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Exploring Current Trends, Gaps & Challenges in Sustainable Food Systems Studies: The Need of Developing Urban Food Systems Frameworks for Sustainable Cities

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Abstract: The current global food system is under threat due to significant global changes such as rapid urbanization, climate change, COVID-19 outbreak, etc. The importance of food system sustainability as a key element of sustainable cities has been gradually recognized in recent years; however, the tools for estimating food system sustainability in cities (i.e., urban food system sustainability) holistically are still scarce. Thus, this study represents a comprehensive investigation into food system studies and their impacts on achieving a sustainable community or city. This study is a subset of larger studies that aim to develop an urban food system framework, which utilizes modern approaches in framework development such as sustainability food indicators and a participatory approach. However, to achieve this, trends, gaps, and challenges of the current approach to food system studies need to be reviewed and discussed. A systematic analysis utilizing the protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was conducted, and network analysis of publications was performed via VOS viewer. The results suggest applying circular principles and merging smartness and resilience thinking in developing strategies for food system sustainability. This study finds that key drivers to mitigate food crisis among countries vary. Furthermore, a context-specific framework with a more comprehensive definition of urban food systems covering the institutional processes, and food governance are also needed to achieve urban food system sustainability.

Keywords: food system framework; sustainability transitions; food security; food system sustainability; urban sustainability transitions; smart resilience; circular economy

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1. Introduction

With the growing population, rapid urbanization, increasing consumption, changing diets and other risks, the global food crisis is recognized as both a demand and supply side issue [1]. Various risks continue threatening the world's food security, including climate change impacts, water scarcity, land degradation, other environmental issues and their combined effect on the global agriculture and food system [1]. Similarly, Cadillo-Benalcazar et al. [2] argue that agriculture is both the main food source and the main driver of land use change resulting in biodiversity loss and environmental degradation. Thus, the tensions between these two objectives reveal a conundrum as increasing the food supply by increasing agricultural practices generally translates into creating more environmental impacts. This conundrum or confluence of food crises calls for new paradigms to examine and study the underlying reasons and facilitate relevant adaptation and mitigation strategies [3].

Additionally, El Bilali et al. [4] state that food systems are the core of current environmental, social, and economic planetary challenges, including poverty, hunger and malnutrition, inadequate diets, resource scarcity, ecosystem degradation, social inequalities, biodiversity loss, and climate change which all implicitly originated from how food is produced, distributed and consumed. In other words, the underlying causes for these global challenges can be found in one or more phases of the life cycle of food. Moreover, Wang et al. [5] argue that with the rapid urbanization and growing population, global challenges such as climate and public health emergencies have augmented the urban food security risks. If these challenges are not properly managed and handled, they will cause serious social consequences [6]. For example, the COVID-19 pandemic is disrupting urban food systems, and many cities in developing countries do not have enough capacity to deal with disruptions caused by this health emergency. Doernberg et al. [7] claim that food supply has become the central issue of human development while urban areas have become hotspots for intensive resource use, further validating the increasingly important role of food systems in the urbanizing world [8]. Additionally, it seems that circular economy principles and practices in the food system have the potential for a promising solution as they can improve sustainability throughout the whole food value chain (FVC) and improve its resilience by supply chain localization that minimizes waste and ultimately promotes sustainable production and consumption [9]. City regions offer a critical lens to understand sub-national dynamics, connect social and economic activities to spaces, as well as examine the material and energy flow to minimize environmental impacts [10]. Thus, cities hold the opportunity to shift the current linear food system to a circular one, which enables eliminating food loss, waste, and pollution; reusing products, by-products and material; regenerating natural systems and creating multiple benefits across the food value chain and the society more broadly [11].

Furthermore, the increasing centralization of FS has been creating multiple concerns about long-term food system sustainability (FSS) at the same time [12]. In general, centralization means the concentration of controlling an activity or decision-making of an organization in the hands of a small group of people [13]. The traditional supply chain model is a centralized supply chain that usually contains a central headquarters and warehouse based in a single location [14]. In terms of management, centralization refers to the condition that all the decision-making (both upstream and downstream) is managed at central headquarters location [14].

With the growing population in urban areas, the concerns of rising trends in centralized food systems are growing as most downstream food system actors (retailers and consumers) are gathering in urban areas. From the perspective of the upstream food system, the top four agricultural companies in the world are Archer Daniels Midland Co., Chicago, IL, USA, Bunge Ltd., St. Louis, MO, USA, Cargill Inc., Wayzata, MN, USA and Louis Dreyfus Co., Rotterdam, The Netherland (also known as ABCD), controlling about 70% of global grain industry [15]. It can tell that the centralization in the food system can undermine food sovereignty, threaten food security globally and locally and reduce food system resilience, further creating hurdles for building a sustainable food system. This calls for sustainable transitions of traditional centralized food systems, while cities play a critical role in those transitions as they hold the most significant parts of food systems (e.g., consumers, food environments). To achieve this, it is essential to continuously make improvements for the sustainable transition of food systems to more sustainable food systems, particularly in cities.

Furthermore, a business-as-usual approach to the present global FS is no longer maintainable due to the fact that global food systems are plagued with unsustainable environmental and social issues [16]. This is further exacerbated by hunger in several developing countries and the triple burdens of malnutrition remain a challenge that plagues all countries irrespective of their GDP [17]. Therefore, the question of how food is produced and consumed in a sufficient and sustainable manner is one of the major challenges for sustainable development and food security in the context of climate change and growing socio-economic inequalities [7]. In response to this question, Gaitan-Cremaschi et al. [16] argue that there is a need for a transition from the dominant FS to alternative FS built around the wider principles of sustainable development and rural development. El Bilali et al. [18] also state that to feed the increasing population in a sustainable and equitable manner, a significant transformation of current FS is required, such as dramatic changes in production and consumption patterns. In addition, the transdisciplinary co-production of knowledge is required during this transformation [19], implying the significance of employing both food system studies and sustainable urbanism in promoting sustainable transitions of food systems in cities.

Based on the challenges stated and current state of affairs of food systems, this paper aims to investigate and provide an in-depth analysis of the current trends, challenges, and existing frameworks regarding sustainability transition of food systems. However, it should be noted that food systems are a complex web of activities involving production, processing, transport, and consumption. Thus, the concept of food system assessment or approach comes into play. This approach has been widely adopted to identify, analyse and assess the impact of food systems by different actors, activities, and outcomes to help identify intervention points for enhancing food sustainability and global environmental change [20,21]. On an urban level, according to Vieira et al. [12], the urban food system (UFS) incorporates activities and actors relating to urban areas' food supply as well as their interaction with the surrounding natural and constructed environments, socio-economic dynamics, and governance. Thus, in order to study FS, we must understand the underlying relationships among different FS activities and interactions. The primary beginning step is to understand what defines an UFS in a detailed and accurate manner.

Therefore, this study represents a comprehensive investigation into food systems. This study is a subset of larger studies that aims to develop an urban food framework system, which utilizes modern approaches in framework development such as sustainability food indicators, an integrated participatory approach to food system design, etc. However, to achieve this, trends, gaps, and challenges of the current approach to food systems need to be reviewed and discussed.

This will help develop a more sustainable urban food framework that is flexible and provides context-specific solutions to the current local and global food crisis.

Hence, the aim of this investigation is the address the following questions:

What are the trends, gaps, and challenges currently facing the development of Sustainable Food Systems and associates frameworks?

- What are the trends with regard to geographical locations?
- What are the trends regarding MDG and SDG time frames?
- What are the definitions of food system?

