19-osios jaunųjų mokslininkų
konferencijos straipsnių rinkinys

JAUNASIS MOKSLININKAS

VYTAUTO DIDŽIOJO UNIVERSITETO ŽEMĖS ŪKIO AKADEMIJA

ISSN 2335-7940 (spausdintas)
ISSN 1822-9913 (internetinis)

SUSTAINABLE FOOD PRODUCTION CHAINS; FOOD SUPPLY CHAIN MANAGEMENT

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Summary

As the public's knowledge of food quality, safety, and freshness grows, FSCM is under growing pressure to satisfy these standards. How can present FSCM be upgraded and transformed to meet the ever-increasing demands of the future? This paper provides an up-to-date review of FSCM systems, implementations, and global movements. Supply chain network structure, data collecting, decision-making models, and implementations are highlighted as current issues and future views.

Keywords: Food Supply Chain Management(FSCM), Sustainable Food Value Chains(SFVC), Sustainable Food Supply Chain Management(SFSCM), Systematic Literature review, Alternative Food Supply Chain(AFSC), Food and Agricultural Organization(FAO), Food Supply Chain (FSC)

Introduction

As the world's population grows, so does the demand for more food, which necessitates a greater supply of high-quality raw materials for the food sector. However, there is concern on the supply side about how the sector will respond to rising demand in terms of quality and yield gains, which are being influenced by variables such as climate change, water scarcity, land use, and reduced returns for agricultural farmers.

Over the next 50 years, the world's population is predicted to grow by one-third (to more than 2 billion people), but the amount of land and water available for agriculture will not increase (Connor and Minguez 2012) and is more likely to diminish owing to urbanization, land erosion, and pollution (IAASTD 2009; Royal Society 2009; FAO 2011).

Further increases in productivity are needed to meet the demand for agricultural products, which is being driven by a growing global population and an improved standard of living in many emerging economies (Rosegrant and Cline 2003; Tilman et al. 2011), but environmental sustainability is also becoming a more important issue globally (Rosegrant and Cline 2003; Tilman et al. 2011), but environmental sustainability is also becoming a more important issue globally (Edwards et al. 1990; Evans 1998; Charles and Godfray 2011; Tilman et al. 2011).

FAO defines sustainable food value chains (SFVC) as "the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based societal benefits, and does not permanently deplete natural resources," according to FAO.

While the food sector continues to grapple with issues such as food security, waste, farming, and public health, new issues such as climate change, oil reliance, fair trade, and localism have emerged. There is growing concern about the food industry's social and environmental sustainability. Basic questions that had previously faded from everyday life are becoming more important to debate – whether food can be supplied, distributed, and consumed in a more sustainable manner without compromising costs; how should standards and technologies be used to improve sustainable development, minimize food waste, and reduce operating costs; and what will be the impacts of standards and technologies on the way food supply chains operate. It is critical for food industry stakeholders to look beyond their organizational borders in order to build a sustainable food supply chain that includes environmental, economic, market, technological, social-economic factors and scientific considerations.

Research aim: The major goal of this special issue on "Sustainable Food Supply Chain Management" (SFSCM) is to reflect on recent developments in this field and to look into research concerns related to analysis and decision support at strategic, operational, and technological levels. Key difficulties and research challenges in the management of a sustainable food supply chain are discussed in this editorial.

The following **objectives** have been set to achieve the aim:

- To provide an overview of the food industry by examining consumer satisfaction in depth.
- To define key research themes in the literature of SFSC and how they contribute towards enhancing sustainability in FSC.
- To analyze the directions in which research in these research themes should be advanced.

Research object and methods

The research technique used in this review of Sustainable food production chain literature is presented in this section. This paper takes a strategy that includes a systematic literature review (SLR), bibliometric analysis, and theme analysis.

For analysis, the current study's research goal necessitates a combination of SLR, bibliometric analysis, and theme analysis. Finding review material is the initial phase in the technique, followed by a comprehensive literature search.

The second step was to conduct literature screening using a set of inclusion and exclusion criteria to determine which papers should be read in-depth.

From the Scopus database, a preliminary data set of 440 entries for the selected article was generated. This data set was further examined using descriptive and bibliometric analysis techniques, analyzed the yearly trend in the number of papers published, the most cited publications, and the authors with the most papers. For the bibliometric analysis step, I employed the bibliographic coupling method.

