Agrifood Sustainability Transitions in Firms and Industry: A Bibliographic Analysis of Research Themes

Nic J Lees *, Sivashankar Sivakumar, Xiaomeng Lucock

Posted Date: 28 May 2024

doi: 10.20944/preprints202405.1807.v1

Keywords: agrifood sustainability transitions; agrifood; agroecology; sustainable innovation; food systems; transition governance

 doi:10.20944/preprints202405.1807.v1

Article

Agrifood Sustainability Transitions in Firms and Industry: A Bibliographic Analysis of Research Themes

Nic J Lees *, Sivashankar Sivakumar and Xiaomeng Lucock

Faculty of Agribusiness and Commerce, Lincoln University, New Zealand
* Correspondence: nic.lees@lincoln.ac.nz

Abstract: There is a growing consensus that the modern food system lies at the centre of the grand challenges facing humanity and requires urgent and profound changes in the way that food is produced, processed, distributed and consumed. This review analyses sustainability transitions within agrifood systems, focusing on the role of firms and industries as defined by the Sustainable Transitions Research Network (STRN). This paper conducts the first systematic literature review using bibliometric analysis to assess the current state of research on this theme. The findings reveal a significant increase in publications related to firms and industries within agrifood sustainability transitions. Furthermore, the current research is geographically concentrated in the European Union. The review identifies four key themes in the literature based on co-occurrence of keywords. These are agriculture, innovation, governance, food systems and agroecology. The review identifies increasing awareness of the role of farmers in driving sustainability transitions at the farm level. Furthermore, there is an increasing awareness of the interrelated characteristics of the agrifood system which acknowledges the need for sustainable innovations to occur at multiple stages of the agrifood system. It also shows that there is growing evidence that innovations can occur through disruptive as well as incremental innovation, and highlights the importance of governance influencing transitions. The literature raises questions about Alternative Food Networks as sustainable innovations, their potential for significant change in the established food system and the validity of their claims to food equity and environmental sustainability. A key theme emerging from the literature is an ecological perspective that identifies the complex biological processes and ecosystems as an integral part of agricultural production. These findings provide a greater understanding of the current literature landscape of agrifood sustainable transitions relating to firms and industries and lay a foundation for future research.

Keywords: sustainability transitions; agrifood; agroecology; sustainable innovation; food systems; governance

1. Introduction

1.1. The Global Agrifood System

The current global agrifood system has fed a rapidly growing population that has more than doubled from 3.5 billion to 7.8 billion in the last 50 years (Ahmad, 2001; Ezeh et al., 2012; United Nations, 2022). To achieve this, food production has tripled, contributing to a significant reduction in levels of malnutrition and hunger (Boliko, 2019; OECD, 2022; UNICEF, 2022). This improved nutrition has supported better human health outcomes such as reduced infant mortality and longer life expectancy (Marinova et al., 2022; Willett et al., 2019). Furthermore, this threefold increase in food production has been achieved with less than a 15% increase in agricultural land use (Godfray et al., 2010; OECD, 2022). This has been accomplished by focusing on increasing output through the intensification and efficiency of food production systems (Gaitán-Cremaschi et al., 2019; Hackfort,

 doi:10.20944/preprints202405.1807.v1

2023; Mehrabi et al., 2022; Wojtynia et al., 2021, 2023). This has required greater inputs of fertiliser and agrochemicals combined with increases in mechanisation, plant breeding, water use and improved management practices (Godfray et al., 2010; OECD, 2022).

However, this increase in production has come at a significant cost to the environment with food production now the largest cause of global environmental change (Marinova et al., 2022; Meynard et al., 2017; Vinnari & Vinnari, 2014; Willett et al., 2019). Food production is a major contributor to climate change, biodiversity loss, contamination, overuse of water resources and land use change (El Bilali, 2019; Mehrabi et al., 2022; Vinnari & Vinnari, 2014). In addition to the environment, there are significant effects on human health (Meynard et al., 2017). It is estimated that 820 million people suffer from chronic malnutrition and two billion are classified as overweight or obese (El Bilali, 2019; Guh et al., 2009; WHO, 2021; Willett et al., 2019).

There is a growing consensus that the modern food system lies at the centre of the grand challenges facing humanity and requires urgent and profound changes in the way that food is produced, processed, distributed and consumed (Bui, 2021; El Bilali, 2019; Meynard et al., 2017; Willett et al., 2019; Wojtynia et al., 2021). For example, research by the Eat-Lancet Commission on healthy diets from sustainable food systems concluded that "the global food system needs to be transformed to reduce its effect on human health and environmental stability" (Willett et al., 2019, p. 450). However, this needs to be achieved with the world population expected to increase to 9 billion by 2050 combined with a global trend towards the adoption of western diets with the associated increase in consumption of animal proteins (Aschemann-Witzel et al., 2023; Vinnari & Vinnari, 2014). Furthermore, this must be achieved in a period where climate change will significantly impact crop yields (Godfray et al., 2010). There is increasing agreement among scholars that to address these multiple challenges requires more than incremental change but a "great food transformation" (Willett et al., 2019, p. 54) changing the way the food system operates requiring a transition to more sustainable practices (Béné, 2022; Bui, 2021; El Bilali, 2019; Kuokkanen et al., 2019; Willett et al., 2019).

1.2. Agrifood Sustainability Transitions

Agrifood sustainability transitions is a field of research that focuses on the systemic changes and reconfiguration of the agrifood system required to move towards more sustainable practices (Kuokkanen et al., 2019; Vinnari & Vinnari, 2014). The study of agrifood transitions sits within a wider body of research on sustainability transitions. Transitions are defined as long-term major shifts in established industries and socio-technical systems, as societies transition to more sustainable modes of production and consumption (Mehrabi et al., 2022; Sustainability Transition Research Network, 2021). Only recently has sustainability transition research been applied to agrifood systems (Aschemann-Witzel et al., 2023; El Bilali, 2019; Gosnell et al., 2019). In this context, agrifood systems refer to all the activities and actors involved in the production, processing, distribution, consumption, and disposal of food and agricultural products (El Bilali et al., 2021).

The initial focus of sustainability transitions research was on energy systems, transport and computing (Aschemann-Witzel et al., 2023; Van den Ende & Kemp, 1999; Verbong & Geels, 2007). Lachman (2013) and Loorbach et al. (2017) identify the major approaches to transition research. These are multi-Level perspective, strategic niche management, innovation systems, techno-economic paradigm and socio-metabolic transitions.

1.3. Sustainability Transitions Research

The multi-level perspective (MLP) is the dominant theoretical framework and is seen as a "fundamental heuristic underpinning transitions studies" (Bui, 2021, p. 1). This perspective views transitions as a multi-Level interaction between landscape, regime and niches (Geels, 2002; Kuokkanen et al., 2019; Lachman, 2013). The regime is a central concept of the MLP. It is defined as the dominant socio-technical system and is often seen as the established unsustainable mode of production requiring destabilisation and transformation (Kuokkanen et al., 2019). The regime has an established set of rules that regulate how the system functions and interacts with a network of actors and functions with existing technology. The regime is seen as resistant to systematic change due to

 doi:10.20944/preprints202405.1807.v1

strong path dependencies and vested interests of the existing actors (Bui, 2021; Kuokkanen et al., 2019; Lachman, 2013). The landscape and niches function outside the established regime. The concept of landscape refers to the context in which the regime operates and incorporates the economic, social and political environment. Examples of landscape changes include shifts in government policy, changing consumer preferences, changes in the economic environment and technological innovations. Niches are defined as experimental spaces where innovations can potentially take place. They often represent small networks of actors with more flexible rules and have some protection from the dominant regime (Bui, 2021; Lachman, 2013). The MLP proposes that certain interactions between the landscape, regime and niches can lead to systemic change that can ultimately lead to a transition to a new socio-technical regime (Bui, 2021; Lachman, 2013).

1.4. Agrifood Sustainability Transitions–Firms and Industries

Sustainability transition research has been applied to a variety of sectors including the agrifood sector. El Bilali (2019) evaluated the literature on agrifood transitions research between 2010 and 2017. This review looked at how the agrifood transitions literature aligned with the themes in the Sustainable Transitions Research Network (STRN) agenda (Köhler et al., 2019). The STRN has developed a research agenda on sustainable transitions with nine themes: understanding transitions, power and politics, governing transitions, civil society, culture and social movements in transitions, firms and industries in sustainability transitions, transitions in practice and everyday life, the geography of transitions, ethical aspects of transitions and methodologies (Köhler et al., 2019).

The STRN theme on firms and industries evaluates how established organisations and sectors contribute to transitions by either slowing down or speeding up the processes of transitions and how changes in these affect the broader aspects of transformation. Köhler et al. (2019) note that research on the theme of firms and industries was less advanced and a relatively new field of research. This was especially valid for studies relating to the agrifood system. More specifically, the review by El Bilali (2019) identified that the literature on agrifood sustainability transitions relating to the "role of industries and firms in enabling and supporting sustainable transitions was a marginal topic" (El Bilali, 2019, p. 358)

Based on the findings of the review by El Bilali (2019), there is a need for a systematic review of the agrifood sustainable transitions literature on firms and industries to identify how the research on firms and industries has developed. In particular, there is a need to evaluate if research on sustainability transitions has become a more central theme rather than a marginal topic. This paper addresses this knowledge gap by providing the first systematic review on this theme. It uses bibliometric analysis and visualisation tools to identify the current state of research on the role of firms and industries within the agrifood sustainability literature.

Within the context of agrifood transitions, the specific aims of this study are to:

1) Evaluate and describe the current state of the literature on the (STRN) theme of firms and industries.
2) Identify gaps and propose areas for future research to address these areas.

Specific research questions are:

1) Is the theme of "industries and firms" still a marginal topic within the agrifood sustainability transitions literature?
2) How has the agrifood sustainability transition literature on "industries and firms" evolved?
3) What are the main themes and topics within this theme and what gaps exist within this literature?
4) What are the potential areas for future research on firms and industries in sustainability transitions?

 doi:10.20944/preprints202405.1807.v1

2. Materials and Methods

2.1. Data Collection

Data was collected from Scopus in the first step of bibliometric analysis. The following search query was used to gather data: ((“sustainability transition*”) AND (agri* OR agro* OR food) AND (firm* OR industry* OR business*)). The search terms were adapted from the STRN research themes. The search terms aimed to identify papers relating to agrifood that met the STRN research theme for the role of firms and industries in transitions (El Bilali, 2019; Köhler et al., 2019). Papers published between 2010 - 2023 were considered for this study. The search criteria covered the Scopus subject areas of Environmental Science, Business Management and Accounting, Agricultural and Biological Sciences, Social Sciences, Economics, Econometrics and Finance. This search identified 63 documents, which after further screening was reduced to 46 documents that were used for the bibliographic analysis (Figure 1).