What are the potential improvements for sustainable transition of food systems to more Sustainable Food systems, particularly in cities?

A brief literature review explains the current status and projections of food systems in Section 2, and materials and methods are explained in Section 3. Results and Discussion are reported in Section 4. Finally, Section 5 summarizes the main findings, highlights the gaps, and provides recommendations for future research.

2. Literature Review

2.1. General Background and Food System Impact

According to World Resource Institute (WRI) [22], one third of all food produced is lost or wasted. However, a considerable proportion of them can be avoided or recovered to feed other people who are still suffering from acute food insecurity in less developing countries. The reasons for wasting food vary in different countries. In developed countries, most food wastes happen in the hands of terminal consumers, while this usually occurs during the stages of storage and transportation in developing countries (High Level Panel of Experts [23,24]. Moreover, it is claimed that more than 98% of nutrients in food by-products and human waste generated in cities are disposed of without reusing or recycling [25]. The disparities between wasteful food consumption behaviours in highly food secured countries and acute food insecurity and poverty in vulnerable countries have formed parts of the global imbalance “triple burden of malnutrition” (i.e., over-nutrition/obesity, undernutrition, and micronutrient deficiencies) [3,26]. There is a continuous debate about whether current global food production can stratify the food needs of all the people in the world. On the one hand, some researchers argue that the world is producing enough food to feed all the people, for now. The true challenge for the current global food system is to make available food accessible, affordable, culturally acceptable, sufficient, healthy, and nutritious [27,28]. On the other hand, some researchers/scholars have different points of view that the lack of sustainability and the inability of current food system to feed the increasing global population are major narratives of food system failure [29,30]. It is claimed that our current food system not only produces insufficient food but is unsustainable, inequitable, and not resilient in economic, environmental, and social dimensions [31].

In addition, food production is the cause of 25% of global GHGs, and about 50% of those emissions come from cows and other ruminant animals. This illustrates how the food system contributes to climate change and the potential to reduce and mitigate climate change impacts through the food system approach. Climate change further impairs the current food system and increases the frequency of phenomenon’s natural disasters and extreme weather events such as droughts. These challenges combined with ongoing global issues such as water shortages and resource scarcity, make it more imperative to enhance the current food system approach. For instance, the New York City council identified energy, water, and land constraints as possible underlying risks to New York’s food supply. Regarding this, a strategy named “FoodWorks” has been implemented covering the development of urban agriculture practices [32] with multiple programs and policies in the vision of promoting community food security by enhancing access to healthy food and advocating local policy against obesity [33,34]. More specifically, these programs include the Supplemental Nutrition Assistance Program (SNAP) to improve access to food support/knowledge, farmers’ market incentive program called «Health Bucks» to improve access to healthy food, rounds of campaigns (e.g., Moooove to 1% Milk, Move to Fresh Fruits and Vegetable), chain restaurants must post calorie information on menus by requirements of The City Health Code and Rules, The Mayor’s Office of Food Policy (MOFP) and so on [34,35]; bring long-term benefits to New York City’s residents in terms of local and community food system sustainability. For instance, people receiving help from SNAP has increased from 10% to 22.5% of the whole city’s population within ten years [34,35], implying the awareness of having a nutrition-balanced healthy diet continues growing while the influence and performance of this program keep going well.

2.2. Current Status: Lack of Equitability and Resilience

Based on FAO (Food and Agriculture Organization of the United Nations), IFAD (International Fund for Agriculture Development), WFP (United Nations World Food Programme), and WHO’s (World Health Organization) report, in 2019, two billion people, or 25.9% of the global population, experienced hunger or did not have stable access to nutritious and sufficient food [36]. According to The State of Food Security and Nutrition in the World 2020 [36], there are big discrepancies in available food per capita for different types of food across countries with different income levels. For instance, low-income countries depend more on staple foods and less on fruits and vegetables and animal source foods than high-income countries. Only people living in upper-middle-income and Asian countries have met the recommended level of fruit and vegetable consumption. From the perspectives of the four pillars of food security (food availability, food accessibility, food affordability, and food stability), it can be understood that approaches to mitigate and resolve the triple burden of malnutrition need to be considered along with poverty alleviations. It is demonstrated that healthy diets cost 60% more than diets that only meet the requirements for essential nutrients and nearly 400% more than diets that meet only the dietary energy needs over a starchy staple [36].

Table 1 shows the USD cost per person per day with respect to different types of diet. Except for low-income countries having a slightly lower energy-sufficient diet cost, high-income countries have the cheapest cost of all other diet types. Besides differences and disparities among all forms of capitals, one underlying reason for this phenomenon might be the centralization of the current food system. As mentioned earlier, the top four "ABCD" companies dominating the global agricultural commodity trade market, are all from high-income countries (France [Louis Dreyfus Co.] and US [Archer Daniels Midland Co., Bunge Ltd., Cargill Inc.]). Notably, this report reveals that the triple burden of malnutrition remains as one of the major global challenges while only slow progress has been made in the issues of child stunting, low birth weight, and exclusive breastfeeding. No progress has been made in reducing childhood overweight while adult obesity is escalating in all regions [36].

Table 1. The Cost of different diets in different countries (adopted from [36]).

	The USD Cost per Person per Day of		
Countries	**Energy Sufficient Diet**	**Nutrition Adequate Diet**	**Healthy Diet**
Low-income	$0.70 USD	$1.98 USD	$3.82 USD
Lower-middle-income	$0.88 USD	$2.40 USD	$3.98 USD
Upper-middle-income	$0.87 USD	$2.52 USD	$3.95 USD
High-income	$0.71 USD	$2.31 USD	$3.43 USD

This is concerning, since technically humanity produces enough food to feed the entire global population [28], yet millions of people still suffer from hunger, food insecurity, and malnutrition. Johnston et al. [28] further highlight this paradox by concluding that though more than one billion people in the world are overweight and obese, 868 million people are still suffering from hunger, and another two billion are suffering from micronutrient deficiencies. This phenomenon highlights the existing wide-spreading global imbalance and is generally termed as the triple burdens of malnutrition (over-nutrition/obesity/overweight, undernutrition, and micronutrient deficiencies) [3,18,28]. Further to this point, Bene et al. [29] state that the major issue of current FS is not so much about how to produce more quantity of food but more on how to "change production systems for food available to meet nutritional needs locally and globally" [29] (p. 119). In addition, a prior study by Li et al. [1] also corroborates this by arguing that limited production diversity and dependence on a few staple crops are the two main limiting factors of the current global agriculture and food system. Li et al. [1] state that food systems which only rely on a few crops or which so-called "monocultures" are likely to be more vulnerable to environmental shocks as monocultures can reduce climate resilience of food system significantly. Clearly, changing the format or approach to current food systems is an urgent and imperative task needed to enhance food sustainability, equity and resilience.

Additionally, it is also highlighted that the essential underlying reason for the triple burdens of malnutrition is the unaffordable cost of healthy diet food [20,37]. Monoculture has also been noted to result in unhealthy diets [1], limited varieties of crops available on the market constrain people's freedom of choosing food and limits the diversity of their nutrition sources while lack of diet diversity is one of the most significant contributors to malnutrition, especially micronutrient deficiencies. For instance, people living in Asia still have a relatively high rate of anaemia due to iron deficiency, and malnutrition is still prevailing among children. A pilot study conducted in Sri Lanka, reveals that feeding mildly anaemic children 50 g of red lentils per day for two months can considerably enhance their iron status [1,36]. It can tell the importance of both diet diversity and reducing crop monoculture. Growing more nutritious and diverse crops instead of focusing only on production and profits are essential to build climate resilience and a sustainable food system and also reducing the triple burden of malnutrition. For example, chickpeas are more nutritious than white rice, which are three times richer in protein, four times richer in dietary fibre, and four times richer in iron [1,36].

