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CAN CLIMATE-SMART AGRICULTURE HELP TO ASSURE FOOD SECURITY THROUGH SHORT SUPPLY CHAINS? A SYSTEMATIC BIBLIOMETRIC AND BIBLIOGRAPHIC LITERATURE REVIEW

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Abstract. *Purpose* – This paper aims to reveal potential research possibilities for enhancing climate-smart agriculture through short supply chains.

Research question – How can short supply chains assure food security and the promotion of climate-smart agriculture?

Research methodology – Bibliographic and bibliometric coupling techniques were employed using data from 1990–2022. The raw data was processed using the VOSviewer 1.6.18 software version.

Findings – The results confirm the positive effect of the systemically important relationship between the short supply chain and food security.

Research limitations – Climate-smart agriculture is a complex and multifaceted phenomenon. Additional variables may have moderating and mediating effects on the impact of short supply chains on food security.

Practical implications – The results establish the importance of having a short supply chain for food security in different aspects of the process from the harvest to the table.

Originality and value – This study confirms the rationale for developing shorter food supply chains to assure food security and climate-smart agriculture when possible.

Keywords: climate-smart agriculture, food security, short supply chain, bibliographic analysis, VOSviewer.

JEL Classification: Q18, Q19.

Introduction

The coronavirus pandemic, which began in 2019, and the 2022 war in Ukraine are the main causes of disruption to the food distribution network (Benedek et al., 2021; Barrett, 2020).

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Sustainability and the food supply chain (from production to consumption) are the key challenges in terms of food loss and waste (FAO et al., 2021; Stanciu et al., 2022). One option for solving this problem is reflected in a growing trend towards a diet based on local products (Constantin et al., 2021). The traditional structure of the supply chain has several limitations within the process (Mirabelli & Solina, 2019). The number of actors in a long supply chain depends on the complexity of the product's production and the ability of one manufacturer to carry out all possible work to enable the product to be used by the end customer (Molnár et al., 2010). Short food supply chains (SFSCs) are recognised as innovative options with the potential to control prices and be independent of other parties (Ilbery & Maye, 2005; Aleksiev & Petrova, 2021). Having a short food supply chain also benefits the producer, who can create a larger one for added value, and the consumer, who receives healthier food from a shorter distance. Supply chain risk can lead to internal and external disturbances (Li et al., 2018; Rauschmayer et al., 2015) regarding sustainability, food security and food waste. Sustainable supply chain management (SSCM) is important not only for the optimisation of the process but also for food security (Tuomala & Grant, 2021). Supply chains can be categorised by different characteristics (e.g., type of product, market demand), which are usually related to food security (Castro & Jaimes, 2017).

1. A brief literature review on the nexus between food security and the short supply chain

Problems concerning food waste were identified in the 1980s by the Food and Agriculture Organization [FAO] and centred on food security and the fight against hunger. As Tuomala and Grant (2021) have identified, security and access to food are dimensions directly related to sustainable development and, thus, to the topics of food security and food waste. The inefficiency of the food supply chain is characterised by two aspects: first, it is a disruption (e.g., pandemic, war) and a dynamic environment, and second, it is the length of the supply chain and the need to compromise between sustainability and economic functioning (Vojtovic et al., 2016; Torero, 2020). Because the full cycle (from the farm to the table) is compressed to meet deadlines and maintain production efficiency, supply chain design must rely on logistics and warehousing functions (Gružauskas et al., 2018; Xue et al., 2017; Diaz-Ruiz et al., 2018; Krishna Bahadur et al., 2016) as the main aspects for preventing food loss. Magalhães et al. (2019) have identified 15 main causes of food loss, including lack of infrastructure and technical management, inefficient storage management, lack of coordination and exchange of information, lack of pricing strategies and advertising management, overproduction and inadequate demand forecasting (Magalhães et al., 2019). Disruptions of transport traffic can also play an important role in reducing the supply chain system efficiency (Castro & Jaimes, 2017). Diaz-Ruiz et al. (2018) categorise the reasons that lead to food security, loss and waste at three different levels: (a) micro-level causes (e.g., packaging); (b) meso-level causes (e.g., infrastructure); and (c) macro-level causes (e.g., purchasing options). Inefficiencies in the food supply chain, leading to food security problems, loss and the generation of waste take place across all of these stages (Hartikainen et al., 2018; Raak et al., 2017).

