importance of human agency, as well as non-human factors, such as technology. There are three important, mutually related dynamic properties of complex adaptive systems: emergence, self-organisation and adaptation. Within non-linear interactions, systematic feedback loops can emerge in the system, which allows small changes to either accelerate the systematic change through a positive feedback loop or diminish the systemic change through a negative feedback loop. This level of operationalisation proposes that we shift the analysis from the individual parts to the systems perspectives. The power dynamics agency has become a topic of interest in the transition towards sustainability, while individual-level factors such as the autonomy of actors and collaboration between them have also started to be topics of interest [35].

Sustainability is defined with seven attributes referring to productivity, stability, reliability, adaptability, equity, self-management and resilience [52]. Resilience is therefore considered as a part of sustainability. Nevertheless, they argue that sustainability cannot be measured directly, but must be measured through transversal evaluation by comparing management systems at the same time, or through longitudinal evaluation, by looking into the evolution of the system over time [54]. Sustainability can work in both ways – governance can work towards achieving sustainability or a need for sustainability can change the governance. Maqueda et al. [54] investigated an intervention project in the Ecuadorian Andes. They investigated the impact on sustainability before and after an intervention by applying the framework for the evaluation of natural resource management systems (MESMIS). Infrastructure networks, such as those for energy, transportation and telecommunications, perform key functions for society. Systems have largely been developed and managed in isolation, however, infrastructure now functions as a system of systems, exhibiting complex interdependencies that can leave critical functions vulnerable to failure [24]. Grafius et al. [24] argue that research efforts and management strategies have so far focused on risks and negative aspects of the complexity of the systems perspectives, however, their case study review identified how interdependencies can also be seen positively, representing possibilities to increase organisational resilience and sustainability. The integrated social innovation

and scenario-thinking mechanism was developed by Bonsu et al. [4] as a bottom-up tool for empowering citizens, including youth and decision-makers, in delivering sustainable development goals, plans, policies and programmes.

Research has become more interested in how humanity can work towards the prosperous development of civilisation. Echaubard et al. [17] refer to socio-ecological systems theory to describe resilience, as this remains the best operational framework for meeting the need for integration and adaptive governance to obtain sustainable development goals. The Anthropocene reality of rising system-wide turbulence calls for transformative change towards a sustainable future. Emerging technologies and social innovations work towards a more resilient biosphere and are considered as essential parts of such transformations [20]. Tim et al. [88] introduced the concept of digital social innovation. They studied e-commerce to bring people out of poverty and how both bottom-up and top-down interventions can be instrumental in overcoming the bottlenecks to developing a resilient community. Gender equality and empowerment are considered as indicators contributing towards the natural sustainability of the system [54]. In their work on a case study of the watchmaking region of the Swiss Jura, Jeannerat [30] introduce the concept of ‘valuation’ to interpret the contemporary territorial dynamics of innovation.

Stakeholders and how they are related to technology are the central part of interconnected systems. Kok et al. [35] refer to this as human and non-human agency. Maqueda et al. [54] and Echaubard et al. [17] investigated communities as stakeholders. Jeannerat [30] looked into whole industries as stakeholders, while Grafius et al. [24] consider a multitude of infrastructure stakeholders including the energy, ICT, transportation, waste and water sectors, while also including stakeholders from academia and governance. Kok et al. [35] consider that both macro- and micro-scales need to be studied to consider the properties of wholes as well as those of parts of the system. Researchers consider spatial scales by referring to large [35] and small scales [20, 67]. Territorial scales local vs global scale are used by Jeannerat [30], with Folke et al. [20] adding planetary scale. Cross-scale scale [4, 17] is also considered by the researchers.

Discussion

The aim of this paper was to highlight the interrelations among resilience, sustainability and innovation, identify the major and emerging themes in the literature and provide an understanding as to how they are studied in practice and identify future research directions.