According to FAO, only three crop species (i.e., wheat, rice, and maize) signify nearly 50% of the average daily calories consumed by all the people in the world, while about 75% of crop genetic diversity has been lost since the 1900s [1,36].This growing dependence on limited crops has caused considerable risks and threats to food security, particularly in the context of rising climate change. Evidence from FAO's projects has shown that relying on only a few crops to close the production gap will deepen the nutrition gap as food monotony elevates the risks of micronutrient deficiency as well as persistent malnutrition [1,36]. Further, it is argued that intensive monoculture systems are more vulnerable than diversified agroecological systems to shocks such as disease, pest outbreaks, and weed invasion, with the risks of catastrophic crop failure [9].

2.3. Future Projections

The total human population is estimated to reach 9 billion by 2050, thus for a sustainable future, it is projected by FAO that the world's total food production must increase by 50% by 2050 in order to meet the growing global demand food [1,29,36,38]. The value estimated by WRI is even higher. WRI argues that there will be nearly a 56% gap between food available today and that demands by 2050 [5]. According to The State of Food Security and Nutrition in the World 2020 [1]. total population affected by hunger in the world has been rising consistently since 2014, even with initiatives in place such as SDG#2, the world is not on track to achieve the zero hunger by 2030. Moreover, the ongoing pandemic of COVID-19 continues to disrupt global food systems with new challenges, making it increasingly difficult to accomplish SDG#2. Hence, the resilience of food systems to shock cannot be ignored and is a key component of making any system more sustainable. Resiliency is food system needs to be flexible enough to address uncertainties and disturbances especially under the current circumstance of global environmental challenges, intensifying climate change, the COVID-19 outbreak and other stressors. Resilience is a kind of capacity, while capacity building usually involves adaptive strategies. Compared to climate resilience or pandemic resilience, food system resilience is harder to build as the stability of the food system relies on both in order to maintain a fundamental basis. The affordability of healthy diets is recognized as a key reason for food insecurity and the triple burden of malnutrition, while the main drivers of nutritious food are discovered throughout food systems involving the whole life cycle of food (e.g., production, supply chain, food environments), market demand and its political economy [1]. Hence, resilience from one perspective cannot constitute the full strength of food system resilience. For instance, COVID-19 has impacted not only climate vulnerable countries but also relatively climate resilient countries in terms of food supply chain disruptions due to multiple reasons, including reduced incomes, lack of labour, and so on, making the world face difficulties in accessing nutritious food. Furthermore, many countries have started banning food exports recently in the face of domestic shortage/conflicts and some are leading global exporters (e.g., Indonesia accounts for over 50% of the world's palm oil supply), further elevating concerns of food shortage and levels of food insecurity. These countries include Indonesia (palm oil), India (wheat), Argentina (soybean oil, soybean meal), Russia (sugar, sunflower seeds, wheat, meslin, rye, barley, maize), Ukraine (wheat, oats, millet, sugar); Egypt (vegetable oil, maize, wheat, flour, oils, lentils, pasta, beans), etc., [39].

As the nature of food systems is connected and interacts with not only ecological and environmental tangibles but also socioeconomic and political intangibles, unprecedented disruptions from external and internal can be reflected and transformed into a series of influences and cause chain reactions. Plus, food systems are very sensitive to any large-scale or wide-scale drivers/impacts due to their complexity and comprehensiveness. FAO et al. [36] state that if the current business-as-usual practices trends are not addressed with a more flexible and resilient approach, the global population affected by hunger by 2030 will be more than 840 million with 653 million people remaining undernourished [18].

In sum, there is a scientific consensus that a food system transformation is needed to change the trends, realize the vision of the 2030 Agenda, and recover from the pandemic [40]. This study aims to contribute to the much-needed transformation by proposing methods to enhance the current food system frameworks in order to not only improve the residency of food systems but to address the issue of supply and demand as well as the trilemma of malnutrition. To achieve this, current food systems tools and methods are investigated to draw out the existing gaps and provide flexible, relevant and sustainable solutions.

3. Material and Methods

This systematic literature review followed the review protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [32]. An initial exploratory search was conducted to complete a review strategy to identify potential keywords for the search string. This search showed that it was not viable to explore "urban food system" and "framework" together as they were rarely seen together in search results.

3.1. Literature Selection

This paper is based on a systematic review of documents indexed in the Web of Science database (Figure 1). A literature search was carried out on 19 May 2021, using the search string: TOPIC ("food system") and TOPIC:(framework). The search yielded 603 documents. Further, six additional papers were added from the references of included papers, and 28 new published articles were also included since the day of the initial search. The date of the cut-off time is 18 June 2021. After screening of titles and abstracts, 152 documents were excluded as they do not have the keywords "food system" and "framework" together in their titles or abstracts. In order to be included in the next phase of the literature review, research articles had to satisfy one of the following three requirements:

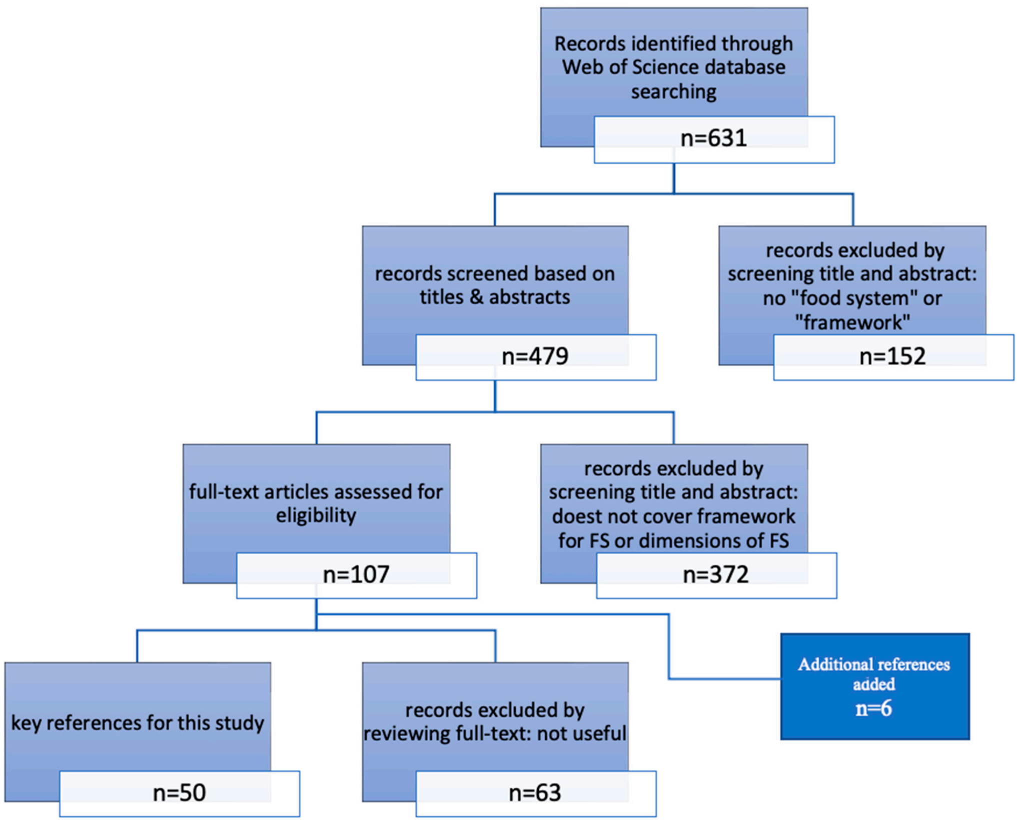

Figure 1. Systematic review process.