The Covid-19 pandemic has had a significant impact on the food security and food supply chain, adding to the rapid increase of food insecurity compared to the pre-Covid-19

period. Pandemics impact food security and cause disruption to the GFSC (global food security supply chain) as well (Alabi & Ngwenyama, 2022).

The food supply chain is influenced by multiple different parties, such as politicians, retailers, society and manufacturers, and farmers/growers (Mithun Ali et al., 2019). The FAO et al. (2013) has identified the need to focus on food loss and waste generation in the initial stages of the food supply chain from the farm/growing area to the distribution stage. In the European context, there are two types of food supply chains: local food systems (LFS) and short supply chains (SFSC) (Floris & Schwarcz, 2018). From a global perspective, the food supply chain usually includes the stages of farm, processing, wholesale, retail and consumer. Many different elements comprise these stages, and each element can influence food loss and waste (Chauhan et al., 2021). A short supply chain has fewer negative impacts (Aleksiev & Petrova, 2021) on food security because of the distance between production and consumption. The quality of the food is mainly reflected in the losses, as it is important to measure food security. It is affected by several feedback loops: two cycles of positive feedback cycles or reinforcement. One of the aspects of the short supply chain is the "local food system", in which the production, processing, marketing and consumption of food takes place in a limited geographic area (Todorova, 2020). The main positive aspect of food supply chains is the number of intermediaries (in principle, using the minimum number is preferable). The ideal is to have direct contact between the producer and the consumer. There are different groups of possible systems, including "community-supported agriculture" and "member states" (Todorova, 2020), and the main issues include direct communication (consumer–producer) and transportation (e.g., farm shops, pick-your-own).

Jarzebowski et al. (2020) classify factors into three groups: (1) creation of short food supply chains (product know-how, innovations, regulatory frameworks and government policies); (2) product development in the short food supply chain (efficient application of technology, investment of time and money, collective branding); and (3) access to market (online sales, sales to local communities) (Hoang, 2021).

Sellitto et al. (2018) have identified nine factors present in the short food supply chain: environmental friendliness of operations; specificity of territorial brands; direct and ethical relationships between producers and consumers; organic production; food safety and traceability; cultural heritage; consumers' health; origin identification of products; and local work and cooperation.

Researchers have found that the supply chain evaluated by the structure has different problems with food security (Castro & Jaimes, 2017). The lack of investment in the agriculture sector is identified as a major barrier to ensuring food security (Kaur, 2021). This finding stresses the importance of the first – economic dimension of climate-smart agriculture.

The main factors influencing food security, loss and waste in the food supply chain in the context of climate-smart agriculture

Beausang et al. (2017) identify pre-harvest conditions and actions in the field that can lead to subsequent losses in the food supply chain due to *differences in the quality at harvest*; specifically, contracts may undersupply quantities more than necessary, and promotions by retailers can manage waste. Janousek et al. (2018) indicate that food producers, retailers and consumers experience financial losses associated with food waste stemming from direct