When two articles quote one or more common documents, this is known as a bibliographic coupling (Rialti et al., 2019). The larger the number of frequently referenced publications in a bibliographic pair, the more likely they are to share the same research theme.

The methodology's first four steps are quantitative and are based on a Scopus database analysis. Many major topics can only be recognized after a comprehensive reading of the articles and qualitative thematic analysis, and the study themes that emerge may not reflect the full of the SFSC area. Mayring (2014) explains how a theme analysis method was employed, and it was also applied in this study (Seuring and Mu, 2008). To complete the major study themes in SFSC, the research papers considered for bibliometric analysis were examined in-depth, and significant themes discovered from each publication were coded and clustered. The results of the methods described above are shown next.

Research results

The regression coefficients in the model (Figure 1) show how the variables interact with one another. On the basis of Kline's values, standard coefficients are discussed (2011). These numbers are classed as having a low effect of 0.10, a medium effect of 0.30, and a high effect of >0.50. (Kline, 2011). Simultaneously, the coefficients of determination (R2) are computed to analyze the links between the model's latent variables. The coefficient of determination ranges from 0 to 1, indicating that the model's explanatory power increases as it approaches 1.00.

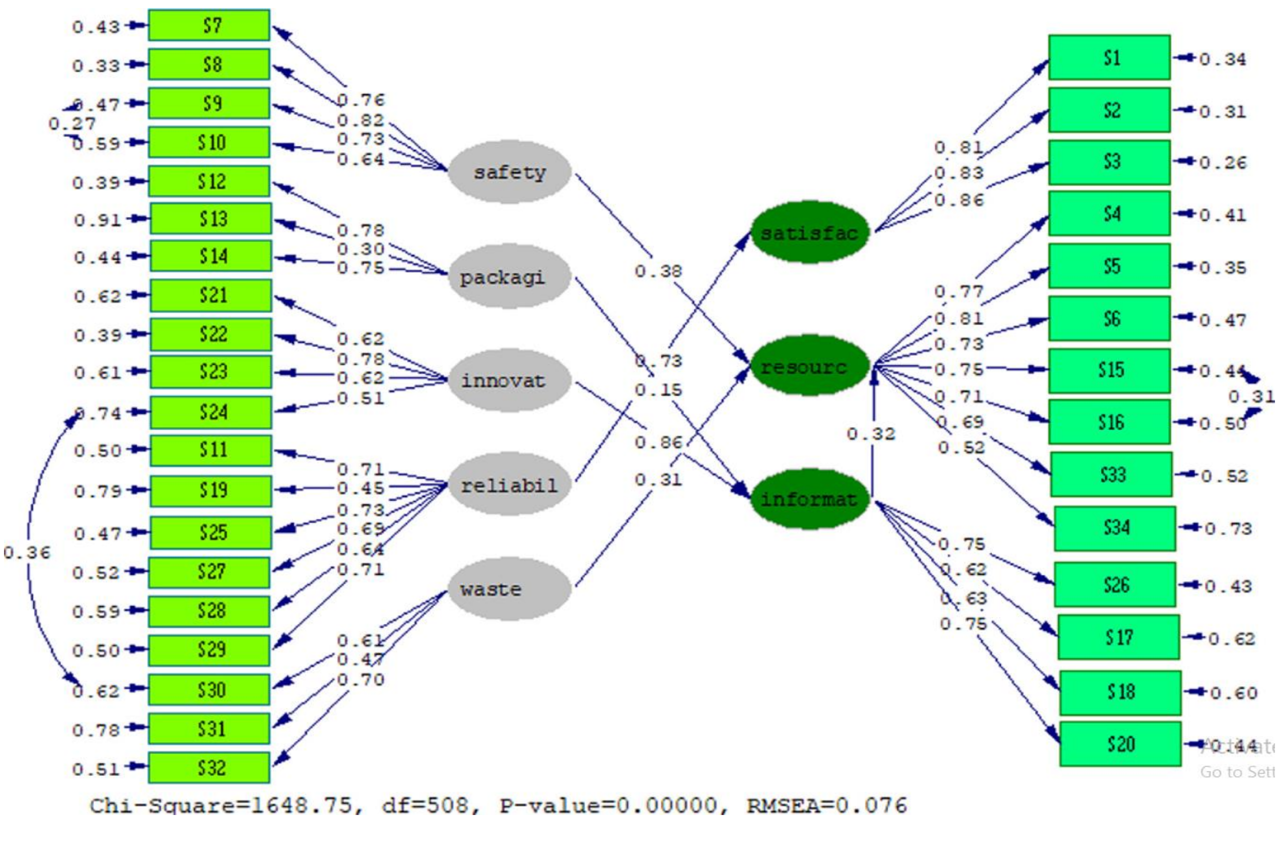

Fig 1. Structural model of the sustainable food supply chain performance index.