 doi:10.20944/preprints202405.1807.v1

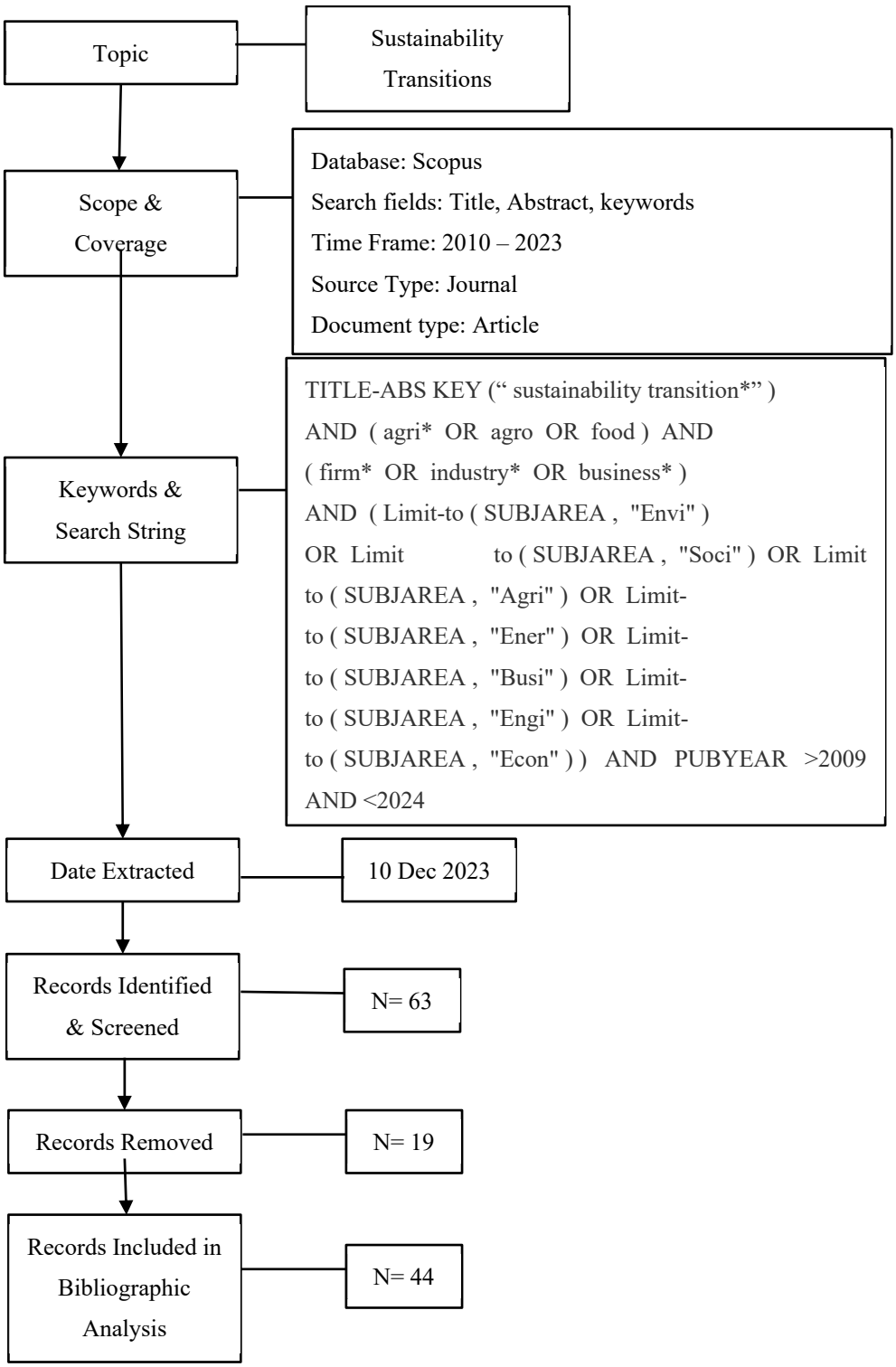

Figure 1. Data selection process.

2.2. Data Analysis

The Scopus database bibliometric tools were used for the initial descriptive analysis of the literature. The Scopus database was used for the search criteria due to its wider coverage of documents than other common databases (Visser et al., 2021).

Following the database search and the descriptive analysis, VOSviewer software was used to develop and analyse the network of relationships between bibliometric items evaluated by co-citations analysis and co-occurrence of keywords (Van Eck & Waltman, 2010).

 doi:10.20944/preprints202405.1807.v1

Co-citation analysis was used to identify the network of relationships between publications based on the number of times an author, publication or journal are cited together in the same publication. Co-occurrence of keywords was used to identify common themes of publications based on the number of times the same keywords are used in the selected documents. The themes identified by the co-occurrence of keywords formed the basis of the themes for the literature review. The papers were then manually allocated to the different themes based on the main topic of the article.

3. Results

3.1. Descriptive Analysis of Publications

This section presents a descriptive analysis of the number of publications, authors, journals, institutions, geographic origin and citations to evaluate the characteristics of the published literature on the topic of sustainability transitions in firms and industries.

Figure 2 shows a recent increase in publications in agrifood sustainability transitions on the theme of firms and industries, with the number of publications increasing from three in 2017 to 19 in 2023. Figure 3 shows that this trend is also reflected in the number of citations of papers on the theme of firms and industries. These have increased from 14 in 2017 to 187 in 2023.

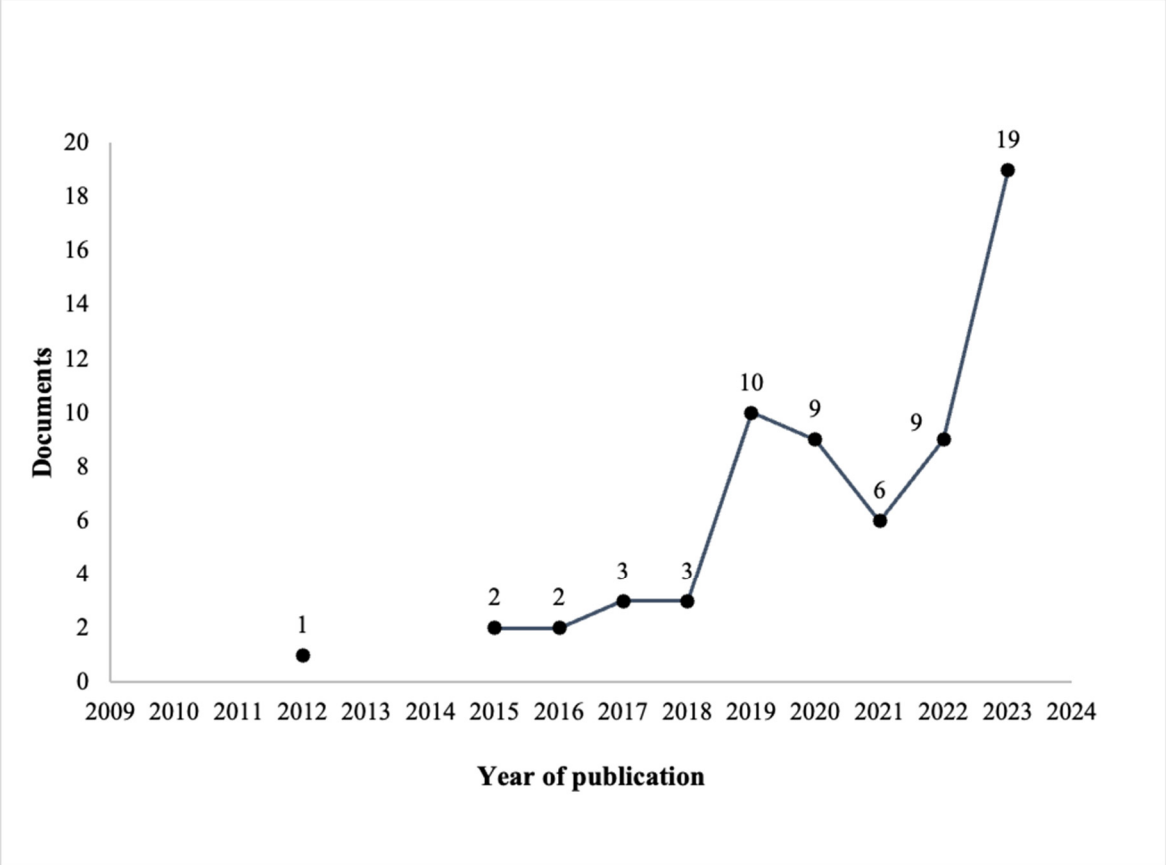

Figure 2. Growth in publications on agrifood sustainability transitions in firms and industries.

 doi:10.20944/preprints202405.1807.v1

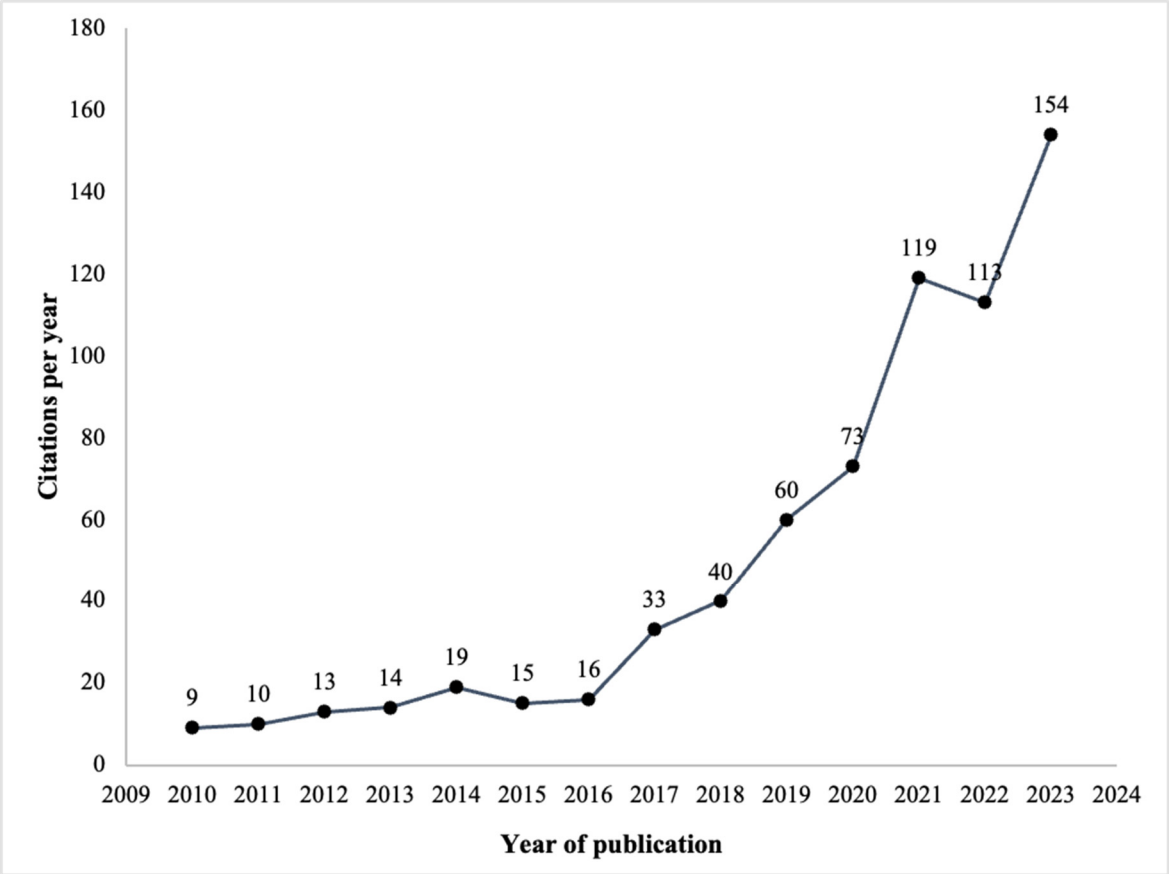

Figure 3. Citations per year on the topic of agrifood "sustainability transitions" - The role of firms and industries.