The development of a conceptual framework or assessment

1. to deal with food system/urban food system/sustainable food system;
2. to deal with one or more dimensions of the FS framework (e.g., a framework for food security, food policy, food sovereignty, food governance);
3. to deal with some aspects of the food system and/or more than just FS (e.g., a framework for reducing nitrogen loads of urban food system; a framework for sustainable diet; framework to study and respond the climate change, food security, and human health nexus).

Based on scrutiny of abstracts, an additional 372 records were excluded. In total, 107 records went through an eligibility check based on a full paper review. Only 50 research articles were included in the systematic review following the screening, scrutiny, and eligibility checks (updated on 18 June 2021). See Figure 1 below for a summary of the methodological process.

3.2. Literature Review and Data Extraction

Step 1: various data related to the retrieved articles were composed in a Microsoft Excel sheet, such as objectives, the definition of food systems, place of case studies, the configuration of the framework, and complied limitations.
Step 2: the collected data were read in detail and coded.
Step 3: another round of review was done to check the accuracy of the coded data
Step 4: another round of review for additional checking/refining by considering the feedback received from the project team Figure 2. Literature Review and Data Extraction

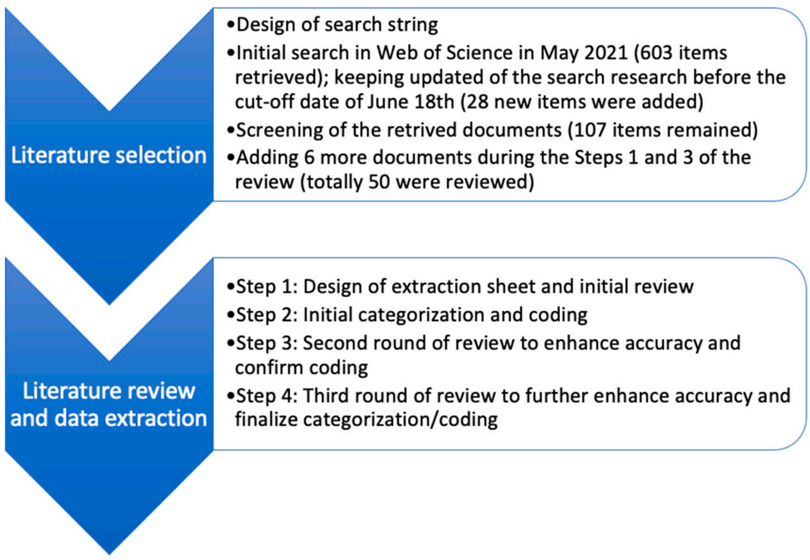

Figure 2. Procedures for literature selection and data extraction.

As one of the most used bibliographic analysis methods, co-occurrence analysis can be used to identify the focus areas and common research topics by mapping the co-occurrence of keywords while creating clusters of keywords that show the most frequently occurring keywords with each cluster [41]. Figure 3 illustrates the output of the network analysis of publications. Bibliographic data of 96 papers were put into VOS viewer, there were 65 keywords of the 628 keywords that met the threshold requirement of a minimum number of three occurrences. For each of the 65 keywords, the total strength of the cooccurrence links with other keywords was calculated based on the frequency of times that they cooccurred with other keywords.

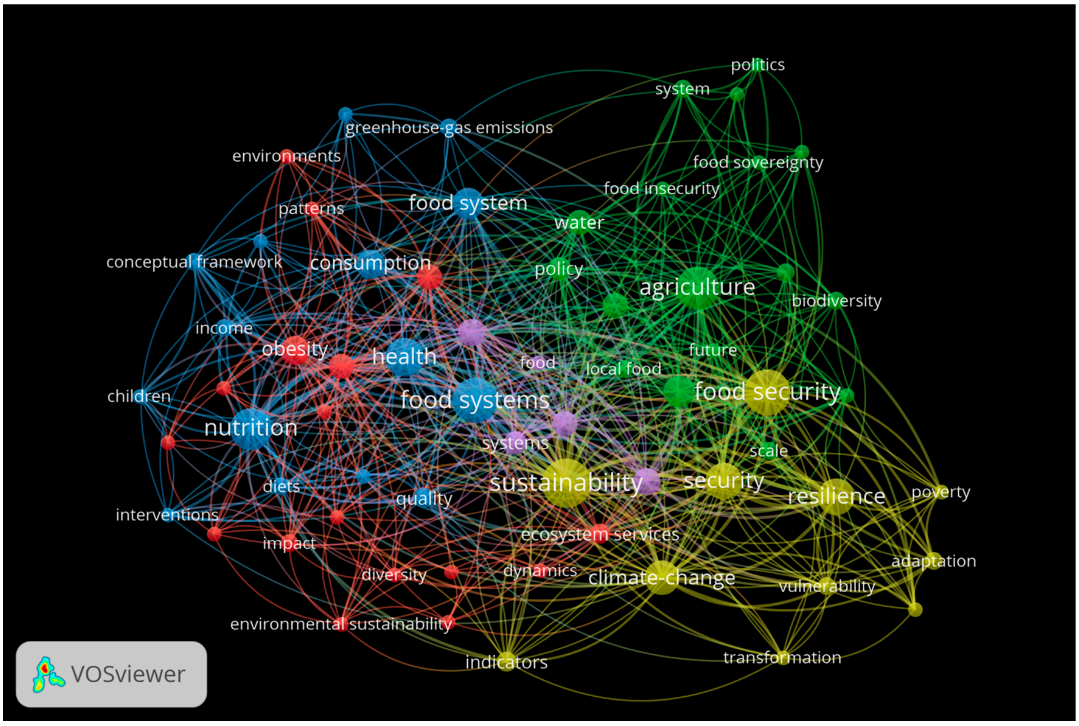

Figure 3. Network map of FSF-related papers by VOS viewer using cooccurrence of keyword analysis (Database-96 papers between 1987 and 2021).

There were five clusters in Figure 3, representing the network map of included studies. Cluster 1 to 5 accounted for about 26.15% (red color), 26.15% (green color), 23.08% (blue color), 16.92% (yellow color) and 7.69% (purple color) of all keywords, respectively. Cluster 1 focused on "sustainable diets" with the terms "environmental sustainability", "food consumption", "ecosystem services", "supply chain", "dietary guidelines", "food policy", "patterns", "environments", "health literacy", "diversity", "impact", "sustainable development", "obesity", "diversity", "dynamics" and "united states". Cluster 2 focused on "agriculture", "agroecology", "food insecurity", "food sovereignty", "urban agriculture", "local food", "water", "biodiversity", "governance", "integrated assessment", "future", "system", "scale", "management", "justice", "policy" and "politics". Cluster 3 covered "food systems", "food system", "environment", "conceptual framework", "greenhouse gas emissions "interventions", "health", "diet", "diets", "quality", "nutrition" and "developing countries". Cluster 4 consisted of "sustainability", "food security", "climate change", "adaptation", "resilience", "global change", "transformation", "indicators", "vulnerability", "security" and "poverty". Cluster 5 studied "framework", "food", "climate change", "impacts", and "systems".