losses, sales losses and the cost of waste management (Buzby & Hyman, 2012; Gunders, 2012; Hickey & Ozbay, 2014). Peira et al. (2018) analyse the management of unsold products and how operators act in such situations. All of these aspects could be identified as stakeholders' attitudes and their importance for food loss and waste, as well as food security in the food supply process. The second important factor is poor management of spoilable foods. Zhu (2017) states that a dynamic pricing policy supported by a traceability system could significantly reduce food waste and improve retailers' performance. Rijpkema et al. (2014) confirmed that the management of the retailer can effectively supply products of appropriate quality with acceptable levels of product waste and security. Product specifications are an important tool in supply chains for managing the quality levels of products offered to (end) customers (de Hooge et al., 2018). This fact confirms and adds additional aspects according to Devin and Richards (2018), who emphasise strict privacy standards as a key to food waste issues in the fresh food supply chains of industrialised countries. Buyer–supplier contracts and agreements that enforce strong conditions for deliveries and unsold products are considered to potentially lead to waste, as food chain operators with greater bargaining power have a "tendency" to shift the risk and costs of unsold products to weaker operators through free returns of last-minute cancellations (Mena et al., 2011; Devin & Richards, 2018). Supply chain interruptions could be identified as several different elements, but Teller et al. (2018) related them to retail operations such as in-store logistics, out-of-stock prevention and the occurrence of waste in the store. In general, Teller et al. (2018) opine that logistics and marketing aspects with not such big idea for food loss and waste prevention. Shelf space in the store is very important when considering food loss and waste (Yang et al., 2017; Grzybowska et al., 2014). Research by Goossens et al. (2019) has proved that secondary packaging in food loss, waste and food security aspects are very important and in some cases can create losses in the distribution stage, although customers can waste food as well. From another point of view, Wohner et al. (2020) note that packaging itself is a problem due to shape, composition, and other factors. The problem regarding quality standards may be invisible because significant amounts of goods are left in the field and will never be transported to the consumer (Gillman et al., 2019). Even food products that do reach retailers can be stopped because of quality and cannot be redistributed (Hermsdorf et al., 2017). Edible products can be removed from the commercial food supply chain, being rejected as outtrades deemed cosmetically defective due to market-based decisions (McKenzie et al., 2017).

In general, a short food supply chain is more environmentally friendly and results in less loss and waste, but it is not always a feasible alternative.

2. Methodology

Various bibliographic coupling techniques are proposed as a research tool to achieve a systematic review of the literature (Habib & Afzal, 2019; Morkunas & Balezentis, 2021; Maseda et al., 2022). Bibliographic coupling is a particularly useful research technique when investigating interdisciplinary (Thurner et al., 2020) or newly derived concepts (Shah et al., 2019). Our research satisfies both of these criteria, as food security is being researched in a variety of disciplines, including economics (Tweeten, 1999; De Haen & Hemrich, 2007; Stevano et al.,

2020), environmental science (Workie et al., 2020), agricultural and plant science (Reddy, 2015; Opitz et al., 2016; Ulian et al., 2020), sociology (Carolan, 2016; Bhandari, 2017) and management (McLaughlin & Kinzelbach, 2015; Abdelkader & Elshorbagy, 2021). Short supply chains appear in fields such as logistics-related research (Paciarotti & Torregiani, 2021), agricultural research (De Fazio, 2016), economics (Kiss et al., 2019) and sustainability science (Kamble et al., 2020). Thus, our research concepts are of a truly interdisciplinary nature. The novelty of our research is confirmed by the information provided in Figure 1, which shows that research on short supply chains under the food security concept has gained momentum only after 2018.

Numerous studies aimed at systematic literature reviews employing various bibliographic coupling procedures (Yu et al., 2020; Abdullah & Naved Khan, 2021; Morkunas et al., 2022) suggest a procedure that determines explicit inclusion and exclusion criteria. These criteria are illustrated in Table 1.

Table 1. Inclusion and exclusion criteria for research

Inclusion criteria	Exclusion criteria
paper included short supply chain and food security subjects among its keywords	paper focused on other research domains
paper is in English	paper is in other than English language
paper is longer than 6,800 characters	paper is shorter than 6,800 characters
paper has been peer reviewed	paper has not undergone a peer review procedure

Multiple rationales motivated the selection of the inclusion criteria noted in Table 1. For one, we are investigating the development of science in short supply chains under the food security domain. We are not fluent in any other scientific language except English. In addition, English is the primary scientific language in the world (Ferguson et al., 2011). Moreover, typical scientific papers are at least four pages long (Morkunas & Balezentis, 2021), which typically equates to more than 6,800 characters (excluding spaces). Lastly, although we do not question the scientific integrity of the Clarivate DB, which we used as a source for our research, and its rigorous peer review procedures, some of the papers in Clarivate DB are not peer reviewed. For example, some editorial addresses or letters are not appropriate subjects for a peer review procedure. Thus, we excluded such documents from our research.