The growth in publications is evenly distributed across a number of authors with only Bui and Hekkert publishing more than two papers (Table 1). In contrast, there is a significant concentration in both institutional affiliation and geographic location. Specifically, only three research institutions have contributed more than three papers (Table 2). This concentration is even more apparent when examining publications by country, with the Netherlands leading significantly with 11 papers published (Table 3). An analysis of the geographic distribution underscores a clear dominance of European countries contributing to publications on this topic.

Table 1. Publications by top 10 authors 2010 – 2023.

Author	Publications
Bui, S.	3
Hekkert, M.P.	3
De Schutter, O.	2
Dedeurwaerdere, T.	2
Feola, G.	2
Giagnocavo, C.	2
Hudon, M.	2
Kuokkanen, A.	2
Mehrabi, S.	2
Moors, E.	2

 doi:10.20944/preprints202405.1807.v1

Table 2. Affiliation of publications by university or research organisations publishing at least two publications.

Rank	Affiliation	No. of papers	Country
1	Wageningen University & Research	6	Netherlands
2	Universiteit Utrecht	5	Netherlands
3	Copernicus Institute of Sustainable Development	5	Germany
4	CNRS Centre National de la Recherche Scientifique	3	France
5	University of Guelph	3	Canada
6	Université Libre de Bruxelles	2	Belgium
7	Université Catholique de Louvain	2	Belgium
8	Lincoln University	2	New Zealand
9	LUT University	2	Finland
10	Universidad de Almería	2	Spain
11	Deakin University	2	USA
12	Groupe de Recherche en Droit, Économie et Gestion	2	France
13	Institut National de la Recherche Agronomique	2	France

Table 3. Publications by country.

Country/territory	No. papers
Netherlands	11
Germany	7
Canada	6
France	5
Australia	3
Belgium	3
Finland	3
Italy	3
New Zealand	3
Sweden	3

Eleven journals were identified as having published a minimum of two papers on the theme of transitions in firms and industries (Table 4). The *Journal of Environmental Innovation and Societal Transitions* had the highest number of publications, totalling six, closely followed by the journal *Sustainability*, with five publications.

Table 4. List of journals publishing more than two articles and their quality rating.

Source	Publications	Impact factor	CiteScore	SJR	SNIP
Environmental Innovation and Societal Transitions	6	9.4	13.1	2.4	1.9
Sustainability	5	3.9	5.8	0.7	1.2
Agriculture and Human Values	3	4.9	5.9	1.0	1.4
Agricultural Systems	2	6.8	11.9	1.6	2.0
Agriculture	2	3.4	3.6	0.6	1.2

 doi:10.20944/preprints202405.1807.v1

Business Strategy and the Environment	2	10.8	17.8	2.9	2.8
Circular Economy and Sustainability	2	N/A	N/A	N/A	N/A
Ecological Economics	2	6.5	11.0	1.9	2.0
Journal of Cleaner Production	2	11.1	18.5	2.0	2.4
Journal of Rural Studies	2	5.1	8.1	1.3	1.9

In terms of journal quality, impact factors varied significantly from 3.4 for the journal *Agriculture* to 11.1 for the *Journal of Cleaner Production*. The journal *Circular Economy and Sustainability* lacked an impact factor or other quality measures. The range of impact factors highlights the diversity of journals publishing on firms and industries in agrifood transitions, encompassing a range of quality measures. Importantly, it signifies that there are high-quality journals that recognise the significance of this field of research.

The Source Normalised Impact per Paper (SNIP) provides a comparative ranking of journals within their respective research fields. All the identified journals exhibited a SNIP greater than 1, indicating their performance exceeds the average for journals in their fields (Table 4). It is noteworthy that only two of these journals deal with agriculture and agricultural systems and there are no journals in agribusiness management or agricultural economics. This suggests that sustainability transitions research has yet to emerge as a significant topic in mainstream agricultural economics or applied agribusiness management journals.

Table 5 identifies the ten most cited papers on the topic. The paper "Designing coupled innovations for the sustainability transition of agrifood systems" by Meynard et al. (2017) has received substantially more citations than all the other most cited papers with approximately 30 citations per year since 2021 (Figure 4). This high level of citation could be because this paper has been published in an agricultural journal (Agricultural Systems) that has a scope that includes a farm-level agricultural production focus (Elsevier, 2024). As a result, many of the citations of this paper have been in agricultural or agronomy journals that include this focus such as the *European Journal of Agronomy*, *Agronomy for Sustainable Development* and *Agricultural Systems* (Table 5). This highlights the potential for sustainable transitions research to provide a framework for understanding transitions in agriculture production systems.

Table 5. The ten most cited papers.

Rank	Authors	Title	Year	Source Title	Cited by
1	(Meynard et al., 2017)	Designing coupled innovations for the sustainability transition of agrifood systems.	2017	*Agricultural Systems*	171
2	(Vinnari & Vinnari, 2014)	A framework for sustainability transition: The case of plant-based diets.	2014	*Journal of Agricultural and Environmental Ethics*	65
3	(Kuokkanen et al., 2018)	Agency in regime destabilization through the selection environment: The Finnish food system's sustainability transition.	2018	*Research Policy*	43
4	(El Bilali, 2018)	Relation between innovation and sustainability in the agro-food system.	2018	*Italian Journal of Food Science*	41
5	(Bui, 2021)	Systemic ethics and inclusive governance: Two key prerequisites for sustainability transitions of agrifood systems.	2019	*Agriculture and Human Values*	40
6	(Vermunt et al., 2020)	Sustainability transitions in the agrifood sector: How ecology affects transition dynamics.	2020	*Environmental Innovation and Societal Transitions*	38

 doi:10.20944/preprints202405.1807.v1

7	(Dedeurwaerdere et al., 2017)	The governance features of social enterprise and social network activities of collective food buying groups.	2017	*Ecological Economics*	35
8	(Pant et al., 2014)	Adaptive transition management for transformations to agricultural sustainability in the Karnali mountains of Nepal.	2014	*Agroecology and Sustainable Food Systems*	29
9	(van Oers et al., 2021)	The politics of deliberate destabilisation for sustainability transitions.	2021	*Environmental Innovation and Societal Transitions*	27
10	(Kuokkanen et al., 2019)	A framework of disruptive sustainable innovation: An example of the Finnish food system.	2019	*Technology Analysis and Strategic Management*	26

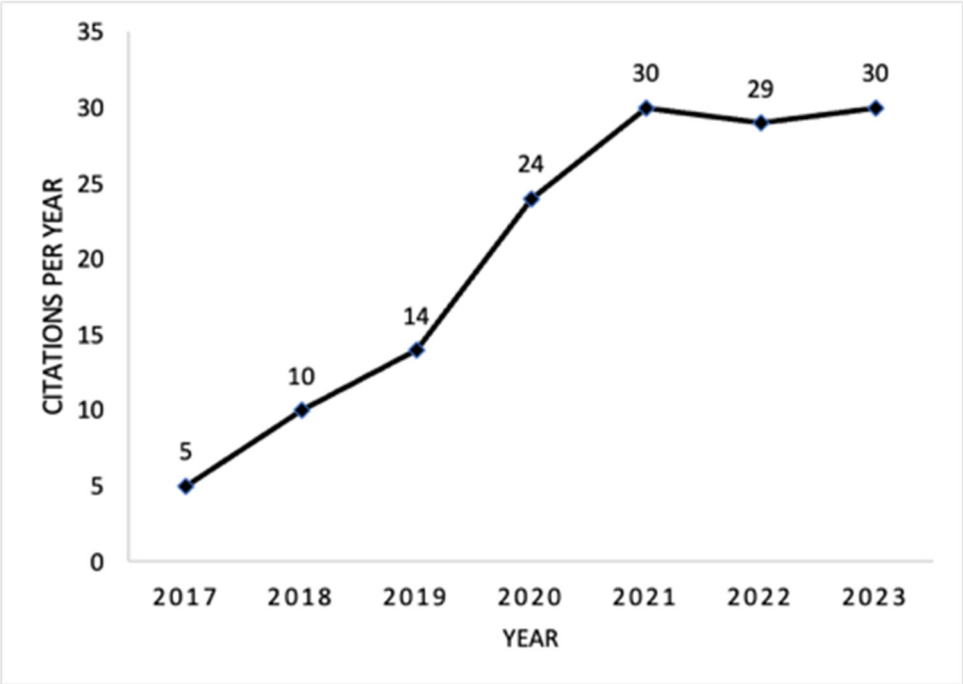

Figure 4. Citations per year for the paper: Designing coupled innovations for the sustainability transition of agrifood systems (Meynard et al., 2017).

3.2. Co-Citation Analysis

Co-citation is a bibliographic analysis that provides a structured and quantitative approach to evaluate the scholarly landscape. It identifies the number of times a journal article, author or journal are cited together in the same publication. It can provide an analysis of relationships, identifying influential articles, journals, and authors that contribute to the current scholarly discourse on agrifood sustainability transitions in firms and industries.

The construction of a co-citation network (Figure 5) visually portrays the scholarly interconnections. Each node represents an article, journal, or author. The links signify frequent co-citations, and the size of the node represents the number of articles, journals, or authors represented by the node.

 doi:10.20944/preprints202405.1807.v1

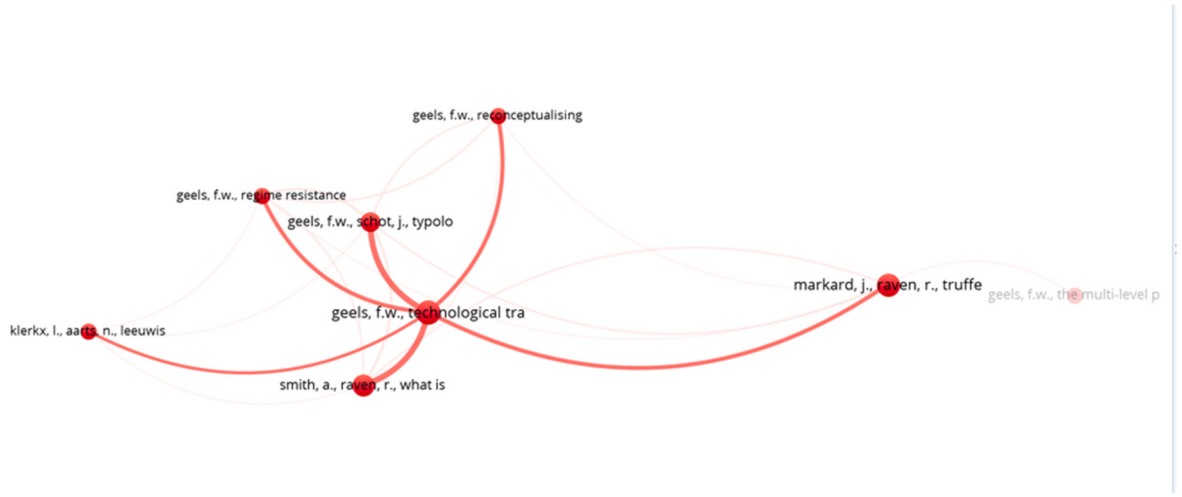

Figure 5. VOSViewer Co-citation analysis by journal article.