Interrelations Among Sustainability, Resilience and Innovation

To answer the first research question on the interrelations of the topics of resilience, sustainability and innovation, our study showed that there is a strong overlap among the constructs, with authors on multiple occasions using the concepts interchangeably or without specifically distinguishing them, only referring to interactions among socio-ecological and economic systems. A majority of the authors identify resilience as a potential pathway to achieving sustainability [1, 10, 13, 14, 63, 69, 97] or a trait of sustainability [54], while innovation is presented as the way to achieve both [1, 13, 14, 18, 19, 21, 69, 71, 97, 98]. The strong overlap between sustainability and resilience can already be seen in the definitions of the terms. For example, Reidsma et al. [76] define resilience as the ‘ability

to ensure the provision of the system functions in the face of complex and accumulating economic, social, environmental and institutional shocks and stresses'. The definition of sustainability, on the other hand, considers the adequate performance of the system across economic, social and environmental domains [76, 83]. Therefore, sustainability can be considered as an umbrella under which resilience can be studied more specifically when referring to interactions between socio-ecological and economic systems. Resilience can mean ensuring adequate performance of the system when faced with shocks and stressors, while sustainability can ensure the adequate performance of the system in general. This could explain why in 2019–2021, the thematic evolution showed there was a move in the research from resilience, which was a major theme of interest from 1999 to 2018, towards sustainability and other topics, such as vulnerability, policy, knowledge, adaptation and impact. Innovation, on the other hand, was not one of the themes identified in the examination of the thematic evolution, which could be explained by the fact that innovation is involved in the processes of obtaining both, and therefore, no specific distinguishment is present.

Resilience encompasses both aspects of adaptation and transformation if it is referred to in the context of sustainability [14, 37, 38, 70, 97] while Reidsma et al. [76] also add the robustness of the system under the resilience domain. Robustness can also refer to the negative side of resilience. Olsson et al. [70] call for a clear distinction between resilience and robustness in this regard. Newer research merges the two concepts of transformation and adaptation together into transformational adaptation when referring to resilience [33]. The literature differs when it comes to social [57, 60, 62, 63, 70, 97, 98], technological [70, 98] and a hybrid version of socio-digital innovation [88], and sustainability requires adequate performance across economic, social and environmental domains [76, 83]. As such, one can argue that resilience and innovation refer to the processes, while sustainability is concerned with the outcomes [76, 83]. Research on integrating the three concepts of sustainability, resilience and innovation shows promising results, with the three concepts being used interchangeably or in relation to each other. Resilience can work as a catalyst in maintaining the sustainability of the system when faced with external pressures and shocks, while sustainability can be considered as a broader concept, which requires adequate functioning of the system even when no external shocks or stressors occur. Furthermore, our overview of the literature suggests that two theories are used when referring to resilience, sustainability and innovation by many of authors – the theories of closing [9, 61, 74] and adaptive cycles [5, 13, 14, 57, 97]. The theory of the adaptive cycle represents the most used theory when looking into processes related to exploitation, conservation, release and reorganisation. The resilience of the system enables the system to continue in an unproblematic manner through the adaptive cycle [14, 37, 38, 97]. The second theory that often appears in the literature, that of the closing cycle, has become more popular in recent years, and especially in relation to the circular economy and minimising waste in the environment [9, 61, 74].

Stakeholders

If we wish to achieve a large-scale change towards utilising innovation to foster resilience and sustainability, then we have to consider the multitude of actors within systems and their interactions in the implementation. To answer the second research question, our review of the literature found that researchers rarely involve one type of stakeholder in their analysis of sustainability, resilience and innovation. The stakeholders range from

individual, organisational and institutional stakeholders [7], while a newly emerging theme on interconnected systems proposes the importance of linking sustainability, resilience and innovation to both human and non-human agency [35]. With regard to the major themes of research, we have seen how complex and important the stakeholders involved in the process are due to the interdisciplinary nature and dependency of the field. We may classify stakeholders in terms of environmental protection organisations [12, 69], farms and agriculture organisations [1, 40, 69], non-profit organisations [13, 18, 19, 98], educational institutions [13], business organisations [40], infrastructure organisations [24] and governmental organisations [7, 21, 40, 60, 62, 70, 98].

Another classification can be based on the individual level [6, 7, 63, 71] such as employees [66] or customers [9] and collectives or communities ([13, 17, 40, 54, 63, 69] institutions and organisations [6, 32, 57, 70, 97], as well as industries [30]. In some instances, the researchers consider social, economic and state actors [60, 62]. Both top-down and bottom-up approaches can be considered as sources of transformational innovation, which is why different stakeholders at different positions of power should not be neglected while studying resilience, sustainability and innovation [23, 98]. The reason why so many different stakeholders were included in the analysis or referred to in the literature could be due to the importance of the inter-connectedness and dependence of different actors within the fields of sustainability, resilience and innovation, which requires us to study the related concepts across multiple stakeholders [12]. Our research shows that sustainability, resilience and innovation can be applied simultaneously by considering the multitude of stakeholders involved in the process. The results also showed the need to consider multi-stakeholder systems and how they interact with each other.