Our research was carried out on 5 May 2022. The keywords used were "food security AND short supply chain". The research sources were articles published in outlets included in the Clarivate Analytics Master Journal List. The time span was 1990–2022. The raw data was processed using VOSviewer 1.6.18 software version.

3. Results

3.1. Bibliometric analysis

Our research produced 134 publications that satisfied the predetermined inclusion criteria. The first publication appeared in 1999, indicating that research on short supply chains in the context of assuring food security represents quite a recent topic. However, as Figure 1

shows, specific research in the area of food security and short supply chains only gained momentum in 2018, confirming the relevance of the current study in analysing trends in a recently emerging research area.

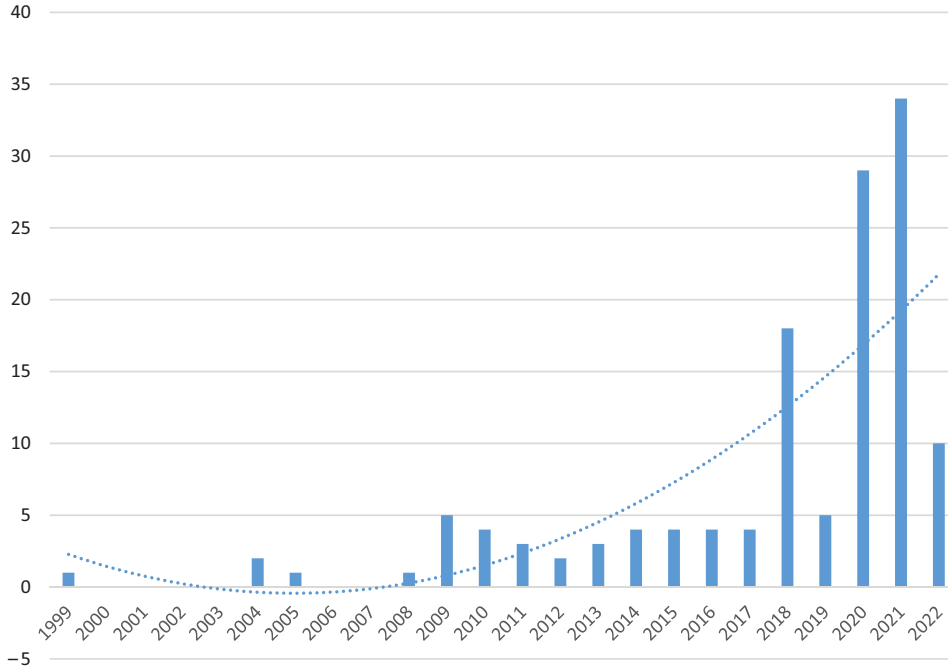

Figure 1. Number of publications in food security and short supply chain area, 1990–2022

When analysing the specific journals that have been most engaged in the area of short supply chains and food security, we identified one polarising centre for the dissemination of scientific knowledge in the area: Sustainability (ISSN 2071-1050), which has published more than 10% of all scientific papers in the field. The remaining scientific outlets have not produced more than 2–3% of all published materials and do not appear to exercise a significant influence on the development of knowledge in the food security and short supply chain area (see Table 2).