The analysis of co-citation of publications (Table 6) and (Figure 6) highlights the central position of Geels (2002) article "Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study within the network". This paper has both the highest number of citations and link strength, signifying that it has extensive connections to other publications in the network. This indicates that the paper occupies a central position in the citations included in publications on firms and industries in agrifood sustainability transitions. In this paper, Geels (2002) addresses the questions about the mechanisms of technological transitions (TT). Drawing from insights in evolutionary economics and technology studies, the paper applies this to a case study on the technological shift from sailing ships to steamships during the period 1780–1900. Among the other strongly linked papers, Smith and Raven (2012) explore the role of "niches" as temporary protective spaces fostering the emergence of pathbreaking innovations. They illustrate this concept with the example of the evolution of solar photovoltaic cells from niche innovations within satellite technology in the 1960s to mainstream solar energy, challenging the established fossil fuel energy generation technology. The third most cited paper by Geels and Schot (2007) contributes to the conceptualisation of the multi-Level Perspective on transitions by developing a more differentiated typology of transition paths. This incorporates distinctions in the timing and nature of multi-level interactions. Although these three publications do not specifically relate to agrifood sustainability transitions, they collectively serve as a theoretical foundation for the examination of transitions in various domains, including firms and industries in agrifood sustainability transitions. It also indicates the strong theoretical roots that firms and industries in agrifood sustainability transitions have within the wider body of transitions literature.

Table 6. Co-citation of publications.

Author(s)	Cited reference	Source	Citations	Total link strength
(Geels, 2002)	Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study.	*Research Policy*	8	18
(Smith & Raven, 2012)	What is protective space? Reconsidering niches in transitions to sustainability.	*Research Policy*	6	16
(Geels & Schot, 2007)	Typology of socio-technical transition pathways.	*Research Policy*	5	15
(Geels, 2014b)	Regime resistance against low-carbon transitions: introducing politics and power into the multi-level perspective.	*Theory Cult. Soc*	3	11

 doi:10.20944/preprints202405.1807.v1

(Markard et al., 2012)	Sustainability transitions: an emerging field of research and its prospects.	*Research Policy*	7	9
(Geels, 2014a)	Reconceptualising the co-evolution of firms-in-industries and their environments: developing an inter-disciplinary triple embeddedness framework.	*Research Policy*	3	8
(Klerkx et al., 2010)	Adaptive management in agricultural innovation systems: the interactions between innovation networks and their environment.	*Agricultural Systems*	3	4
(Geels, 2011)	The multi-level perspective on sustainability transitions: responses to seven criticisms.	*Environmental Innovation and Societal Transitions*	4	1

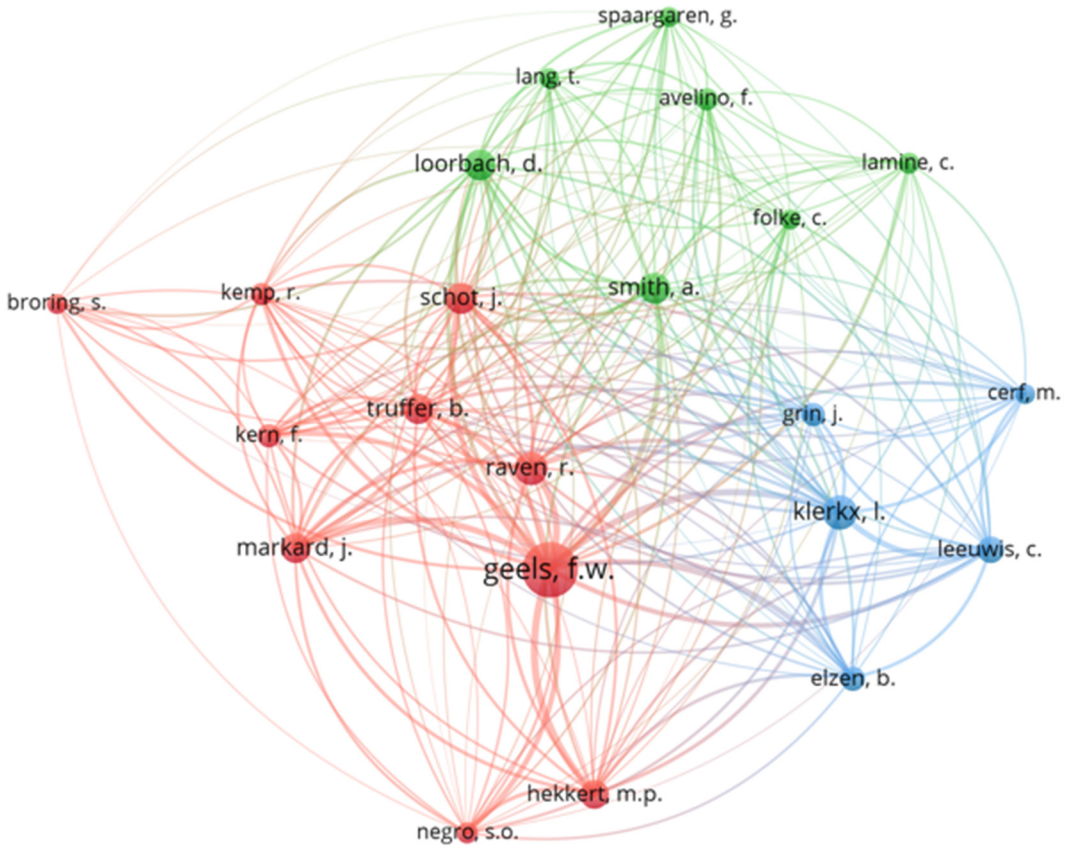

Figure 6. VOSViewer co-citation analysis by author.

Co-citation analysis by author (Figure 6) maps the number of times authors are cited together in the same publication. This analysis again highlights the central role of Geels as an author in the network and his foundational works on the conceptualisation of transitions. The analysis identifies three predominant clusters of authors (Figure 6). Cluster 1 is centred on authors Geels, Raven, Truffer, Markard and Schot. Cluster 2 is centred on Klerkx and Cluster 3 is centred on Loorbach and Smith. This indicates that there are three groups of authors that are commonly cited together, suggesting that these research groups have shared research themes or collaborations.

 doi:10.20944/preprints202405.1807.v1

3.3. Co-Occurrence of Keyword Analysis

The final analysis uses the co-occurrence of keywords to provide an understanding of the knowledge structures of this field of research by examining the links between keywords in publications. Keywords were extracted from the Scopus file and processed through VOSViewer. VOSViewer identified 367 keywords from the 46 articles in the literature search. Keywords were selected based on occurring more than five times in the selected publications. This resulted in 11 keywords and identified five themes based on the following keywords: agriculture, innovation, governance, food system and agroecology. Keywords that had a similar meaning were combined (for example, sustainability transition and sustainability transitions). The five themes were used to structure the literature review by classifying articles into these categories.

Table 7. Co-occurrence of keywords.

Keywords	Occurrence	Links	Total Link strength
Sustainable transitions	28	6	28
Agriculture	12	6	23
Food system	12	6	22
Innovation	10	5	21
Governance	9	5	14
Agroecology	6	4	12

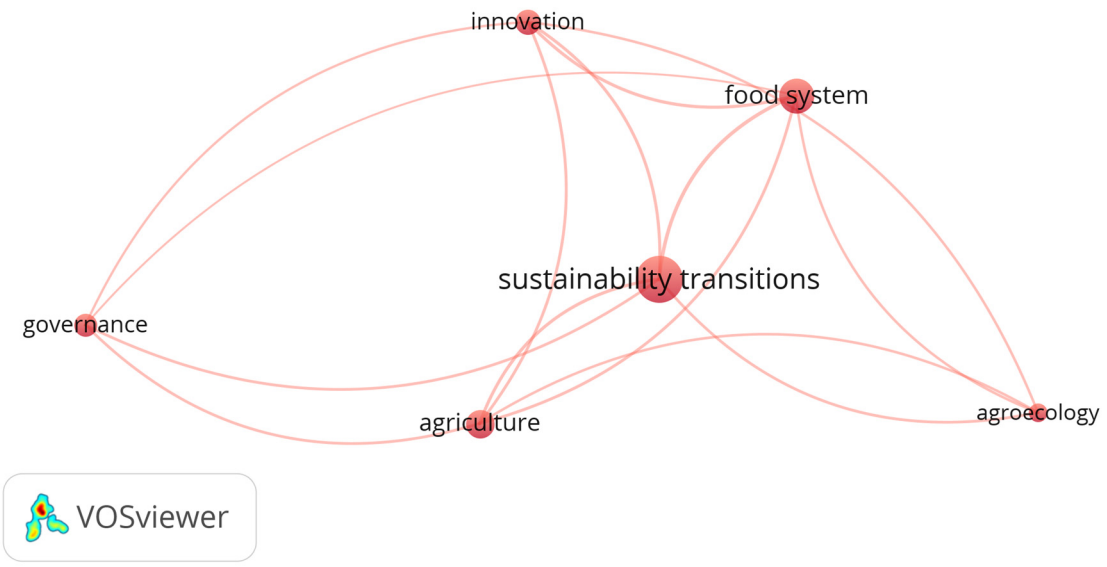

Figure 7. Network analysis: Co-occurrence of keywords.

3.3.1. Agriculture

Transitions in agricultural systems focus on the systematic changes needed to reduce the impact of agricultural production on the environment (Viola & Mendes, 2022). There is an emphasis on technological innovations as solutions to the environmental issues associated with agrifood production. These identify technologies such as remote sensors, artificial intelligence, precision agriculture, autonomous vehicles and high-technology urban agriculture as potential solutions (Farhangi et al., 2020; Hackfort, 2023). However, widespread adoption of these technologies is hindered by the significant capital investment required. This especially impacts small farmers with

 doi:10.20944/preprints202405.1807.v1

limited financial resources (Pant et al., 2014; Swaffield et al., 2019; Viola & Mendes, 2022). Furthermore, large-scale agribusinesses with significant capital and technological resources may adopt these technologies to improve productivity rather than transitioning to more sustainable practices (Hackfort, 2023). Financial barriers also exist when transitioning from conventional farming systems. These can include contractual obligations, high levels of debt, investments in existing farming methods and loss of income through reduced production and higher costs (van der Gaast et al., 2022). For example, converting to organic production can involve a period of up to two years, with reduced production and income and additional expenses for certification (Horn et al., 2023; van der Gaast et al., 2022).

Wojtynia et al. (2023) and Williams et al. (2023) highlight the central role farmers play in influencing sustainability transitions within agricultural production systems due to the significant impact of farm production on environmental sustainability (Williams et al., 2023; Wojtynia et al., 2023). These impacts include greenhouse gas emissions, nutrient losses, biodiversity, and land use changes. As a result, farmers' agency becomes essential for implementing sustainable production at the farm level. However, studies show that farmers have diverse motivations for implementing sustainable farming practices (Davidson et al., 2016; Horn et al., 2023; Wojtynia et al., 2023). These include a recognition that conventional systems are unsustainable, awareness of the environmental impacts of their farming practices, proactively making changes ahead of regulatory requirements and a desire to create a legacy for future generations (Bulah et al., 2023). Farmers' individual characteristics also affect the adoption of sustainable practices. These include openness to new ideas, reflective capacity, risk aversion, and sociability with peers (Williams et al., 2023; Wojtynia et al., 2023). Power dynamics, especially between farmers and large corporate agribusiness firms and retailers can also be an obstacle to farmers adopting sustainable practices (Hackfort, 2023; Williams et al., 2023). Although these businesses may adopt sustainability initiatives, they can also create "lock-ins" that perpetuate the status quo of productivist farming systems (Giagnocavo et al., 2022; Hackfort, 2023; Kinniburgh, 2023; Manuel-Navarrete & Gallopín, 2012; McInnes, 2019). Agribusiness firms and retailers who participate in sustainability initiatives often do this for a variety of motivations. These include meeting environmental regulations, improving food security, enhancing consumer confidence, competition, branding, adding value, strengthening relationships with local communities, maintaining social capital, workplace values, preserving a social license to operate and mitigating the risk or regulations and reducing compliance costs (Swaffield et al., 2019).