Methods and Scales

The third research question was concerned with which methods are used by researchers in studying resilience, sustainability and innovation. Literature reviews were the main method used, followed by case studies. Among the major themes, there were only two quantitative and qualitative studies in the works examined, while researchers also used example reviews. In recent years within the emerging themes, there has been a shift towards more sophisticated methods, such as systematic literature review, comparative analysis of investment criteria and surveys, although literature reviews and case studies still dominate the research.

Our review of the literature showed that changes in one system may only be achieved on certain occasions by if there are also changes in another system. Our fourth research question was therefore concerned with what scales the research should be conducted at. Researchers emphasise the importance of studying the concepts across different scales or including a multi-scale approach [6, 7, 60, 62, 63, 70], as this is fundamental to the interplay between persistence, change, adaptability and transformability. Researchers have used several different scales referring to the spatial (large, medium, small), territorial (organisational, local, regional, national, international, planetary), temporal (short-term, mid-term, long-term) and functional. Researchers have also considered classifications on the micro-, meso- and macro-scales [57, 98].

Major and Emerging Themes of Research

Concepts of resilience, sustainability and innovation are often used as solutions to the most pressing issues that humanity is facing; this can also be seen in the topics for major and emerging themes. To answer the fourth research question, our literature review identified three major themes: ‘transformational innovation’, ‘political governance’ and ‘socio-ecological systems’. The first major theme of transformational innovation emerged as a type of innovation that can establish the move to resilient and sustainable systems. The reason why this theme emerged could be due to the rising importance of linking innovation to ecological integrity [98] and socio-ecological transformation [63, 70, 71, 97]. This theme also emerged due to relatability to the concepts of resilience to transformation trait as necessary to be included in contributing towards sustainability [14, 37, 38, 70, 97]. The second major theme of political governance studied how policymaking can be guided to implement innovation or to achieve resilience and sustainability. Political governance is crucial, although while it may present the pathway towards achieving resilience and sustainability of the system, it has also shown limited results in Butler et al. [6, 7]. This theme could have emerged due to the importance of linking political governance in implementing resilience, sustainability and innovation [12]. In fact, a study by Feola and Nunes [18, 19] clearly showed the importance of initiatives to be supported by the policymakers to be successful. Finally, research on socio-ecological systems showcases the importance of studying these concepts from both the social and ecological dimensions. For example, Cumming et al. [13] placed the social and ecological dimensions under the definition of resilience. Such a definition is possible when referring to resilience in the context of sustainability, which encompasses both social and ecological dimensions [1, 13, 14].

Our article also identified three emerging themes: ‘food security and agriculture’, ‘business and finance’ and ‘interconnected systems’. The first of these, on food security and agriculture, was the theme with the highest number of research articles. The reason being could be due to the growing need to assess and design solutions necessary to combat food insecurity, as well as to get to reach sustainable development goals such as ending world hunger by 2030 [67]. There is a shift into resilience-focused eco-friendly agriculture [16], which could explain why the need for research in this domain rises in its importance. The second emerging theme referred to business and finance. Research in this domain has started to introduce the concept of organisational resilience, as well as the concepts of circular economy ([9, 74, 61]. The need to consider the resilience of the system has shown to be especially crucial during the COVID-19 pandemic, which is why research has looked to digital technology can improve resilience aftershocks in a-post COVID-19 context [3, 24, 43, 90]. The third emerging theme of interconnected systems reveals the importance of considering sustainability, resilience and innovation from the systems perspective, and how human agents and non-human agents interact. There is thus a move from looking at individual parts to the system as researchers start to consider how individual parts are nested inside the overall system [35]. The importance of interdependency begins to be an issue within this emerging theme, when interdependencies of the system can also play a positive role in influencing the system towards achieving resilience [24].

Limitations and Areas of Improvement

This literature review is limited to the interrelations among the concepts of sustainability, resilience and innovation, and thus, it did not include studies that investigated these

separately. Our study only reviewed the most highly cited articles and the articles within the emerging themes and thus did not consider previous research that could have examined these concepts but was not highly cited or recent enough to be included in the review. This is especially true for the research on methods. It may be the case that literature reviews are more highly cited than empirical research, and therefore, our study did not identify more research that uses an empirical approach to study these concepts. Moreover, due to the complex nature of urban planning, infrastructure and other related concepts, the current study did not consider research in these areas that investigated sustainability, resilience and innovation in different domains. There is a need for more empirical work looking into the three concepts of sustainability, resilience and innovation together.