4. Results and Discussions

4.1. Brief Summary of the Trends

In total, 50 publications were analysed, as shown in Figure 4 and Table 2 [39] and present the total number of publications regarding the published year. The earliest article was published in 2003. The total number of publications has dramatically increased since then: From one article in 2003 to eight articles in 2021, while the total number of publications is still growing in the current year. The most included literature was published in 2020 (thirteen), and the year with the second-highest number of publications was 2019 (nine), followed by 2021 (eight) and 2015 (six). Based on the results, the gaps and trends identified in this study are discussed in detail. These challenges are discussed in order to formulate a strategy to enhance the development of a sustainable food system framework.

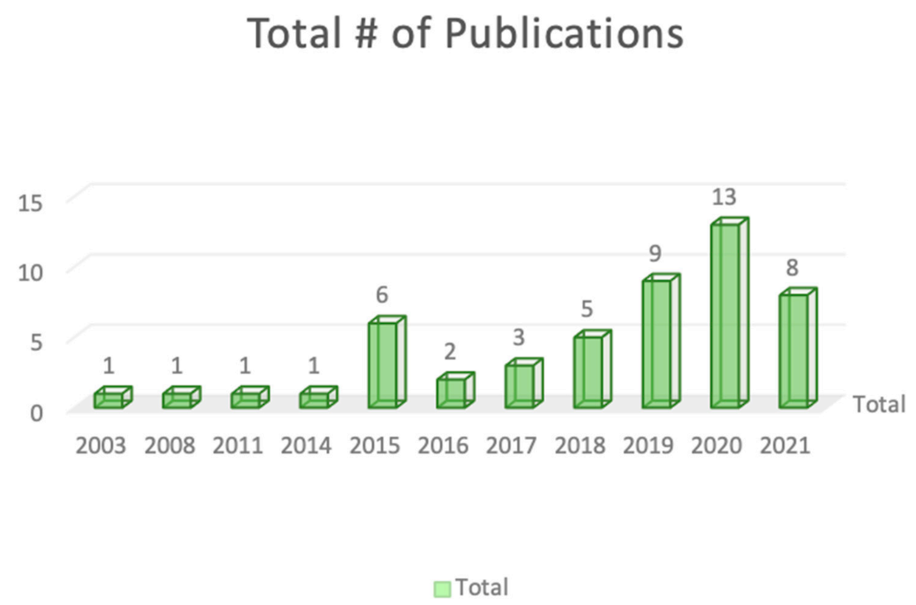

Figure 4. The total number of included FSF-related publications with the publication year.

Table 2. Key drivers of the food crisis for selected countries in food crisis.

Region/Continent [42]	Country	Country Income	Climate Shocks	Conflict and Insecurity	Displacement	Economic Shocks
Sub-Saharan Africa	Ethiopia	Low	X	X	X	
	The Niger	Low	X	X		X
	Kenya	Lower middle	X	X		X
	Nigeria	Lower middle	X	X		X
Latin America and Caribbean	Honduras	Lower middle	X			X
South Asia	Bangladesh	Lower middle	X	X	X	

4.2. Network Analysis of Publications

The major implications of network analysis results are the lack and/or limited usage of ICT and smartness in food system research. Figure 4 illustrates that Food system framework related studies showed close relationships with terms of sustainable diets (7 occurrences, 30 links, and 46 total link strength), agriculture (17 occurrences, 41 links, and 77 total link strength), food systems (18 occurrences, 46 links, and 93 total link strength), sustainability (21 occurrences, 43 links, and 100 total link strength) and framework (9 occurrences, 30 links, and 47 total link strength). The "sustainability", "food security", "agriculture", "food systems", "climate change", "resilience", "nutrition" and "health" were the popular keywords identified by FSF-related papers.

Furthermore, it indicated that FSF-related publications did not cover any terms linked to circularity such as "circular economy", "cradle to cradle", "closed-loop systems", "circular design", "3R principles", "4R principles", "5R principles" and so on. Meanwhile, "urban food systems", "city", "urban" are also lacking, and the only keyword relating to urban study found in the clusters was "urban agriculture"; which implies the potential research gaps in developing sustainable urban food systems through the lens of circular principles. It also implies that the terminology of urban food or urban food systems is not popular. Similarly, there were no terms such as "smart", "smartness", "smart environment" or "ICT" found in the network map, showing that most of current food system framework related studies have not considered merging smart city construction or smart technology into the strategies and/or actions of food system transformation. Maye [43] argues that urban food research is not only about food security, but also connects to various areas, including social well-being, community cohesion, urban food innovations, and so on, while smart technology can be an important part of the solutions to city food challenges. Regarding the scales of urban food research, it is stated that the city region is the most suitable scale to construct and apply an integrated and holistic approach to design urban food systems [43].

Four key elements of a smart food city (SFC) proposed by Maye [43] are:

City regionalism
New organizational structures and connectedness (e.g., multifunctional urban and peri-urban agroforestry)
Circular metabolism
Social practices as a form of innovation and learning

Meanwhile, smart agriculture is usually placed at the global scale, aiding businesses, and researchers to build smarter food production systems through technological innovations for solving food security issues. Some examples include agricultural robotics and smart machines, drones, the Internet of Things (IoT), and other vertical farming technologies, providing innovative technical support for improving efficiencies and sustainability of urban food systems [43]. To build food-smartness, it would be affordable and cost-effective for smart cities, which have substantial digital infrastructures, good e-business environment, efficient supply chain (i.e., fast delivery service), and high levels of urban innovation rate to improve food security and manage food system in a smart manner. For example, the City of Wuhan, China, a smart city beat COVID-19 early crisis at the beginning of the pandemic without any major food shortage issues.

Additionally, another implication found here is that frameworks for urban food systems or City Region Food Systems (CRFS) are currently under the primary concept development phase or at the early stage of application and approach exploration, large-scale applications or further massive thorough studies in this research area are very limited. In a literature review covering all food system frameworks and food-system-related frameworks, the authors found that 46% are conceptual, which only offers a visual illustration of theories and concepts (e.g., diagram conceptualization of proposed food system) without any testing experiments or practical application [44]. For instance, the most popular framework for the food system proposed by Ericksen, is a diagram demonstrating key ideas of the authors' theory [20]. In addition, those most recent ones are also conceptually based, such as a table for the framework for food systems transformation after COVID-19 [17], a diagram for the food systems framework for pandemic prevention, response, and recovery [1], etc. On the other hand, the significance of smartness and big data analytics in reaching urban sustainability is highlighted in research on Neighbourhood Sustainability Assessment Tools (NSAT) and the built environment. Topics related to themes such as smartness, health, and wellbeing are escalating in NSAT as it is argued that integrating health and resilience-based dynamics in tools or framework are essential to resolve current major global challenges [45]. The food system issue is one of major global challenges closely linked to health and wellbeing. It is also important for the food systems framework to take smartness topics into account as health and wellbeing are inherited from food system outcomes directly. Owing to the evolving movement of the built environment driven by economic digitalization and the contribution of smartness in sustainable development, it is expected that the recognition of covering an aspect of smartness will keep growing in NSATs development [46]. Accordingly, with the emerging smart technologies such as ICT, Artificial Intelligence, and other digital technologies, their interactions, interfaces, and influences with/to/on food system will become closer. Hence, integrating smartness into the food system is an inevitable process in the context of Industry 4.0 and Web 3.0.