Table 2. Scientific outlets most engaged in the dissemination of knowledge in the food security and short supply chain area, 1990–2022

Journal	Number of publications related to food security and short supply chains
SUSTAINABILITY	14
GLOBAL FOOD SECURITY –AGRICULTURE POLICY ECONOMICS AND ENVIRONMENT	4
ACTA HORTICULTURAE	3
AGRICULTURAL SYSTEMS	3

End of Table 2

Journal	Number of publications related to food security and short supply chains
AGRONOMY (BASEL)	3
FOOD AND ENERGY SECURITY	3
SCIENCE OF THE TOTAL ENVIRONMENT	3
BRITISH FOOD JOURNAL	2
CHINA AGRICULTURAL ECONOMIC REVIEW	2
FRONTIERS IN SUSTAINABLE FOOD SYSTEMS	2
IOP CONFERENCE SERIES: EARTH AND ENVIRONMENTAL SCIENCE	2
JOURNAL OF AGRIBUSINESS IN DEVELOPING AND EMERGING ECONOMIES	2
LAND	2
NATO SCIENCE FOR PEACE AND SECURITY SERIES C: ENVIRONMENTAL SECURITY	2

A comparative analysis of countries and geographic entities which are the most involved in research on short supply chains in the context of food security was not as easily ascertained as the analysis of scientific publications (Table 2). The leading country is the United States, closely followed by the United Kingdom. Other countries heavily involved in this area of research include Italy, Australia and India. Notably, the 13 countries listed in Table 3 account for 100% of the research in the area (134 out of 134).

Table 3. Countries and geographic entities most engaged in the dissemination of knowledge regarding food security and short supply chains, 1990–2022

Country	Number of publications
USA	31
UK	21
Italy	13
Australia	10
India	9
PRC	8
Spain	8
Canada	7
Kenya	6
Netherlands	6
Brazil	5
France	5
Romania	5

3.2. Bibliographic coupling analysis

In total, five clusters with 130 links and a total link strength of 216 were identified during the bibliographic coupling procedure.

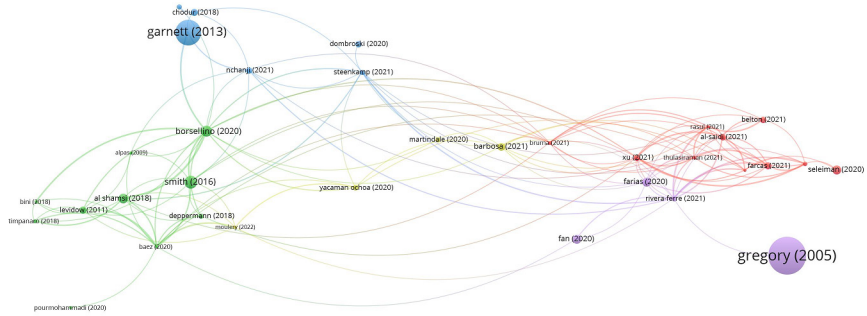

Figure 2. Bibliographic coupling of research in the food security and short supply chain area, 1990–2022

We start our analysis with a violet cluster (please see Figure 2) which has 15 links and a total link strength of 34. Although some may find the study by Gregory et al. (2005) to be the polarising element within the network, the largest number of links (thus, the strongest networking influence) is displayed by the Rivera-Ferre et al. (2021) study on the effects of the Covid-19 pandemic on food security. Similar tendencies are being displayed by the blue cluster, where the network polarising study is considered to be Garnett's study on food sustainability (2013), although the Nchanji and Lutomia (2021) research covers the broadest scope in the science, with nine links and total link strength of 11. Once again, the study about the effects of the Covid-19 pandemic on the resilience of food systems appears to be the most influential. The green cluster seems more balanced than the previous ones. It has two focal items authored by Smith et al. (2016) and Borsellino et al. (2020), the latter being the most influential with 17 links and a total link strength of 37. The red cluster also displays a balanced character with quite equal weights of network items and dense links within the network. The leading, although not dominating, item is Xu's et al. (2021) research about the compound effects of the Covid-19 pandemic on food security and food supply chains. The smallest cluster (here, the yellow one) displays not only the lowest number of items within the network but also the least density and importance to the development of the science. The loose bounds and small weight of the network items indicate that they are only loosely connected. The most important item within the network is Barbosa's (2021) bibliometric study about the management of the agri-food supply chain. It displays a total link strength of 11, achieved by 11 links. This correspondence between total link strength and number of links indicates that this study does not have explicitly expressed relationships with any of the other scientific publications.