The literature on agriculture and transitions provides insights into challenges and opportunities in agricultural systems, highlighting the crucial role of farmers in adopting more sustainable practices. At the same time it identifies significant barriers including financial constraints, power imbalances and the need to understanding the diverse motivations and individual characteristics of farmers in adopting sustainable practices.

3.3.2. Innovation

Disruptive innovation is a core concept in the sustainability transitions literature. A clear distinction is made between disruptive and incremental innovation. Incremental innovations emerge within the established system or regime, whereas disruptive innovations aim to fundamentally transform the established regime (Marletto & Sillig, 2019; Meynard et al., 2017). Niches are another key concept and are identified as protective spaces for disruptive innovations to become established and then expand beyond the niche and destabilise the existing system (Davidson et al., 2016; Geels, 2011; Kuokkanen et al., 2019). However, recent studies have recognised that significant systemic change can unfold incrementally within the established system and that the regime can play a role in the adoption of sustainability practices (Bui, 2021; Kuokkanen et al., 2019). This suggests that both radical and incremental innovations are needed for transformation (Block et al., 2023). Furthermore definitions of sustainable innovations and their ability to transform the established regime are still highly contested (El Bilali, 2018; Meynard et al., 2017)

There are some sustainable innovations that are emerging within the agriculture and food system that aim to address the significant impact of conventional practices on the environment. These

 doi:10.20944/preprints202405.1807.v1

innovations include alternative protein sources, precision fermentation, alternative distribution channels and more sustainable production systems (Kuokkanen et al., 2019). Grassroots innovations are a category of innovations that are viewed as potential disruptive. These include practices such as community-supported agriculture, urban farming and local food networks, which emphasise innovation in the production and distribution of food outside of the dominant regime (Marletto & Sillig, 2019). These innovations promote local, small-scale and organic practices, which aim to shift away from large-scale monoculture systems and promote soil health, biodiversity and reduced use of agrochemicals. However, it is acknowledged that some innovations such as organic production, fair trade and veganism can be absorbed by the dominant regime and become mainstream (Marletto & Sillig, 2019). In this case, large agrifood companies and food retailers observe shifts in consumer demand and see these innovations as a profit opportunity (van der Gaast et al., 2022). The mainstreaming of these innovations can result in deviation from the values that initiated the innovation, and diminish the radical critique of the established system (Marletto & Sillig, 2019).

There is a growing understanding emerging from the complex nature of the agrifood system, suggesting that sustainable innovations need to encompass the whole food system, emphasising coordination along the supply chain, between agricultural production, processing, and consumers (Block et al., 2023; Meynard et al., 2017; Trotter et al., 2023). This means, for example, that transitions require multiple niche innovations that occur simultaneously at different components of the agrifood system (Bui, 2021; Long et al. 2019; Meynard et al., 2017). Furthermore, the regime can play a part in the transition process through the emergence of within-regime socio-technical configurations (Bui, 2021). The literature on this theme highlights the complex nature of innovation by firms and industries in agrifood systems, as well as the need for a more holistic understanding of sustainable innovation with coordination across various aspects of the food system.

3.3.3. Governance

Transition governance involves managing transitions to more sustainable food systems. Kinniburgh (2023) and Vinnari and Vinnari (2014) highlight the crucial role of governance in incentivising and supporting these transition processes. Transition governance is often implemented by policymakers and government bodies. However, Kinniburgh (2023) points out that government policy can oppose change due to embedded political interests that resist change by influencing government policies to support the status quo. illustrate the impact of the regime on government regulations that create barriers that don't support transformation to new sustainable production systems. Horn et al. (2023) highlight the importance of devolving knowledge governance to farmer organisations to improve access to information on research that supports the adoption of sustainable farming practices.

Transition governance has its roots in complex systems theory (Vinnari & Vinnari, 2014). However, governance studies frequently overlook the characteristics of complex systems, in particular, the concept of emergence, where outcomes cannot be predetermined, making traditional planning approaches ineffective (Keating et al., 2017). Halbe and Pahl-Wostl (2019) emphasise that managing transitions is especially challenging in agrifood systems due to the high levels of uncertainty, complexity, ambiguity and distributed control. Rossing et al. (2021) try to address this through a co-innovation approach to the governance and management of sustainable transition projects. This explicitly acknowledges that sustainable transitions involve complex adaptive systems where different outcomes can arise despite similar approaches to governance and management. Their approach views project interventions as "sustainability experiments" and incorporates farmers and researchers in the process of co-innovation. It emphasises that supporting sustainable transitions requires a complex adaptive system perspective with an environment that supports social learning and incorporates dynamic project monitoring (Rossing et al., 2021). Despite the variety of approaches to transition governance and the challenges of implementation in complex agrifood systems, transition governance is likely to continue as an important focus of sustainable transitions research.

 doi:10.20944/preprints202405.1807.v1

3.3.4. Food System

Transformation of the food system requires an understanding of the factors that support or hinder this process (Aschemann-Witzel et al., 2023; Farhangi et al., 2020). Food system transformation is a central principle in the sustainable transitions perspective. However, within the food system transformational literature, the concept of sustainability remains contentious and ill-defined (Ribeiro & Turner, 2021). Although there is some consensus as to the need for firms and industries to move away from the current unsustainable agrifood system, the notion of what represents a sustainable transition outcome has many definitions (McInnes, 2019; Ribeiro & Turner, 2021). Some sustainability outcomes include protecting the environment, supporting the development of alternative food networks, reconfiguration of value chains, reducing waste and addressing social equity (Bui et al., 2019; Davidson et al., 2016; Ribeiro & Turner, 2021). Marinova et al. (2022) emphasise the importance of situating transitions within the historical context of the evolution of human society from hunter-gatherer to the farming of crops and livestock through successive transformations until the recent development of industrialised agriculture. From this perspective, the current agrifood sustainability transitions are understood as the most recent transformation in a series of historical changes in food systems.

A dominant theme of the current food system transformation is the emergence of alternative food networks (AFN) that seek to transform or replace conventional food chains (Audet et al., 2017; Bui et al., 2019; Davidson et al., 2016; Stephens & Barbier, 2021; van Oers et al., 2023). AFNs are characterised as self-governing collectives with diverse objectives including reconnecting producers and consumers, promoting social and food justice, ensuring equitable access to food, and promoting healthy nutrition and sustainable practices (Audet et al., 2017). However, there are significant issues and challenges for AFNs. Evidence of substantial transformation of established food systems by AFNs is limited (Bui et al., 2019; Desa & Jia, 2020; Marletto & Sillig, 2019). Furthermore, many of these organisations struggle to scale up and often have to deal with tensions between social and environmental concerns and economic viability. (Audet et al., 2017; Desa & Jia, 2020; Donati et al., 2023; Ribeiro & Turner, 2021).

Research by Stephens and Barbier (2021) identifies that most customers of AFNs also purchase food from conventional channels such as supermarkets and specialty stores. This suggests that AFNs represent a niche food retail channel that sits alongside conventional production and food retail supply chains (Davidson et al., 2016). Furthermore, rather than the transformation of the regime, the established food system may assimilate certain aspects of the alternative food systems without there being a fundamental transformation. For example, supermarkets may offer local produce, organic, fair trade and vegan options as a part of their product offering, co-existing with conventional products (Aschemann-Witzel et al., 2023; Audet et al., 2017; Bui et al., 2019; Davidson et al., 2016; Gonera et al., 2023; Marletto & Sillig, 2019; Ribeiro & Turner, 2021). Additionally, the role of the regime is acknowledged in the transformation process (Aschemann-Witzel et al., 2023; Gonera et al., 2023; Kuokkanen et al., 2018). There is evidence that incumbent firms are incorporating sustainability priorities in their vision, goals and practices often driven by regulations or pressure from shareholders, customers and consumers (Bulah et al., 2023). In this way, incumbent agrifood firms and industries can become a positive force for food system sustainability (Bulah et al., 2023; Gonera et al., 2023). The literature in this cluster acknowledges that there are multiple perspectives on what transformation may look like and what problems need to be addressed (Kuokkanen et al., 2018; Wojtynia et al., 2021).

3.3.5. Agroecology

Agroecology is a production system that contests the conventional perspective of human control over nature and recognises humans as an integral part of the natural ecosystem. It challenges the assumptions of industrial or conventional agriculture with its reliance on substantial inputs such as chemical fertilisers, pesticides, mechanisation, and genetic technologies. It recognises soil as a living ecosystem interacting with the environment through dynamic biological processes (Giagnocavo et al., 2022). Agroecology proposes that the answer to the established unsustainable agrifood system

 doi:10.20944/preprints202405.1807.v1

lies in connecting with ecosystem services and the concept of natural capital in contrast to a technology-driven approach (Pellizzoni & Centemeri, 2022). Therefore, sustainable transitions from an agroecology perspective require a holistic long-term view that recognises the evolving complex and interacting biological systems involved in transitioning to more sustainable production practices (Vermunt et al., 2020). Systematic regime change therefore evolves over a long period and requires time for farmers to learn and adopt new practices that work with the natural systems (Giagnocavo et al., 2022).

Vermunt et al. (2020) argue that sustainability transitions in agrifood systems do not conform to the predominant transition models of socio-technical transitions in other sectors such as mobility and energy. This is due to place-based dependencies where landscapes show significant differences in geographical, biophysical and ecological dimensions. Furthermore, the public good nature of environmental sustainability requires incentive mechanisms for established farmers to adopt more sustainable practices. Agroecological principles also advocate for closer interaction between producers and consumers, enabling the latter to have a greater understanding of the biological processes in food production and a deep connection to the natural environment (Giagnocavo et al., 2022; Mehrabi et al., 2022).

Agroecology makes a distinct contribution to sustainable transitions literature due to its explicit acknowledgement of the complex biological systems involved in food production. It emphasises that supporting sustainability transitions requires an understanding of these natural systems and the adoption of agroecological principles that work with the natural environment to achieve more sustainable outcomes.

4. Discussion and Conclusion

4.1.1. Key Findings

This paper provides the first systematic review of the literature on the Sustainable Transitions Research Network theme of firms and industries in agrifood sustainability transitions. It demonstrates the significant development of this literature which has progressed from being a "marginal topic" El Bilali (2019, p. 358) to a significant body of work across multiple themes. These themes include agriculture, innovation, food systems, governance and agroecology each shedding light on different aspects of agrifood sustainability transitions in firms and industries.

Agriculture and transitions stressed the importance of on-farm sustainability practices due to the major impact that agricultural production has on the environment. As a result, there is increasing recognition of farmers as key actors in the process of sustainability transitions at the farm production level. It highlights the significant challenges faced by individual farmers in adopting sustainability practices. These include power dynamics between farmers and large corporate agribusiness firms and food retailers that resist change and perpetuate the status quo. There are also barriers to the adoption of technical innovations that may improve sustainability due to the lack of financial resources and limited technical skills of smaller-scale farmers. The critical role of individual farmers necessitates understanding the diverse motivations for farmers implementing sustainable farming practices.

Establishing disruptive innovations in the food system has been a core concept in bringing about the transformation of the established regime. However, the analysis highlights that incremental innovations can evolve from within the dominant regime and can also result in significant change. Another important aspect of the literature on sustainable innovations is that there is growing awareness of the complex interconnected nature of agrifood systems and, for change to occur, sustainable innovations need to simultaneously occur at multiple stages of the agrifood system from production through to consumption.