When the model's impacts are investigated, it turns out that the criterion of resolved customer complaints has the strongest link with the customer satisfaction component (= 0.86). They have a positive and meaningful relationship. The resolved customer complaints criterion appears to explain 74 per cent of the hidden variable of customer happiness. The association between customer happiness and the level of after-sales service among the customer criteria for the client has a coefficient of 0.83, indicating that the relationship is substantial.

This criterion is seen to explain 69 per cent of the hidden variable of customer happiness. The association between the satisfaction dimension and the last measuring variable, the ability to respond quickly to customers, is likewise quite strong (= 0.81). At a rate of 61 per cent, the ability to reply to customers quickly describes the dimension of customer happiness. These measurement factors have a large (>0.50) effect on the latent variable of customer satisfaction in this situation, making them valuable tools for assessing long-term supply chain effectiveness.

Table 1. Standardized λ, error rate, and *R*2 values of the structural equation model.

Latent variables	Measurement variables	λ	Error rate	R^2
Customer satisfaction	Ability to respond instantly to the customer	0.81	0.34	0.66
	After-sales service level for customer	0.83	0.31	0.69
	Resolved customer complaints	0.86	0.26	0.74
Resource utilization	Renewable energy usage	0.77	0.41	0.59
	Eco-friendly product and material usage	0.81	0.35	0.65
	Reduction in consumption of rare products	0.73	0.47	0.53
	Reduction in greenhouse gas emissions in production	0.75	0.44	0.56
	Reduction in greenhouse gas emissions in storage and transportation	0.71	0.50	0.50
	Energy savings in the food supply chain	0.69	0.52	0.48
	Water consumption and water hygiene	0.52	0.73	0.27
Safety of products	Timely delivery	0.76	0.43	0.57
	Selection of protective packaging according to product	0.82	0.33	0.67
	Selection of the type of transport according to the product	0.73	0.47	0.53
	Selection of distribution network according to product	0.65	0.59	0.41
Innovation	Number of innovations for environmental protection (projects related to sustainability)	0.78	0.39	0.61
	Product content improvement time	0.62	0.61	0.39
	Use of waste products for another purpose	0.51	0.74	0.26
	R&D capacity of the company	0.62	0.62	0.38
Reliability	Supplier reliability	0.73	0.47	0.53
	Importance of deliveries	0.69	0.52	0.48
	Order tracking	0.64	0.59	0.41
	Traceability of food products	0.71	0.50	0.50
	Corporate image	0.45	0.79	0.21
	Ensuring food safety	0.71	0.50	0.50
Company information	The efficiency of information flow	0.62	0.62	0.38
	Number of ISO 14000, ISO 22000, HACCP certificates	0.63	0.60	0.40
	Number of supplier partnerships for environmental responsibility	0.75	0.43	0.57
	Environmental awareness of chain employees	0.75	0.44	0.56
Packaging	Use of protective packaging	0.78	0.39	0.61
	Use of aesthetic packaging	0.30	0.91	0.093
	Use of recyclable packaging	0.75	0.44	0.56
Waste management	Number of recycled products	0.61	0.62	0.38
	Waste level during production	0.47	0.78	0.22
	Waste-water treatment cost	0.70	0.51	0.49

Bibliometric analysis. Based on published searches from a reputable database, the bibliometric analysis allows us to create a quantitative map of research trends. We provide here an approach based on the bibliographic coupling to filter out research trends.

Four distinct clusters of articles based on SFSC, colour-coded red, yellow, blue, and green, can be seen. We examined the word co-occurrence in each cluster and assessed articles that represented larger nodes in each cluster to find theoretical viewpoints coming from each cluster (Dixit et al., 2021).

The words in the green cluster, as seen on the word co-occurrence map, can be divided into two groups: one related to AFSC, such as alternate food network, region, farm, market, actor, stakeholder, and so on, and the other related to FSC impact and sustainability assessment, such as impact category, environmental sustainability, life cycle assessment, carbon footprint, cradle, and so on.