The density map (Figure 3) illustrates that there are no overlying heat areas, so the research in this area is quite fragmented, not allowing identification of the main research streams. Two studies, namely Gregory et al. (2005) and Garnett (2013), dominate the scientific landscape in the area.

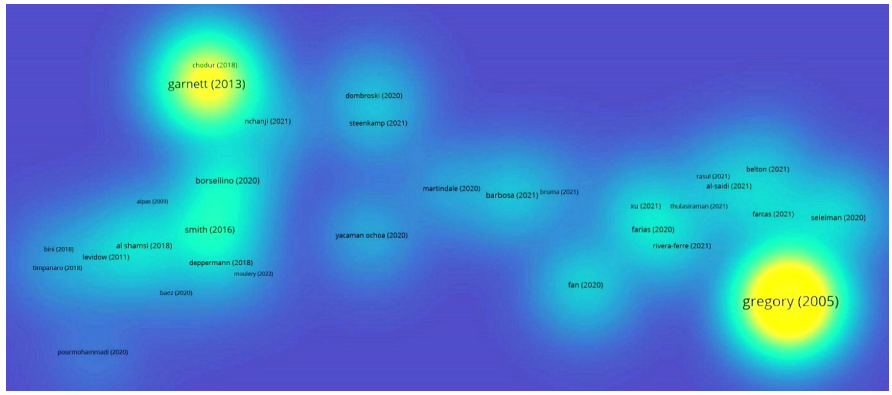

Figure 3. Density map of bibliographic coupling of research in the food security and short supply chain area, 1990–2022

Generalising this part of the research, it appears that from a scientific perspective, food security and short supply chains started being more intensively researched together only after the Covid-19 pandemic outbreak. It may be a shortcoming, as Ilbery and Maye (2005) have previously demonstrated, that short supply chains were not identified earlier as a solution to food security problems. And if researched earlier, they may have helped to feed a substantial portion of the world population much earlier.

3.3. Citation analysis

The citation analysis (Figure 4) also revealed five main clusters in the area. The corresponding number of clusters obtained during bibliographic coupling and co-citation analysis confirms the robustness of the research results. All five clusters contain 120 items with 1,393 links and a total link strength of 1,594.

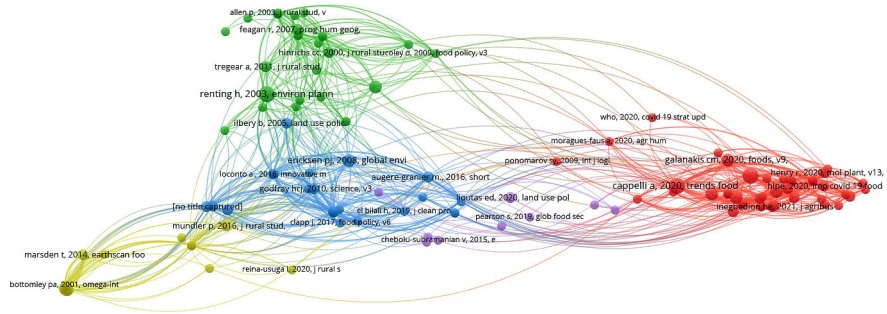

Figure 4. Citation analysis of research in the food security and short supply chain area, 1990–2022