4.3. Trends Related to Geographical Location

The main findings of this section suggest the impact of context in food systems—food resilience in Low- and Middle-Income Countries (LMICs) and High-Income Countries

(HICs). In terms of geographic location, Food system frameworks are shown in Figure 4 to have originated from 12 different countries. While most frameworks were developed in the US, which occupies 24% of the total frameworks identified, others originated from Canada (12%), the Netherlands (8%), the UK (8%), Australia (8%), and Italy (8%), indicating that the majority of frameworks were developed in High-Income Countries (HICs) and/or developed ones. This implies that the countries which put the greatest efforts in this field of study and making progress on developing a food system and/or FS related frameworks towards food system sustainability are mainly HICs.

As shown in Figure 5, the US has the greatest proportion (24%), double that of Canada (12%). One underlying reason might be the fact that the US owns four of the world's top agribusiness companies, including Cargill, DowDuPont, Archer Daniels Midland Company, and Deere and Company [47]. According to the Global Food Security Index (GFSI) (2020) [48], the ranking for countries developed food system related frameworks in Figure 5, respectively, are as follows: 11th for the US, 12th for Canada, 3rd for The Netherland, 6th for the UK, 31st for Australia, 15th for Italy, 10th for Switzerland, 1st for Finland, 39th for China, 17th for France, 26th for Spain, 34th for Chile. This implies that countries with higher food security are more likely to be committed to food system studies and research such as framework development. Interestingly, although Low- and Middle- Income Countries (LMICs) and/or developing countries in Asia and Africa have higher food insecurity issues and rapid urbanization rates, only a few frameworks were created from those countries. One possible reason for this might be linked with fundings received by researchers and the number of higher educational intuitions are much fewer HICs. Meanwhile, some LMICs are still suffering acute or severe levels of food insecurity, mostly driven by food shortage, and food affordability combined with other fundamental socioeconomic concerns such as poverty, sanitation, clean water, and even peace. For example, only 2% of the food system related frameworks originated from China, while China has 19% of the global population with a rapidly growing economy facing multiple food-related threats and food security risks [49]. In the context of China, it is ranked only 39th in the global food security index, which implies that Chinese researchers may have more interest in studying food security instead of food systems sustainability or frameworks as it is still a significant problem in their country which cannot be ignored. Secondly, China is one of the countries that have the most significant gap between the rich and the poor due to its rapid economic growth in recent years; hence the income level does not reflect the full picture of Chinese people's daily life, especially for the poor. Some of them may live a life no better than people in LMIC. Thus, reducing and eliminating poverty has more research priorities and interests in China rather than food system framework development.

When analysing the first authors' countries, these included publications varied from 17 different countries. Figure 6 (geographical location of the first author) shares a very similar distribution with the origins of the frameworks, but with a slight difference. Most authors are from the US (twelve), Canada (six), The Netherlands (four), the UK (four), Australia (four), and Italy (four). At the same time, only five first authors are from LMIC and/or developing countries, respectively, China (two), Colombia (one), Philippines (one), and Brazil (one). Similar to the locations of the developed frameworks (Figure 5), the geographical locations of the country of the first author share the same trend as the origins of frameworks, illustrating that there is a lack of research and development of food-system-related frameworks in LMIC and/or developing countries. Yet these regions are more vulnerable when facing the negative impact of climate change, pandemic activities and other internal and external shocks. Another underlying reason for this might be that most of the current sustainability studies are focusing on energy conservation, while food system sustainability (FSS) has often been ignored [4,18]. For example, regarding China's carbon peak and carbon neutrality targets, as a part of climate action and sustainable development, the Chinese government has published The Action Plan for Reaching Carbon Dioxide Peak Before 2030 consisting of ten tasks and three milestones for the years 2025, 2030, and 2060. The documents show that the Action Plan intensively focuses on minimizing unsustainable energy consumption and controlling the growth of energy-intensive industries. Of the four goals of China's 14th Five-Year Plan (FYP) for 2025 two are related to energy consumption. The others are forest coverage and CO2 emission. Moreover, two of the six goals of China's FYP for 2030 are linked to energy consumption, and of the remainder one is linked to energy transition [50].

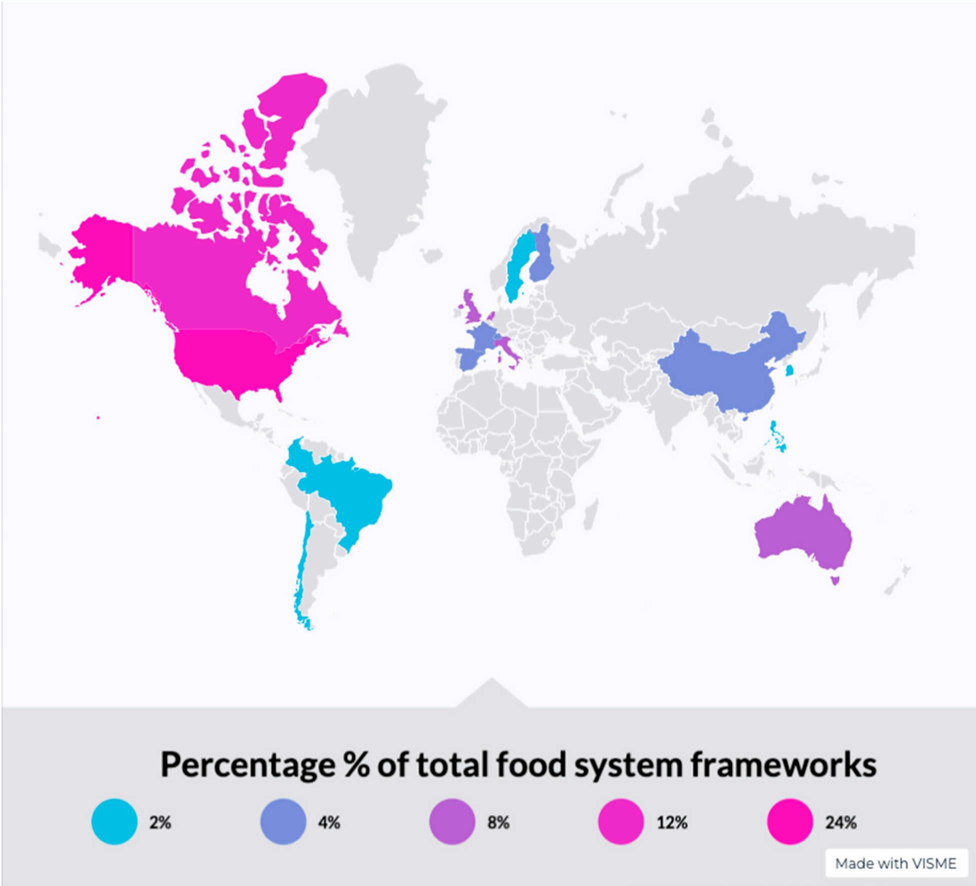

Figure 5. The locations of the Food system frameworks developed (by authors).