The review of the governance literature provides insight into interventions that can potentially influence sustainability transitions. It highlights that although governments and policymakers play an important role in the management of transitions, they can also be affected by embedded political interests that can influence and lead to policies that support the status quo. Furthermore, transition governance faces significant challenges due to the complexity of agrifood systems. These systems

 doi:10.20944/preprints202405.1807.v1

have high levels of uncertainty, complexity, ambiguity and distributed control, which combined with emergence means, outcomes of governance interventions are highly uncertain.

Food system transformation faces significant challenges. There is currently no consensus on the definition of the concept of sustainability with multiple definitions that focus on different aspects of sustainability. In many cases, certain systems are promoted as sustainable agrifood systems without clear evidence of how this is determined. For example, AFN's aim to transform or replace conventional agrifood systems. However, they lack clear evidence of sustainability credentials, face challenges in scaling up, and often struggle to be independent of existing supply chains. Furthermore, there is evidence that the established agrifood systems may adopt some aspects of AFNs and may incorporate sustainability practices due to the influence of shareholders, customers and consumers.

The agroecology literature emphasises the complex biological processes and ecosystems involved in agricultural production. This biological aspect of sustainability transition is less recognized in the main body of sustainability literature that has developed from energy and transportation systems. The literature is therefore more aligned with the incremental innovation perspective. In agrifood systems, biological ecosystems evolve and change over time and changes in farming practices may only be evident in the long term. The agroecology perspective also highlights the importance of the farmer in this process and advocates for support for farmers to adopt agroecological production practices.

The review makes a significant contribution to the literature on sustainability transitions in agrifood systems. It highlights the critical role that individual farmers play in the adoption of sustainability practices. It emphasises that incremental innovations that emerge within the established agrifood system can lead to significant change. Key challenges to the governance of agrifood systems are identified in particular as influencing complex agrifood systems. It identifies the lack of consensus regarding definitions of sustainability and the need for clear measures of environmental impact. Agroecology makes an important contribution highlighting the importance of the complex biological aspects of agrifood systems.

4.2. Research Gaps and Future Research

This review identifies a number of gaps in the research and potential avenues for future research. Firstly, there is a need to expand the geographical scope of the research to non-western countries addressing critical issues of scarcity of resources, food safety, security and access to affordable nutritious food. Given the central role of agriculture and food in these economies, this is an urgent focus for research. Furthermore, there is a need to broaden the current Eurocentric focus of the research to develop a global perspective on agrifood sustainability transitions.

Secondly, there is an opportunity for research to focus on the dynamics of the current food system and if there can be substantial change generated from within. Research could identify the role of both disruptive and incremental innovations and the role of the influence of external landscape factors in supporting change. This could focus on the role of governments and regulations in supporting sustainability transitions and understanding how these affect the established regime and niches in sustainability transitions.

Thirdly, there is a need to empirically evaluate definitions of "sustainability" and validate the claims of sustainability of various alternative agrifood systems. There also is the opportunity to operationalise sustainability with concepts such as planetary boundaries (Willett et al., 2019), sustainable development goals (Hák et al., 2016) and the social, environmental and economic sustainability framework.

Finally, there is an opportunity to broaden the research methodology from the primary use of case study analysis and the MLP. This could involve comparative case studies across regions and industries as well as empirical studies that can enhance the ability to generalise study findings and test theoretical assumptions.

 doi:10.20944/preprints202405.1807.v1

4.3. Theoretical Contribution

The review makes a valuable contribution to sustainable transitions theory by describing the development of the literature on agrifood sustainability transitions providing insight into the role of firms and industries. It highlights the development of key themes which include transitions in agriculture, innovation, food systems, governance and agroecology. The contribution of these themes to the wider body of agrifood transitions theory is identified and explained. Key contributions include the critical role of individual farmers and the effect of power dynamics in their adoption of sustainability practices. The effects of both disruptive and incremental innovations are highlighted and their potential for them to drive significant change including from within the regime. Furthermore, the review highlights governance challenges relating to the complexities of agrifood systems. The perspective of agroecology provides an important contribution to understanding the complex biological systems involved in agrifood systems. The review of the existing research provides a foundation for future research and the development of theory in the study of sustainable transitions in agrifood firms and industries.

4.4. Implications for Managers and Policymakers

The focus on firms and industries has significant implications for managers and policy makers. For managers involved in sustainability initiatives within established agrifood firms, it identifies the key challenges and opportunities for driving transformational change. The insights from agroecology, incremental innovation, sustainable agricultural production systems and the important role of farmers can inform strategies for effectively implementing sustainable practices.

The review is relevant for policymakers seeking to support sustainable transitions in the agrifood industry. Understanding how specific interventions can influence change is an important priority. Furthermore, for policy makers the insights into the challenges of governance of complex agrifood systems, as well as the role of individual farmers and the opportunities of agroecological practices can assist in the design of regulatory and policy interventions. The review also showed the interconnected nature of different stages of the food systems and emphasised the importance of engaging with actors at all stages of the supply chain to achieve transformational change.

Appendix A. List of Papers

Reference	Definition of sustainability	Methodology	Sample	Theoretical framework
Agriculture				
(Davidson et al., 2016). Food safety risks, disruptive events and alternative beef production: A case study of agricultural transition in Alberta.	Alternative food producers, organic production.	Case study	Alternative beef producers, Alberta, Canada	Sustainable transitions theory. Multi-Level perspective
(Hackfort, 2023). The power of corporate lock-ins and how they shape digital agriculture in Germany	Critique of agro-industrial farming models	Case study	Stakeholders in the German agriculture industry	Political economy
(Horn et al., 2023). Translating Environmental Potential to Economic Reality: Assessment of Commercial Aquaponics through Sustainability Transitions	Circular economy	Semi-structured interviews, literature, and policy review	American aquaponic producers	Technology innovation system framework, Multi-Level Perspective (MLP).
(Kinniburgh, 2023). The politics of expertise in assessing alternatives to glyphosate in France.	Alternatives to pesticide use (glyphosate)	Case study	Actors in the agricultural sector and experts in pesticide policy	Boundary work concept
(McInnes, 2019). Integrating sustainability transitions and food systems research to examine consultation failures in Canadian food policymaking	Food sovereignty	Case study	Canadian food policy making	Multi-Level Perspective (MLP)
(Pant et al., 2014) Adaptive transition management for transformations to agricultural sustainability in the Karnali mountains of Nepal.	Resilience, biodiversity	Single case study	Karnali mountains Nepal	Multi-Level Perspective (MLP). Adaptive transition management
(Swaffield et al., 2019) Connecting business with the agricultural landscape: business strategies for sustainable rural development.	Agricultural landscape sustainability	Multiple case studies	Four cases of business-landscape engagement	Landscape perspective
(van der Gaast et al., 2022). Conceptualizing sustainable food entrepreneurship	Relocalisation	Literature review and case study	Dutch city region of Almere-Flevoland	Sustainable food entrepreneurship framework
(van Oers et al., 2021). Unlearning in sustainability transitions: Insight from two Dutch community-supported agriculture farms.	Community-supported agriculture	Case study	Phase out and ban on battery cages for laying hens in the Netherlands	Political economy
(Viola & Mendes, 2022). Agriculture 4.0 and climate change in Brazil.	low carbon/climate change	Single case study	Brazilian agribusiness	Multi-Level Perspective (MLP).
(Williams et al., 2023). Synthesising the diversity of European agri-food networks: A meta-study of actors and power-laden interactions.	None	Meta-analysis	European case studies	

doi:10.20944/preprints202405.1807.v1

(Wojtynia et al., 2023). Spheres of transformation: Exploring personal, political and practical drivers of farmer agency and behaviour change in the Netherlands	Regenerative farming practices	Case study	Dutch farmers adopting regenerative farming practices	Spheres of transformation
References in other clusters	Cluster			
(Giagnocavo et al., 2022)	Agroecology			
(McInnes, 2019)	Food system			
(Farhangi et al., 2020)	Food System			
(Manuel-Navarrete & Gallopín, 2012)	Governance			
(van der Gaast et al., 2022).	Innovation			
(van Oers et al., 2021	Food System			
(Kinniburgh, 2023)	Governance			
Innovation				
(Block et al., 2023) Selecting technologies to engage in sustainability transitions—A multi-stakeholder perspective.	Sustainability transitions from a fossil-based toward a bio-based economy	Mixed-method research design	Stakeholders from multiple stages of the value chain	Transition theory. Selection criteria for Sustainability Orientated Technologies SOT's
(Bui, 2021) Enacting transitions—the combined effect of multiple niches in whole system reconfiguration.	Organic farming	Ethnographic study and archival work	Drôme valley in southeast France	Multi-level perspective
(El Bilali, 2018). Relation between innovation and sustainability in the agro-food system.	UN Sustainable development goals	Literature review	Sustainability literature	Multi-Level Perspective (MLP).
(Kuokkanen et al., 2018) Agency in regime destabilization through the selection environment: The Finnish food system's sustainability transition	Nutrient recycling, vegetarian diet and organic foods	Discourse analysis	Finish food system	Tripple embeddedness framework. Agency in the selection environment
(Kuokkanen et al., 2019) A framework of disruptive sustainable innovation: An example of the Finnish food system.	Reduced meat consumption, local food, direct farm sales, Organic production	Multiple case studies	Finnish food system	Practice-based view on disruptive innovation, Multi-Level Perspective (MLP).
(Long, et al., 2019). The diffusion of climate-smart agricultural innovations: Systems level factors that inhibit sustainable entrepreneurial action	Earth system biophysical threasholds, climat smart agriculture	QP-=[]'P Multi-Level Perspective (MLP).	Semistructured interviews. Climate smart providers and policy makersAZ	Multi-Level Perspective (MLP). Entrepreneurial ecosystem persperctive

doi:10.20944/preprints202405.1807.v1

(Marletto & Sillig, 2019). Lost in mainstreaming? Agrifood and urban mobility grassroots innovations with multiple pathways and outcomes	Grassroots innovation: Fairtrade, organic, veganism, carsharing, cycling, and shared space.	Multiple case studies	Grass root innovations	Sustainability transitions framework
(Meynard et al., 2017). Designing coupled innovations for the sustainability transition of agrifood systems.	Reduced energy use, increased biodiversity, improved soil and water quality, decreased pesticide use, preventing nutritional deficits and obesity	Multiple case study	Examples of coupled innovations	Multi-Level Perspective (MLP), Innovative design theory
(Trotter et al., 2023). The role of supply chains for the sustainability transformation of global food systems: A large-scale, systematic review of food cold chains.	Sustainable development goals	Literature review	Food cold chain	None
(van der Gaast et al., 2022). Conceptualizing sustainable food entrepreneurship	Relocalisation	Literature review and case study	Dutch city region of Almere-Flevoland	Sustainable food entrepreneurship framework
Governance				
(Dedeurwaerdere, et al., 2017). The governance features of social enterprise and social network activities of collective food buying groups	Collective food buying groups	Semi-structured questionsnaire	104 collective buying groups, Belgium	Sustanablity transitions theory
(Halbe & Pahl-Wostl, 2019). A methodological framework to initiate and design transition governance processes	Alternate food systems, urban farming, community gardens, local production	Single case study	Sustainable Food Systems, Ontario, Canada	Multi-Level learning processes
(Horn et al., 2023). Translating Environmental Potential to Economic Reality: Assessment of Commercial Aquaponics through Sustainability Transitions Theory	Aquaponic food production, circular economy	Semi-structured interviews	25 North American producers	Technological Innovation System (TIS) assessment Multi-Level Perspective (MLP)
(Kinniburgh, 2023). The politics of expertise in assessing alternatives to glyphosate in France.	Reduced pesticide use.	Single case study	French pesticide regulation on glyphosate alternatives	Concepts of co-production and boundary work
(Marletto & Sillig, 2019). Lost in mainstreaming? Agrifood and urban mobility grassroots innovations with multiple pathways and outcomes	Grassroots innovation: Fairtrade, organic, veganism, carsharing, cycling, and shared space.	Multiple case studies	Grass root innovations	Sustainability transitions framework
(Manuel-Navarrete & Gallopín, 2012). Feeding the world sustainably: Knowledge governance and sustainable agriculture in the Argentine Pampas.	No-till practices. Reduced soil degradation and ecosystem disruption	Single case study	Argentine farmers	Actor centred approach