The dense red cluster is centred around Hobbs' (2020) research, with 38 links and a total link strength of 53. Analysing network-to-network dependency, we found moderate relationships with blue and green clusters and only weak interdependences with violet and yellow clusters, indicating the distinctiveness of the red cluster research, which is generally based on the Covid-19 effects on food supply chains and networks. The green cluster is based on

more conceptual research focusing on the food supply industry in general and its influence on the various forms of rural development. The leading article is the Marsden et al. (2020) study on the impact of various forms of food supply chains on the development of rural regions. This study has 39 links and a total link strength of 43. The most influential is Renting's et al. (2003) research aimed at disclosing the positive effects short food supply chains have on rural development. The blue cluster is focused on various issues related to food security and the possible role of short supply chains in it. It is being dominated by the Godfray et al. (2010) conceptual study aimed at raising discussion about the drawbacks that the world must accept in a quest to feed a population that is approaching 9 billion people. Its total link strength is 41, achieved by 36 links. The yellow cluster can be viewed as a methodological one. This cluster is dominated by research investigating various new approaches for supply selection in food supply chains, risk measurement methods and similar topics. The leading study is Forman and Penivati (1998), which examined adjustments to the analytical hierarchy process (AHP) individual judgement scales. The least important is the violet cluster, which has the fewest number of items, and the relationship between network participants is the weakest. The most important study is Lioutas and Charatsari's (2020) investigation of the possibility of integrating short supply chains into the smart farming concept. Its total link strength is 20, with 20 links. This research is also related to three of the four remaining clusters (blue, red and green).

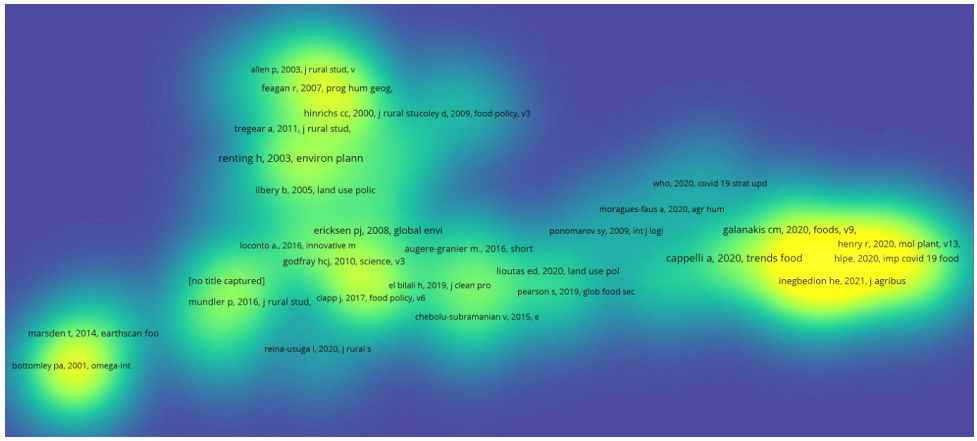

Figure 5. Density map of citation analysis of research in the food security and short supply chain area, 1990–2022

The density analysis (Figure 5) clearly indicates the extreme proximity of the red cluster research – the studies aimed at investigating possible solutions to food security problems that are offered by short supply chains in the wake of the Covid-19 pandemic. The distinctiveness of the research comprising the role of the short supply chain in the evolution of rural areas can also be observed.

In view of these findings, we can conclude that based on co-citation analysis, we revealed the following scientific trends: short supply chains are seen as one of the factors for rural development, and another emerging research direction is to consider a short supply chain as a possible response to food shortages that have been intensified by the Covid-19 pandemic.

3.4. Keywords analysis

The keywords analysis (Figure 6) provided 21 clusters with 290 items, which are bonded by 2,059 links, with a total link strength of 2,125.