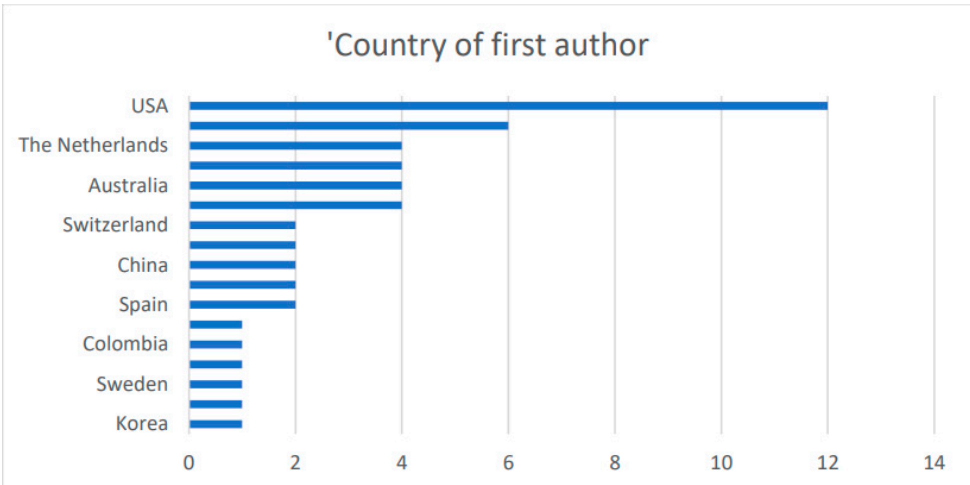

Figure 6. Country of first authors in Food systems research.

In total, out of 50 included studies, 23 (46%) of them undertook case studies. More specifically, fifteen (65%) case studies were in LMIC (1, 2, 5, 6, 8, 15, 25, 26, 31, 32, 35, 42, 48, 49, 50); ten (43%) case studies were undertaking in HIC (2, 9, 17, 18, 19, 20, 21, 22, 36, 48); and two (9%) of them (2, 48) covers both HIC and LMIC. Based on the Global Report on Food Crisis's newest available data, there were 53 countries affected by the food crisis in 2018, with a total population of 113 million people facing acute food insecurity (Food and Agriculture Organization of the United Nations (FAO) [51], and all of them were LMIC [52]. These data point to the fact that food insecurities are a phenomenon more popularly studied as case studies by both developed and developing. It should also be noted that the situation describing when a person's life is in immediate danger due to food shortage or lack of food, is considered as acute food insecurity. Due to conflicts, extreme weather events, and other impacts of climate change, and COVID-19, over 155 million people suffered from food crisis levels of food insecurity in 2020. Humanitarian Aid [31] claims that African countries remained "disproportionally affected" by the food crisis, while other countries in Asia (Yemen, Afghanistan, and Syria), and North America (Haiti) are also affected. Data from IPC (Integrated Food Security Phase Classification) also suggests that from 2019 to 2021, countries under acute food insecurity are mostly from Africa, followed by Asia, and North America [53].

In Appendix A.1, there are four case studies (6, 26, 35, and 50) that cover six different countries in food crises. They are Honduras, Kenya, Ethiopia, Bangladesh, Nigeria, and Niger. Different key drivers of the food crisis for those countries are identified by FAO [51] as follows:

As can be seen in Table 2, the top three drivers of food crisis identified by FAO [51] are climate shocks, conflict and insecurity, and economic shocks. All the countries in the food crisis included in those case studies have been facing climate shocks, highlighting the critical role and urgent need to foster climate resilience in addressing the food crisis. Furthermore, this trend is also agreed on by Humanitarian Aid [31], who identified conflict as the top cause of acute food insecurity, followed by economic shocks and then extreme weather events.

Furthermore, the pandemic of COVID-19 has created severe challenges to global food systems from 2020 to 2021, including reduced incomes and disruption of the food supply chain (see Figure 3 publication increase). It is estimated by the World Food Programme (WFP) that 232 million people are already or are highly likely to be exposed to acute hunger [52,54].

Additionally, The World Bank [54] argues that the world's hunger tended to keep increasing even before the outbreak of COVID-19, which aggravated existing impacts from extreme weather events, climate shocks, conflicts, natural hazards, and other shocks to economic opportunities. For instance, the locust outbreak and other zoonotic diseases are still a reoccurring threat to the food system of the affected countries and regions (e.g., East Africa, India, and Pakistan [55].

According to FAO et al. [36], low-income countries depend more on staple foods and less on fruits and vegetables and animal source food than high-income countries; however, only upper-middle-income and Asian countries have sufficient fruits and vegetables to meet people's daily minimum consumption recommended by FAO and WHO. In addition, the cost of a healthy diet not only exceeds the international poverty line but also exceeds the average food expenditures in most countries in the Global South. It is estimated that approximately 57% of people living in Sub-Saharan Africa and South Asia cannot afford a healthy diet [36,56].

Furthermore, The World Bank [54] states that higher retail food prices combined with decreased households' incomes are the major risks to food security at the national level since more and more households are tending to reduce their quantity and quality of food consumption due to the financial difficulties. LMICs are much more vulnerable to these risks associated with increasing food prices and reducing incomes. In fact, households in LMICs spend a greater portion of their incomes than those who live in HICs [52,54]. In low-income countries, food expenditure in cities may be as high as 2/3 of total household expenditure, while the agro-industry accounts for more than 50% of value-added manufacturing [51,56].

In short, the variety of fundamental drivers reflects the complexity of food issues, revealing the fact that FS is a "problem-determined system" [37] and the fundamental rationale for employing a systematic approach to dealing with food issues. Further, all the key drivers, or influential factors of food crisis provide an implication for exploring the opportunities to eradicate food issues and build capacities in FS of the vulnerable countries while facing future shocks and uncertainties through a resilience approach. Resilience and sustainability can be seen as complementary concepts since sustainability connotes maintaining the capacity of a system to function in the future, and resilience entails the capacity to provide a function continuously over time in the face of disturbances and shocks [57]. It can be argued that taking resilience thinking in developing strategies for addressing food crisis will benefit fostering food system sustainability holistically at the same time.

4.4. Trends Related to MDG and SDG Time Frame

This section employs a case study of SDGs and unveils the impacts of initiatives and policy on food system. As Figure 7 illustrates, from 2003 to 2014, the publication number stayed the same, and there was a peak at six in 2015, which was also the year that the UN established 17 SDGs [18,58]. After 2015, the total FSF-related publications dropped from six to two in 2016 and grew dramatically afterward. The second peak of the diagram represents 13 publications in 2020, indicating the increasing trends of recognition of food system-related issues in this field. For now, the total publication was 8 in 2021, which is less than the value in 2020, but the total number of FSF-related publications will likely surpass 13 by the end of the year as it keeps increasing since the initial day of literature search.

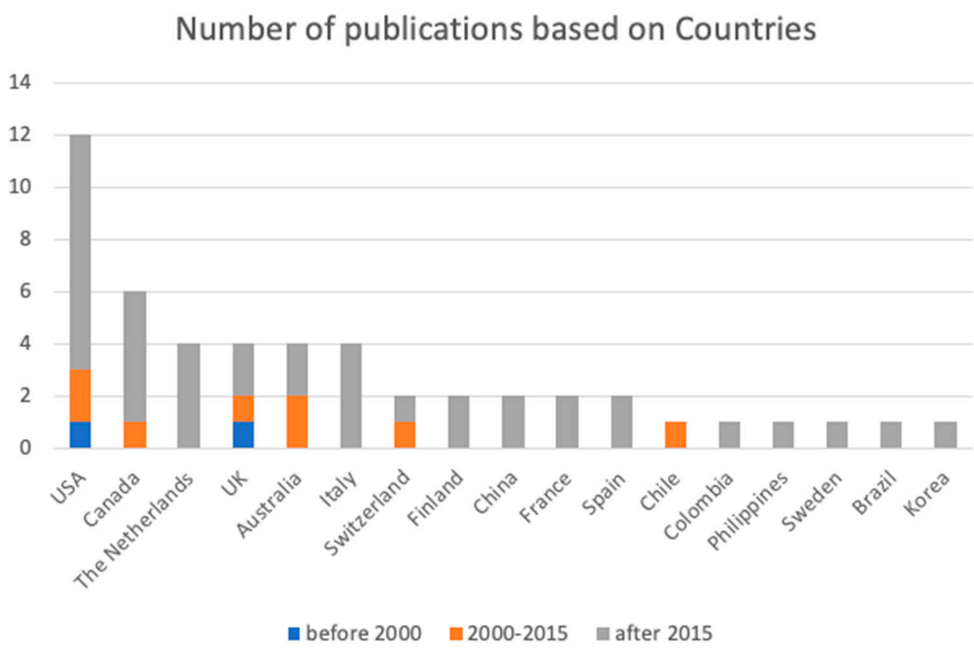

Figure 7. The number of included FSF-related papers vs. country of first author regarding the time frame of MDG (2000) and SDG (2015).