Short FSCs, for example, have a favourable impact on local territorial development and communities while also making safe and fresh food products available (Mundler and Laughrea, 2016).

The cluster's second focus is on impact assessment, which has mostly relied on LCA-based methodologies. Scholz et al. (2015) investigated the environmental impact of food waste at the store level, examining the disparity between food waste volume and the carbon footprint of various perishable food waste.

The other two clusters aren't as prominent in this study; one collects publications on SSCM practices, sustainable performance, and the theoretical idea of sustainability in FSCs, while the other cluster concentrates on decision assistance and numerical and mathematical modelling of FSCs.

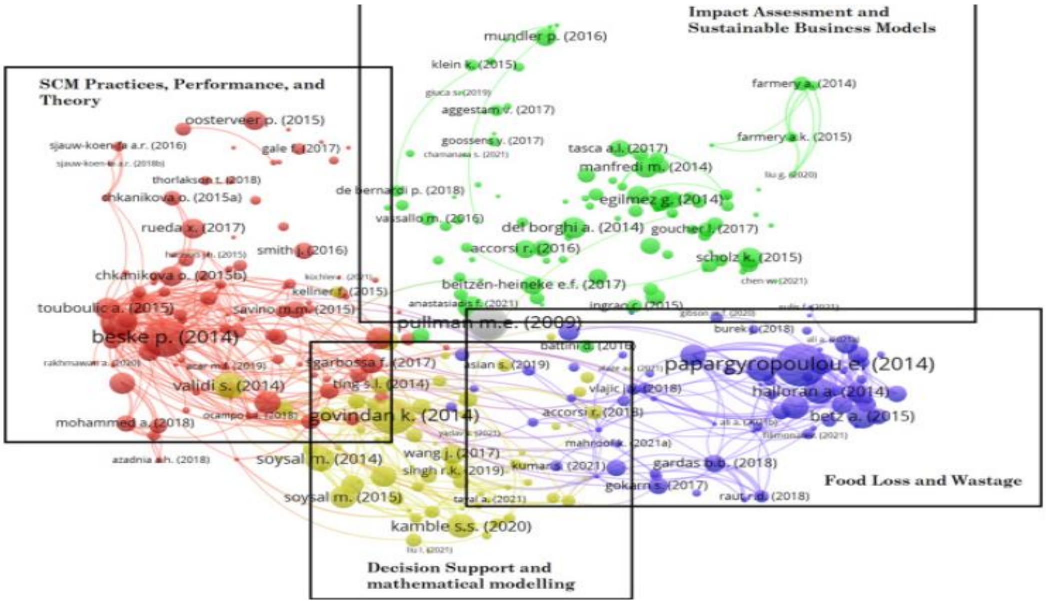

Fig. 2. bibliographic coupling based map

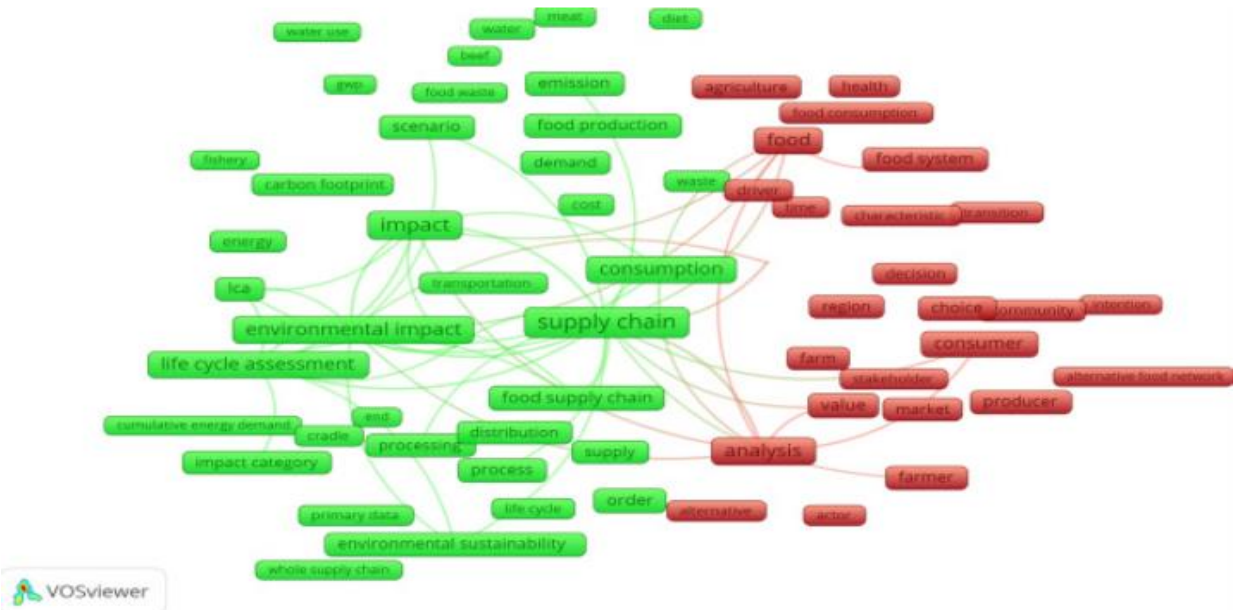

Fig. 3. Word co-occurence map of articles

Thematic analysis of SFSC literature. FSCs cover a wide range of study topics, many of which are different in nature, such as product attributes such as perishability and freshness (Bortolini et al., 2016), environmental performance and impact (Bortolini et al., 2016), and more (Konstantas et al., 2019; Validi et al., 2014), Cost optimization (Sel et al., 2018), efficiency and uncertainty (Govindan et al., 2014), assessing trade-offs between sustainability targets (Fracarolli Nunes et al., 2020), climate change (Oglethorpe and Heron, 2010), sustainable agriculture intensification (Belton et al., 2020), modelling, benchmarking (Yakovleva et al., 2012), and policy-focused research for sustainability in FSC are all topics covered.

In SFSC, there are over a hundred sub-themes that can be identified. Because it is impossible to discuss them all separately, they have been grouped into nine key themes: "Waste management," "SC sustainability and impact assessment," "Decision support," "Operations management and optimization," "Sustainable business models," "Food quality and safety," "Innovation and technological solutions," "SC strategy," and "Social sustainability." We would be discussing a few of the themes.

Discussions

Waste Manangement. Waste management is a major issue in SFSCM, with over a fifth of the total number of papers devoted to it. Food loss and waste (FLW) and post-harvest losses (PHL) are two commonly explored sub-themes in this issue in SFSC (Balaji and Arshinder, 2016). "Food loss" is defined by the United Nations' Food and Agriculture