doi:10.20944/preprints202405.1807.v1

(Rossing et al., 2021) Crafting actionable knowledge on ecological intensification: Lessons from co-innovation approaches in Uruguay and Europe	Ecological intensification	Six case studies from three co-innovation projects.	Co-innovation research projects in Uruguay and Europe	Complex adaptive systems, social learning, dynamic monitoring and evaluation
(Vinnari & Vinnari, 2014) A Framework for Sustainability Transition: The Case of Plant-Based Diets.	Social, Economic, environmental, cultural, and ethical dimensions of sustainability	Case study	Plant-based diets	Sustainability transitions theory
Food system				
(Aschemann-Witzel et al., 2023). Outside-in and bottom-up: Using sustainability transitions to understand the development phases of mainstreaming plant-based in the food sector in a meat and dairy focused economy.	Planetary boundaries, Reduce GHG, land use change and biodiversity loss	Semi-structured interviews with businesses and experts	Denmark plant-based products	Multi-Level Perspective (MLP).
(Audet et al., 2017). Structuring tensions and key relations of montreal seasonal food markets in the sustainability transition of the agri-food sector.	Local food, seasonal production	Action research, case study	Three Montreal seasonal food markets	Multi-Level Perspective (MLP)
(Bui et al., 2019). Systemic ethics and inclusive governance: two key prerequisites for sustainability transitions of agri-food systems	Small-scale production, local food	Case study	Belgian supermarkets	Sustainability transitions perspective
(Bui et al., 2019) Systemic ethics and inclusive governance: Two key prerequisites for sustainability transitions of agri-food systems	local, low-input, small-scale farmers' products	Case study	local sourcing in Belgian supermarkets	Sustainability transitions perspective
(Bulah et al., 2023) Incumbent entry modes and entry timing in sustainable niches: The plant-based protein transition in the United States, Netherlands, and United Kingdom	Plant-based meat substitutes	Multiple case studies	Firms adopting plant-based meat substitutes in the US, The Netherlands and the UK.	Entry mode theory
(Crivits et al., 2018).Using policy discourses to open up the conceptual space of farm education: inspiration from a Belgian farm education network	Small-scale artisan bakers	Case study	Australian baking industry	Multifactor productivity
(Desa & Jia, 2020). Digital fooding, cashless marketplaces and reconnection in intermediated third places: Conceptualizing metropolitan food provision in the age of prosumption.	Sustainable food systems	Desktop analysis	Review of special issue literature in the journal Agriculture and Human Values	Sustainable development goals

doi:10.20944/preprints202405.1807.v1

(Donati et al., 2023). The evolutionary emergence of quintuple helix coalitions: A case study of place-based sustainability transition	Local food production, short supply chain, production and sales of ancient grains (wheat varieties)	Case study	Value chain of ancient wheat varieties in Tuscany	Triple Helix
(Farhangi et al., 2020) High-tech urban agriculture in Amsterdam: An actor-network analysis	High-tech urban agriculture	Case study	Amsterdam: Hi technology urban agriculture	Actor-network theory, /Multi-Level perspective, Technology driven transition framework
(Gonera et al., 2023). Incumbents' capabilities for sustainability-oriented innovation in the Norwegian food sector—An integrated framework.	UN Sustainable development goals	Multiple case study	Norwegian food sector	Theory of dynamic capabilities
(Marinova et al., 2022). China and changing food trends: A sustainability transition perspective	Reduced environmental footprint and better human diets. Planetary boundaries	Desktop analysis of literature and secondary data.	Online sources related to major societal shifts in food consumption and production.	Transition theories
(McInnes, 2019). Integrating sustainability transitions and food systems research to examine consultation failures in Canadian food policymaking	Food sovereignty	Case study	Canadian food policy making	Multi-Level Perspective (MLP)
(Stephens & Barbier, 2021). Digital fooding, cashless marketplaces and reconnection in intermediated third places: Conceptualizing metropolitan food provision in the age of prosumption.	Local food (>250 km)	Case study	Ruche digital platform for food provisioning in France	Pro-Sumption
(van Oers et al., 2023). Unlearning in sustainability transitions: Insight from two Dutch community-supported agriculture farms.	Alternative food networks	Case study	Two Dutch Community Supported Agriculture groups	Organisational change theory, Sustainability transitions perspective
(Wojtynia et al., 2021). A new green revolution or agribusiness as usual? Uncovering alignment issues and potential transition complications in agri-food system transitions.	Identified issues: Agrochemical use, Biodiversity, antibiotic uses	Vision documents for Dutch agricultural transition	Dutch agrifood system	Mission-orientated perspective, Visioning
(Ribeiro & Turner, 2021) Sustainability buckets: A flexible heuristic for facilitating strategic investment on place-dependent sustainability narratives	Nourish the body, nourish the planet, socially just relationships, circular economy and economic viability	Two case studies	New Zealand egg sector and honey distributor	Multi-level perspective, sustainability cultures

References in other clusters	Cluster
(Bui et al., 2019)	Innovation

doi:10.20944/preprints202405.1807.v1

(Marletto & Sillig, 2019).	Innovation			
(Davidson et al., 2016).	Agriculture			
Agroecology				
(Giagnocavo et al., 2022). Reconnecting farmers with Nature through agroecological transitions: Interacting niches and experimentation and the role of agricultural knowledge and innovation systems.	Agroecology	Case study	Greenhouse sector, Almeria, Spain	Multi-Level perspective, agroecological frameworks
(Horn et al., 2023) Rranslating environmental potential to economic reality: Assessment of commercial aquaponics through sustainability transitions theory	Sustaining ecosystem services	Vision documents for Dutch agricultural transition	Dutch agrifood system	Mission-orientated perspective, Visioning
(Mehrabi et al., 2022). The role of consumer-citizens and connectedness to nature in the sustainable transition to agroecological food systems: The mediation of innovative business models and a Multi-Level perspective.	Agroecology		Theoretical	Multi-Level Perspective (MLP).
(Vermunt et al., 2020) Sustainability transitions in the agrifood sector: How ecology affects transition dynamics	Biodiversity enhancement	Case study of four biodiversity initiatives	Dutch dairy sector	Multi-Level Perspective (MLP), Innovation system perspective
(Pellizzoni & Centemeri, 2022). Tackling material dependency in sustainability transition: Rationales and insights from the agriculture sector	Addressing the ecological crisis	Descriptive	Agriculture	Material dependency
References in other clusters	Cluster			
(Horn et al., 2023).	Governance/Agriculture			

doi:10.20944/preprints202405.1807.v1

 doi:10.20944/preprints202405.1807.v1

References

Ahmad, K. (2001). Global population will increase to nine billion by 2050. *The Lancet*, *357*(9259), 864.

Aschemann-Witzel, J., Mulders, M. D. G. H., & Mouritzen, S. L. T. (2023). Outside-in and bottom-up: Using sustainability transitions to understand the development phases of mainstreaming plant-based in the food sector in a meat and dairy focused economy. *Technological Forecasting and Social Change*, *197*. https://doi.org/10.1016/j.techfore.2023.122906

Audet, R., Lefèvre, S., Brisebois, É., & El-Jed, M. (2017). Structuring tensions and key relations of montreal seasonal food markets in the sustainability transition of the agri-food sector. *Sustainability*, *9*(3), 320.

Béné, C. (2022). Why the Great Food Transformation may not happen–A deep-dive into our food systems' political economy, controversies and politics of evidence. *World Development*, *154*, 105881.

Block, C., Rennings, M., & Bröring, S. (2023). Selecting technologies to engage in sustainability transitions—A multi-stakeholder perspective. *Business Strategy and the Environment*, *32*(6), 3569-3595.

Boliko, M. C. (2019). FAO and the situation of food security and nutrition in the world. *Journal of Nutritional Science and Vitaminology*, *65*, 4-8.

Bui, S. (2021). Enacting transitions—The combined effect of multiple niches in whole system reconfiguration. *Sustainability*, *13*(11), 6135.

Bui, S., Costa, I., De Schutter, O., Dedeurwaerdere, T., Hudon, M., & Feyereisen, M. (2019). Systemic ethics and inclusive governance: Two key prerequisites for sustainability transitions of agri-food systems. *Agriculture and Human Values*, *36*(2), 277-288. https://doi.org/10.1007/s10460-019-09917-2

Bulah, B. M., Tziva, M., Bidmon, C., & Hekkert, M. P. (2023). Incumbent entry modes and entry timing in sustainable niches: The plant-based protein transition in the United States, Netherlands, and United Kingdom. *Environmental Innovation and Societal Transitions*, *48*, 100735.

Crivits, M., De Krom, M. P., Block, T., & Dessein, J. (2018). Using policy discourses to open up the conceptual space of farm education: Inspiration from a Belgian farm education network. *Environmental Education Research*, *24*(9), 1320-1339.

Davidson, D. J., Jones, K. E., & Parkins, J. R. (2016). Food safety risks, disruptive events and alternative beef production: a case study of agricultural transition in Alberta. *Agriculture and Human Values*, *33*(2), 359-371.

Dedeurwaerdere, T., De Schutter, O., Hudon, M., Mathijs, E., Annaert, B., Avermaete, T., Bleeckx, T., de Callataÿ, C., De Snijder, P., Fernández-Wulff, P., Joachain, H., & Vivero, J. L. (2017). The governance features of social enterprise and social network activities of collective food buying groups. *Ecological Economics*, *140*, 123-135.

Desa, G., & Jia, X. (2020). Sustainability transitions in the context of pandemic: An introduction to the focused issue on social innovation and systemic impact. *Agriculture and Human Values*, *37*(4), 1207-1215. https://doi.org/10.1007/s10460-020-10129-2

Donati, L., Stefani, G., & Bellandi, M. (2023). The evolutionary emergence of quintuple helix coalitions: A case study of place-based sustainability transition. *Triple Helix*, *3*(3), 1-31. https://doi.org/10.1163/21971927-12340010

El Bilali, H. (2018). Relation between innovation and sustainability in the agro-food system. *Italian Journal of Food Science*, *30*(2), 200-225.

El Bilali, H. (2019). Research on agro-food sustainability transitions: A systematic review of research themes and an analysis of research gaps. *Journal of Cleaner Production*, *221*, 353-364.

El Bilali, H., Strassner, C., & Ben Hassen, T. (2021). Sustainable agri-food systems: Environment, economy, society, and policy. *Sustainability*, *13*(11), 6260.

Elsevier. (2024). *Agricultural Systems - Aims & Scope*. Retrieved 9th January from https://www.sciencedirect.com/journal/agricultural-systems

Ezeh, A. C., Bongaarts, J., & Mberu, B. (2012). Global population trends and policy options. *The Lancet*, *380*(9837), 142-148.