Future Research Directions

In the following sections, we highlight opportunities for knowledge integration and new research directions. Given the substantial overlap among the three concepts, the question arises as to whether sustainability, innovation and resilience could be integrated and in what ways can they be researched together. Future research is needed to study the propositions of inter-relatedness of the topics empirically by applying quantitative studies that would compare the systems response and involvement in sustainability, resilience and innovation across multiple cases and stakeholders. Furthermore, longitudinal research is needed to study these concepts in practice. In the next section, we review potential new directions in research on these concepts.

Transformational Innovation

Future research on transformational innovation could examine how technological innovation has caused a change in certain environmental outcomes (CO₂ emissions, atmospheric temperature and rising sea levels). Research is necessary to identify how transformational innovation can contribute to longitudinal changes in socio-ecological systems, and what can be done when innovation reaches the routinised phase. Much more research is needed on how to classify the differences between harmful and non-harmful innovation [57]. A coherent theory could also be developed on the emergence of transformational innovation [70, 71].

Political Governance

The researchers working on this theme of political governance mainly focused on developing countries [6, 7], while research on developed countries remains limited. Moreover, Feola and Nunes [18, 19] argue that studies on the dynamic nature of local and global linkages are rare, and their work was the only one among the highly cited articles included in our research that performed such investigation. More research is necessary on support by policymakers [18, 19]. Future research could also explore factors contributing towards the emergence of bad resilience and the role power plays in implementing resilience towards achieving sustainability and innovation.

Socio-ecological Systems

The frameworks developed by Darnhofer et al. [14] and Cumming et al. [13] can be used by researchers to study the concept of resilience in practice, although more research is needed to test these approaches. Future research should identify which feedbacks from the interactions between socio-ecological systems can shape the transformation towards achieving resilience and sustainability [13, 14]. The results of such work could be used to identify how human factors interact with the environmental aspects [14].

Food Security and Agriculture

With climate change, the interest in the topics of food security and agriculture is likely to rise in its importance. More research should be done to explore how innovation can potentially address the challenges posed by climate change in this context of food and agriculture. Even though changes in consumer preferences have started to attract the interest of researchers, research work on the policy agendas that contribute towards more sustainable food consumption choices remains limited [81]. Future research could explore how farming systems evolve to integrate consumption choices in their decision-making.

Business and Finance

Research on business and finance could, in the future, consider both sides of the coin – what it takes to implement sustainability, resilience and innovation in practice, as well as what this means in terms of ecological, economic and social changes as such actions are taken. It is important to define and agree on the measure of sustainability; however, Carrarsi and Broring [9] argue that no such measure has been proposed that would include both the elements of environmental as well as financial sustainability. Research could explore how can the two processes of the adaptative and closing cycles interact and contribute towards sustainable, resilient and innovative outcomes for organisations.

Interconnected Systems

Future research could test the propositions of systems, as proposed by Kok et al. [35]. The research on interconnected systems considers that specific community-level interventions can offset certain changes on a societal level. More research is needed on how the individual-level factors such as belief in free will, attitudes, autonomous motivation, norms or learning can contribute towards a system that is innovative, resilient and sustainable. Kok et al. [35] also mention non-human agency, and much more research should be done to define the interactions between humans and technology in building adaptive and transformational systems that are sustainable.

Conclusion

The systematic review of the literature presented in this work shows there is considerable potential regarding studying resilience, innovation and sustainability together, as there is a great overlap among these concepts. Innovation is important for obtaining both resilience and sustainability, while resilience is involved in processes towards achieving and maintaining sustainability. Resilience is more concerned with processes and sustainability with outcomes. We identified three major themes in the literature: ‘socio-ecological systems’, ‘transformational innovation’ and ‘political governance’. We also found three emerging research streams: ‘food security and agriculture’, ‘business and finance’ and ‘interconnected systems’. The results indicate that multi-scale and multi-stakeholder approaches should be adopted when studying resilience, sustainability and innovation simultaneously. The predominant methods for studying these concepts in the literature were case studies and literature reviews. There remains a need for cross-scale and multilevel empirical quantitative studies that would investigate how these concepts are applied and work longitudinally and across different stakeholders and organisational levels. Future research should consider the human aspects of implementation, what fosters and what creates a barrier in implementation.

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Author Contribution This article is the work of the author named on the submission of the manuscript. The author of this manuscript has drafted the work or revised it critically, approved the version to be published and agreed to be accountable for all aspects of the work, including that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data availability All the abstracts of the articles used in the review of this study have been made available in the Supporting information.

Declarations

Competing Interests The author declares no competing interests.

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