Organization (FAO) as any qualitative (safety, economic, nutritional, or customer appreciation loss) or quantitative (physical loss) reduction in food (that is intended for human consumption only).

According to the FAO, nearly one-third of all food produced is wasted or lost (Food and Agriculture Organization of the United Nations, 2019). Inadequate market evaluation, climate conditions, usage of non-refrigerated vehicles, bad packaging, poor handling and storage, too many intermediaries, poor post-harvest temporary conditions, and poor market access are some of the reasons cited in the literature. It has been discovered that inadequate supply chain structure and infrastructure-related inefficiencies are the primary causes of PHL and food waste in developing nations. The majority of food waste occurs at the customer level in industrialized countries (Balaji and Arshinder, 2016), with demand side issues playing a big role (Putten et al., 2019). Food wastage in industrialized countries is also influenced by the cosmetic and physical characteristics of food goods (De Hooge et al., 2018).

During our review, we discovered a number of gaps and potential research areas. FSC should investigate waste-producing management techniques. The paper emphasizes a need for further research into FLW management tactics in FSC network architectures. To balance FLW reduction and environmental implications, a mix of FLW reduction and loss treatment options is used (Willersinn et al., 2017). The majority of studies in the literature focused on industrialized countries, according to the findings. Developing countries that rely significantly on livestock should focus their efforts on waste treatment scenarios in which food waste could be used as animal feed (Thi et al., 2015). As a result, a significant research field in developing countries is waste identification, measurement, and waste management solutions. The resources used in food production, as well as the resources used to produce discarded food, are extensively documented, but the resources used in waste management are not (Kibler et al., 2018).Trash management in FSCs is a complicated issue that costs money and necessitates the use of energy and resources to collect, transport, and treat waste. As a result, study into waste management and valorization strategies is required when evaluating these concepts. Furthermore, FSCs consume a lot of energy and water; 'as a result, instead of focusing solely on waste, we must also consider water and energy' (De Amorim et al., 2018).