Farhangi, M. H., Turvani, M. E., van der Valk, A., & Carsjens, G. J. (2020). High-tech urban agriculture in Amsterdam: An actor network analysis. *Sustainability*, *12*(10).

Gaitán-Cremaschi, D., Klerkx, L., Duncan, J., Trienekens, J. H., Huenchuleo, C., Dogliotti, S., Contesse, M. E., & Rossing, W. A. H. (2019). Characterizing diversity of food systems in view of sustainability transitions. A review. *Agronomy for Sustainable Development*, *39*(1). https://doi.org/10.1007/s13593-018-0550-2

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8-9), 1257-1274.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24-40.

Geels, F. W. (2014a). Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework. *Research Policy*, *43*(2), 261-277.

Geels, F. W. (2014b). Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, culture & society*, *31*(5), 21-40.

 doi:10.20944/preprints202405.1807.v1

Geels, F. W., & Schot, J. (2007). Typology of socio-technical transition pathways. *Research Policy*, *36*(3), 399-417.

Giagnocavo, C., de Cara-García, M., González, M., Juan, M., Marín-Guirao, J. I., Mehrabi, S., Rodríguez, E., van der Blom, J., & Crisol-Martínez, E. (2022). Reconnecting farmers with Nature through agroecological transitions: Interacting niches and experimentation and the role of agricultural knowledge and innovation systems. *Agriculture*, *12*(2), 137. https://doi.org/10.3390/agriculture12020137

Godfray, H. C. J., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Nisbett, N., Pretty, J., Robinson, S., Toulmin, C., & Whiteley, R. (2010). The future of the global food system. *Philosophical Transactions of the Royal Society: Biological Sciences*, *365*(1554), 2769-2777. https://doi.org/10.1098/rstb.2010.0180

Gonera, A., Nykamp, H. A., & Carraresi, L. (2023). Incumbents' capabilities for sustainability-oriented innovation in the Norwegian food sector—An integrated framework. *Circular Economy and Sustainability*, *3*(3), 1299-1326. https://doi.org/10.1007/s43615-022-00234-1

Gosnell, H., Gill, N., & Voyer, M. (2019). Transformational adaptation on the farm: Processes of change and persistence in transitions to 'climate-smart'regenerative agriculture. *Global Environmental Change*, *59*, 101965.

Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C. L., & Anis, A. H. (2009). The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. *BMC Public Health*, *9*(1), 1-20.

Hackfort, S. (2023). Unlocking sustainability? The power of corporate lock-ins and how they shape digital agriculture in Germany. *Journal of Rural Studies*, *101*.

Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators*, *60*, 565-573.

Halbe, J., & Pahl-Wostl, C. (2019). A methodological framework to initiate and design transition governance processes. *Sustainability*, *11*(3).

Horn, E. K., Joyce, A., Chowdhury, R. B., Caputo, S., Jacobs, B., Winkler, M., & Proksch, G. (2023). Translating Environmental Potential to Economic Reality: Assessment of Commercial Aquaponics through Sustainability Transitions Theory. *Circular Economy and Sustainability*, 1-32.

Keating, C. B., Katina, P. F., Pyne, J. C., & Jaradat, R. M. (2017). Systemic intervention for complex system governance development. The American Society for Engineering Management 2017 International Annual Conference.,

Kinniburgh, F. (2023). The politics of expertise in assessing alternatives to glyphosate in France [Article]. *Environmental Science and Policy*, *145*, 60-72. https://doi.org/10.1016/j.envsci.2023.01.017

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, *103*(6), 390-400.

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M. S., . . . Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental Innovation and Societal Transitions*, *31*, 1-32. https://doi.org/10.1016/j.eist.2019.01.004

Kuokkanen, A., Nurmi, A., Mikkilä, M., Kuisma, M., Kahiluoto, H., & Linnanen, L. (2018). Agency in regime destabilization through the selection environment: The Finnish food system's sustainability transition. *Research Policy*, *47*(8), 1513-1522.

Kuokkanen, A., Uusitalo, V., & Koistinen, K. (2019). A framework of disruptive sustainable innovation: An example of the Finnish food system. *Technology Analysis & Strategic Management*, *31*(7), 749-764.

Lachman, D. A. (2013). A survey and review of approaches to study transitions. *Energy Policy*, *58*, 269-276.

Long, T. B., Blok, V., & Coninx, I. (2019). The diffusion of climate-smart agricultural innovations: Systems level factors that inhibit sustainable entrepreneurial action. Journal of Cleaner Production, 232, 993-1004.

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: Transforming science and practice for societal change. *Annual Review of Environment and Resources*, *42*, 599-626.

Manuel-Navarrete, D., & Gallopín, G. C. (2012). Feeding the world sustainably: Knowledge governance and sustainable agriculture in the Argentine Pampas. *Environment, Development and Sustainability*, *14*, 321-333.

Marinova, D., Bogueva, D., Wu, Y., & Guo, X. (2022). China and changing food trends: A sustainability transition perspective. *Ukrainian Food Journal*, *11*(1), 126-147. https://doi.org/10.24263/2304-974X-2022-11-1-13

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955-967.

Marletto, G., & Sillig, C. (2019). Lost in mainstreaming? Agrifood and urban mobility grassroots innovations with multiple pathways and outcomes. *Ecological Economics*, *158*, 88-100.

McInnes, A. (2019). Integrating sustainability transitions and food systems research to examine consultation failures in Canadian food policymaking. *Journal of Environmental Policy and Planning*, *21*(4), 407-426.

Mehrabi, S., Perez-Mesa, J. C., & Giagnocavo, C. (2022). The Role of Consumer-Citizens and Connectedness to Nature in the Sustainable Transition to Agroecological Food Systems: The mediation of innovative

business models and a Multi-Level Perspective. *Agriculture*, *12*(2), 203. https://doi.org/10.3390/agriculture12020203

Meynard, J.-M., Jeuffroy, M.-H., Le Bail, M., Lefèvre, A., Magrini, M.-B., & Michon, C. (2017). Designing coupled innovations for the sustainability transition of agrifood systems. *Agricultural Systems*, *157*, 330-339.

OECD. (2022). *How we feed the world today*. Retrieved 4 November from https://www.oecd.org/agriculture/understanding-the-global-food-system/how-we-feed-the-world-today/

Pant, L. P., Bahadur, K., Fraser, E. D., Shrestha, P. K., Lama, A. B., Jirel, S. K., & Chaudhary, P. (2014). Adaptive transition management for transformations to agricultural sustainability in the Karnali mountains of Nepal. *Agroecology and Sustainable Food Systems*, *38*(10), 1156-1183.

Pellizzoni, L., & Centemeri, L. (2022). Tackling material dependency in sustainability transition: Rationales and insights from the agriculture sector. *Journal of Environmental Policy & Planning*, *24*(3), 355-366.

Ribeiro, B., & Turner, J. A. (2021). Sustainability buckets: A flexible heuristic for facilitating strategic investment on place-dependent sustainability narratives. *Sustainability*, *13*(16).

Rossing, W. A. H., Albicette, M. M., Aguerre, V., Leoni, C., Ruggia, A., & Dogliotti, S. (2021). Crafting actionable knowledge on ecological intensification: Lessons from co-innovation approaches in Uruguay and Europe. *Agricultural Systems*, *190*, 103103.

Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy*, *41*(6), 1025-1036.

Stephens, R., & Barbier, M. (2021). Digital fooding, cashless marketplaces and reconnection in intermediated third places: Conceptualizing metropolitan food provision in the age of prosumption. *Journal of Rural Studies*, *82*, 366-379. https://doi.org/10.1016/j.jrurstud.2020.11.009

Sustainability Transition Research Network. (2021, 2022). Retrieved July 2022 from https://transitionsnetwork.org/

Swaffield, S. R., Corry, R. C., Opdam, P., McWilliam, W., & Primdahl, J. (2019). Connecting business with the agricultural landscape: Business strategies for sustainable rural development. *Business Strategy and the Environment*, *28*(7), 1357-1369.

Trotter, P. A., Becker, T., Renaldi, R., Wang, X., Khosla, R., & Walther, G. (2023). The role of supply chains for the sustainability transformation of global food systems: A large-scale, systematic review of food cold chains. *Journal of Industrial Ecology*.

UNICEF. (2022). *In brief to the state of food security and nutrition in the world 2022*. FAO, IFAD, UNICEF, WFP and WHO.

United Nations. (2022). *World Population Prospects 2022, Online Edition.* Department of Economic and Social Affairs, Population Division. Retrieved October from https://population.un.org/wpp/

Van den Ende, J., & Kemp, R. (1999). Technological transformations in history: How the computer regime grew out of existing computing regimes. *Research Policy*, *28*(8), 833-851.

van der Gaast, K., van Leeuwen, E., & Wertheim-Heck, S. (2022). Food systems in transition: Conceptualizing sustainable food entrepreneurship. *International Journal of Agricultural Sustainability*, *20*(5), 705-721. https://doi.org/10.1080/14735903.2021.1969163

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538.

van Oers, L., Feola, G., Moors, E., & Runhaar, H. (2021). The politics of deliberate destabilisation for sustainability transitions. *Environmental Innovation and Societal Transitions*, *40*, 159-171.

van Oers, L., Feola, G., Runhaar, H., & Moors, E. (2023). Unlearning in sustainability transitions: Insight from two Dutch community-supported agriculture farms. *Environmental Innovation and Societal Transitions*, *46*. https://doi.org/10.1016/j.eist.2023.100693

Verbong, G., & Geels, F. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy*, *35*(2), 1025-1037. https://doi.org/10.1016/j.enpol.2006.02.010

Vermunt, D. A., Negro, S. O., van Laerhoven, F., Verweij, P. A., & Hekkert, M. P. (2020). Sustainability transitions in the agri-food sector: How ecology affects transition dynamics. *Environmental Innovation and Societal Transitions*, *36*, 236-249. https://doi.org/10.1016/j.eist.2020.06.003

Vinnari, M., & Vinnari, E. (2014). A framework for sustainability transition: The case of plant-based diets. *Journal of Agricultural and Environmental Ethics*, *27*(3), 369-396.

Viola, E., & Mendes, V. (2022). Agriculture 4.0 and climate change in Brazil. *Ambiente & Sociedade*, *25*.

Visser, M., van Eck, N. J., & Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative Science Studies*, *2*(1), 20-41. https://doi.org/10.1162/qss_a_00112

WHO. (2021). *Obesity and overweight*. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

 doi:10.20944/preprints202405.1807.v1

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., & Wood, A. (2019). Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, *393*(10170), 447-492.

Williams, T. G., Bui, S., Conti, C., Debonne, N., Levers, C., Swart, R., & Verburg, P. H. (2023). Synthesising the diversity of European agri-food networks: A meta-study of actors and power-laden interactions. *Global Environmental Change*, *83*. https://doi.org/10.1016/j.gloenvcha.2023.102746

Wojtynia, N., van Dijk, J., Derks, M., Groot Koerkamp, P., & Hekkert, M. (2021). A new green revolution or agribusiness as usual? Uncovering alignment issues and potential transition complications in agri-food system transitions. *Agronomy for Sustainable Development*, *41*(6), 1-20.

Wojtynia, N., van Dijk, J., Derks, M., Groot Koerkamp, P., & Hekkert, M. (2023). Spheres of transformation: Exploring personal, political and practical drivers of farmer agency and behaviour change in the Netherlands. *Environmental Innovation and Societal Transitions*, *49*.