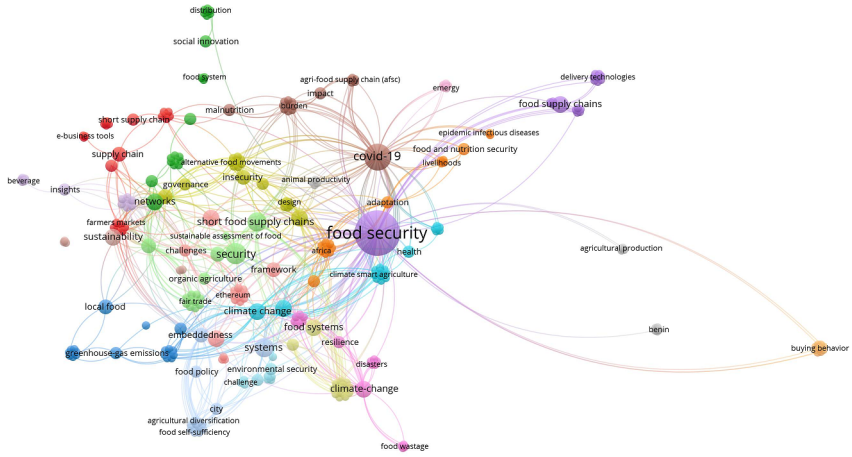

Figure 6. Keywords analysis of research in the food security and short supply chain area, 1990–2022

The overwhelming majority of network influence is executed by the food security concept, displaying a total link strength of 243, with 204 and 28 occurrences which (together with concepts of food supply chains and delivery technologies) comprise the violet cluster. The brown cluster is focused on the Covid-19 pandemic and its influence on malnutrition, food supply and agri-food supply chains (particularly in Africa). It has 69 links, with a total link strength of 78 and 10 occurrences. Three different clusters (blue, light blue and purple) are focused on various aspects of climate change. In all of this research, short supply chains are considered one of the focal actors in mitigating climate change. The blue cluster is more oriented toward micro-level agricultural interventions helping to facilitate local food production and short supply chains. The focal keyword is "greenhouse gas emissions", with 21 links and a total link strength of 21 in three occurrences. Light blue is more oriented towards macro-level actions and policy measures in supporting short supply chains as an approach to lowering the carbon footprint. The main keyword in this cluster is "climate change", with 30 links, a total link strength of 34, and four occurrences. The purple cluster focuses on the resilience and vulnerability of food systems in light of climate change. The most frequent keyword here is "climate change", with 39 links, a total link strength of 43, and four occurrences. The light green cluster evaluates food security through the lens of alternative agri-food networks. The most influential keyword in this network is "security", with a total link strength of 72 in 64 links and six occurrences.

In sum, we can state that a significant part of the research on food security and short supply chains falls under a broader climate-change-mitigation umbrella. Another significant research direction is a response to the Covid-19 pandemic and resulting food security issues. A smaller yet significant research direction is aimed at solving food security challenges with the help of short supply chains in the least developed countries, in particular sub-Saharan Africa.

Conclusions

The short supply chain management in the context of climate-smart agriculture covers several unique aspects of sustainability, including food loss and food waste, but food security is the most important. All aspects are even more important because of unusual situations such as the pandemic (Covid) or war (in Ukraine). Accordingly, producers and farmers are taking increasing care regarding food security in supply chain management. The wider implementation of short supply chains provides more leverage and bargaining power for farmers, thus improving their economic position. This action strengthens not only the economic but also the social dimension of climate-smart agriculture.

Analysis of short supply chain management shows a clear solution for the food security (and food waste) issue in the context of climate-smart agriculture: its short supply chain management and local food system (where possible). Both solutions are related to having as short of a supply chain as possible between the producer/farmer and the consumer.

The bibliometric analysis proves that the investigation of short supply chains in the context of food security is a new and promising research avenue. Current research is focused on a few directions, namely Covid-19-induced challenges to food security, environmental concerns and climate change mitigation policies, which represent the adaptation facet of the climate-smart agriculture concept.

Due to the novelty of the idea, the research on short supply chains in the context of food security is highly polarised. All 100% of the publications were produced by 13 leading countries in this particular research area. This situation requires urgent attention, as climate-smart agriculture initiatives as well as food shortage supply chains are context-sensitive; thus, the solutions offered must be tailored to local needs. The expansion of the research geography would allow solving food security problems in a greater number of struggling countries, especially in Africa and Southeast Asia, where food security remains a major issue (Chan et al., 2019).

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