Decision support. Supplier selection, location, transportation mode , routing , energy mode, capacity, quality, and packaging are all decisions that have a significant impact on SFSC's sustainability. These decisions, as well as the performance meter, driver, impediments, and indicators for strategic, tactical, and operational planning of sustainable practices in FSC, will require support (Chauhan et al., 2018; Ghadge et al., 2017; Mangla et al., 2018).

Supplier management, as well as supplier and sub-supplier compliance, are critical for SFSC. Many papers have discussed pressure from various stakeholders such as the government, customers, and suppliers (Mangla et al., 2018b), company reputation (León-Bravo et al., 2019), training and awareness (Chauhan et al., 2018), and information-related enablers for SFSCM (Chauhan et al., 2018). (Singh et al., 2019). Researchers have recently backed the idea of identifying hurdles to implementing circular economy methods (Farooque et al., 2019; Mangla et al., 2018a). The scientific community is enthusiastic about incorporating sustainability considerations into decisions. It's critical to reconsider decision-making structures in terms of sustainability, and to examine how the use of these elements will affect SC performance.

Food safety and quality. As important as sustainability is, food quality is an inherent aspect of it and a basic requirement of living. Consumers are becoming increasingly concerned and aware about the quality and safety of the food they eat (Zhong et al., 2017). Food waste at the customer end is exacerbated by customer concerns about food quality (Kibler et al., 2018; Srivastava et al., 2015). While food safety is a concern, SFSC also addresses food quality degradation and perishability. Food quality and deterioration are strongly affected by exposure to light, temperature stressors, and mechanical strains during SC activities (Manzini et al., 2014). The use of a cold chain, temperature management, and enhanced packing can all help to avoid quality loss (Zhu et al., 2018).

Traceability has been linked to reduced food loss, product value preservation, cost reduction, decision assistance, enhanced food safety, and customer communication in the literature (Accorsi et al., 2018; Kittipanya-ngam and Tan, 2020; Ringsberg, 2014) In FSCs, traceability can be achieved in two ways: first, logistical traceability, which focuses solely on the product's physical movement and treats food like any other commodity. To better address food safety and standards, qualitative traceability provides information on real-time product quality, logistics conditions, and pre- and post-harvest practices (Aung and Chang, 2014). As a result, research into the implementation of traceability in FSCs in developing countries could be an important future path.

Innovation and technological solutions. In FSC, technology is a key enabler of sustainability, enabling waste prevention, cooling technologies, information flow, digitization, tracing, and tracing; using data analysis, forecasting, monitoring, shelf life extension, and value upgradation; and using data analysis, forecasting, monitoring, shelf life extension, and value upgradation (Ciccullo et al., 2021). To increase FSC's overall sustainability, data on consumption patterns, market pricing, crop and soil health, climatic information, production and inventory levels, transportation tracking, packaging technologies, recovery, recycling, and energy indices can be collected and monitored across the FSC.

The application of these cutting-edge technology will undoubtedly increase the performance and long-term viability of FSCs. However, their applicability and the amount of their impact in FSC are still unknown and are a developing study issue. Furthermore, there are few application-based studies that show how such technologies are used in SFSC. We discovered a major void in the literature about available disruptive technology use cases in SFSC.

Social sustainability. The relationship between social and environmental sustainability is substantial, and it feeds the firm's performance (Acar et al., 2019). As a result, in SFSCM-related research, it is critical to explore themes of social sustainability. Health (Bravo et al., 2019), food security (Bravo et al., 2019), and other research topics for social sustainability are diverse (Jennings et al., 2016) Customer expectations and satisfaction (Suryaningrat, 2016; Wang and

Yue, 2017), buyer behavior (Sun et al., 2017), consumption behavior (De Bernardi and Tirabeni, 2018), community attitudes and motivations (De Bernardi and Tirabeni, 2018), social capital (Longoni and Luzzini, 2016), fair trade practices (Estevez et al., 2017), job creation (Allaoui et al., 2018), focal organization.

The majority of studies on this topic are qualitative or empirical research. Because the social part is difficult to measure, the social issue has received less attention in modeling papers. Fair trade groups and community-supported companies are two examples of how FSC's social sustainability may be leveraged to improve economic sustainability. However, future research will be needed to determine how and how strongly cam social sustainability influences SFSC's environmental and economic sustainability. Furthermore, the literature on incorporating social sustainability into SFSC models is currently lacking.

Conclusions

This review is limited to publications that focus on the economic, environmental, and social elements of FSC, rather than FSC or SC in general, and is limited to articles that focus on the sustainable food supply chain. It adds to the current understanding of sustainable food supply chains by collecting the literature on SFSC into several research subjects. Collaboration research and decision theory-based techniques are critical for FSC sustainability. SFSCM research should focus on quantifying waste streams and finding hotspots in the future. The employment of sophisticated technology to enable circularity and sustainability, as well as the circular economy and AFSC, offer a lot of potential.

Although these findings are significant, the research is constrained by the broad breadth and huge number of papers examined. It was difficult to quantify and classify such a large range of issues, which hampered my capacity to focus on a single topic. Future evaluations could use natural language processing-based technologies like topic modeling and text mining to improve the quantification and classification of individual topics.

Future study should focus on finding other research themes and building a deeper knowledge of the ones mentioned in this article. As the number of papers in SFSC grows, literature reviews will become more crucial to help researchers focus on important themes. Future research in this area can concentrate on the specific topics revealed in this study.

References

1. Konstantas A., Stamford L., Azapagic A. 2019. Evaluating the Environmental Sustainability of cakes. *Sustainable production and consumption*, Vol. 19, pp. 169-180, 10.1016/j.spc.2019.04.001
2. Belton B., Reardon T., Zilberman D. 2020. Sustainable Commoditization of Seafood. *Nature Sustainability*, Vol. 3, pp. 677-684, 10.1038/s41893-020-0540-7
3. Sel Ç., Soysal M., Çimen M. 2018. A green model for the catering industry under demand uncertainty. *Journal of Cleaner Production*, Vol. 167 , pp. 459-472, 10.1016/j.jclepro.2017.08.100
4. Connor DJ, Minguez MI. 2012. Evolution not Revolution of Farming Systems will Best Feed and Green the World. *Global Food Security*, Vol. 1, p.106–113
5. Oglethorpe D., Heron G. 2010. Sensible Operational Choices for the Climate Change agenda. *International Journal of Logistics Management*, Vol. 21, pp. 538-557, 10.1108/09574091011089844
6. FAO. 2014. Developing Sustainable Food Value Chains – Guiding Principles. Rome.https://www.fao.org/sustainable-food-value-chains/library/details/en/c/265156/
7. IAASTD. 2009. Agriculture at a crossroads. A Global Report, Washington
8. Stone J., Rahimifard S. 2018. Resilience in Agri-food Supply Chains: A Critical Analysis of the Literature and Synthesis of a Novel Framework. *Supply chain management*, Vol. 23 (3), pp. 207-238, 10.1108/SCM-06-2017-0201
9. Govindan K., Jafarian A., Khodaverdi R., Devika K. 2014. Two-echelon multiple-vehicle location-routing problem with time windows for optimization of sustainable supply chain network of perishable food. *International Journal of Production Economics*, Vol. 152, pp. 9-28, 10.1016/j.ijpe.2013.12.028
10. Lusiantoro L., Yates N., Mena C., Varga L. 2018. A refined framework of information sharing in perishable product supply chains. *International Journal of Physical Distribution & Logistics Management*, Vol. 48 (3), pp. 254-283, 10.1108/IJPDLM-08-2017-0250
11. Bortolini M., Faccio M., Ferrari E., Gamberi M., Pilati F. 2016. Fresh food sustainable distribution: cost, delivery time and carbon footprint three-objective optimization. *Journal* of *Food Engineering*, Vol. 174, pp. 56-67, 10.1016/j.jfoodeng.2015.11.014
12. Validi S., Bhattacharya A., Byrne P.J. 2014. A case analysis of a sustainable food supply chain distribution system - a multi-objective approach. *International Journal of Production Economics*, Vol. 152, pp. 71-87, 10.1016/j.ijpe.2014.02.003
13. Society Royal 2009. FAO 2011. Reaping the benefits. Science and the sustainable intensification of global agriculture. Royal Society, London, http://www.fao.org/nr/solaw/en/
14. US Census Bureau. 2004. Global population profile: 2002. US Census Bureau, Suitland, Maryland. http://www.census.gov/population/international/files/wp02/wp-02.pdf