In 2000, Millennium Development Goal (MDGs) #1 to halve hunger by 2015 was established by the United Nations (UN) [58]. In 2015, Sustainable Development Goal (SDG) #2 to achieve zero hunger by 2030 was adopted by the UN. Regarding the time frame of establishing MDGs and SDGs, Figures 6 and 7 show that all the frameworks developed before 2015 were from developed and/or HIC (USA and UK), and most of them were developed after 2015, the date of SDG#2. FAO [56] states that an SFS lies at the centre of SDGs. After its adoption in 2015, countries around the world have been putting a lot of effort among various sectors into major transformations in agriculture and FS to eliminate hunger, improving food security and nutrition, resolving the triple burdens and unsustainability of FS to achieve SDG by 2030. This matches with the trend in FSF-related studies publication as well (See Figure 6). Only two included frameworks were developed before the establishment of MDG and SDG, the period between the years 2000 and 2015 has witnessed an increasing trend in FSF development, while after 2015 (i.e., the year of SDG) this trend keeps going up more rapidly.

More specifically, only six countries (USA, Canada, UK, Australia, Switzerland, Chile) published FSF-related papers before 2015. A total of 11 countries (Italy, Finland, China, France, Spain, Colombia, the Philippines, Sweden, Brazil and Korea) have published FSF-related papers after 2015. Although Asia is the largest continent accounting for about 1/3 of the world's land with 60% of the world's population [59] while presenting severer food vulnerabilities when compared with other continents except Africa, its countries (China, Philippines, Korea) have started developing food system frameworks after 2015 as well. No countries in Africa have published any FSF-related papers in this area but various authors conducted their case studies in Africa (See Appendix A.1). More accurately, the locations of the 23 case studies were spread over 84 countries across the world. With respect to different continents, all the case studies involved 41 countries in Europe (48.81%); twelve countries in Asia (14.29%); ten countries in Africa (11.9%) and North America (11.9%); and only three countries are from South America (3.57%). This shows that most countries of case studies are in Europe as the majority of frameworks were developed in Europe and mostly from European authors. One underlying reason for this might be that Food and Healthy Diet is one of the key research areas supported by the Horizon 2020 programme, which was "the biggest EU research and innovation programme ever" [60] before the implementation of "Horizon Europe". The horizon 2020 programme was identified to have an allocated budget of €95.5 billion for the period between 2021 and 2027.

It seems that financial support and governmental policies are the key drivers of research and development into food system. As LMICs' governments may put economic development as their development priorities, saving energy to save money seems to be much more important that healthy and nutritious diets. Reducing poverty can improve food security but improving food security can not necessarily reduce poverty. Making a living is much harder than sustaining a living for individuals.

FOOD 2030 is one of the food-system-related policies and initiatives of the EU, aims to transform food systems into resilient, inclusive, and sustainable food systems [61]. This is aligned with and supports another policy called The Farm to Fork Strategy of the European Green Deal, aiming for a fair, healthy, and environmentally friendly food system [62]. More significantly, urban food system transformation, and food waste and resource efficiency are highlighted as two of the ten pathways for achieving Food 2030′s goals [61], emphasizing the importance of urban food system and efficiency enhancement in fostering sustainable food system. As for the Farm to Fork Strategy, its initiatives cover all the stages of food activities from food production to food loss and waste prevention, implying that a full life cycle (principles of circularity) approach to addressing food issues is a key method to aid the current food systems transition towards sustainability.

FAO et al. [36] further claim that it is vital to identify trade-offs and synergies regarding other SDGs as all diets have hidden costs. For instance, it is well known that vegetables have low carbon footprints, but vegan and vegetarian diets are not as "healthy" as they appear which are more likely to cause micronutrient deficiencies and difficulty in maintaining well-being. Our dietary choices have significant hidden costs and intangible consequences that relate to both health (SDG#3) and climate (SDG#13). The concept of circularity comes from the circular economy. The Circular economy (CE) is recognized as one of the most promising strategies to reach sustainability in recent years, which is featured with three principles [11]: Eliminate and/or design out waste and pollution; Circulate products and materials/keep them in use at their highest value; Regenerate natural system. It is believed that promoting circularity has huge potential to resolve major global challenges through a systematic approach.

In sum, since European countries account for almost half of the case studies, the rest of the world shares a very small proportion of case studies. It was expected that there would be more studies geared towards Africa and Asia as they have already been identified as the regions with the highest food insecurity risks and worst food crisis concerns. However, only a very limited number of case studies were in African and Asian countries. The limited case studies of food system related frameworks may leave a potential gap in applying those proposed frameworks to vulnerable targets/people/stakeholders/regions and countries in practice. The consequence of this is that food frameworks become geared toward societies with higher GDP, adequate funding, education, and resources. This is because some LMIC and/or developing countries are plagued with various layers of inefficient governance and underfunded/inept research bodies, thereby limiting the adequate support and funding that can be provided in research areas of Food System Sustainability. Furthermore, climate, geography, terrain, socio-cultural practices, diet and nutrition, etc. vary across these regions thus allowing for the strong possibility of failure, if a European framework, policy or regulation is exported to other developing regions. At the same time, this also implies that developing context-specific policies, solutions and strategies is essential to achieving the food system sustainability.

4.5. Definition of Food System

In order to present the definition of FS, Ericksen [20] outlines a framework for studying the multiple interactions of the broadly defined food systems with global environmental change and evaluating the major societal outcomes affected by several interactions, namely, food security, ecosystem service, and social welfare. More specifically, this framework consists of four categories of FS activities (1. producing, 2. processing and packaging, 3. distributing and retailing, and 4. consuming) with three different types of outcomes (1. food security, 2. social welfare, and 3. environmental security/natural capital) and two sets of drivers (global environmental change drivers (GEC) and socioeconomic drivers). This has led to the most cited definition of food system (FS) by Ericksen [20]. This definition considers FS as a series of human and environmental activities from food production to food consumption [20] and is defined specifically as "The interactions between and within biophysical and human environments, which determine a set of activities; the activities themselves (from production through to consumption); outcomes of the activities (contributions to food security, environmental security, and social welfare); and other determinants of food security" [16,20,24,57,63]. Although it is the most frequently used conceptual framework of FS, there is a limitation that the nature of institutional processes and food system governance has not been addressed in this work [45]. Appendix A.2 below shows some examples of FS and related definitions.

On the other hand, there is a trend of increasing studies dealing with SFS rather than just FS, especially in the year 2020 [3,4,9,14,64]. While the most cited definition of a sustainable food system (SFS) was proposed by HLPE in 2014 as "food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" [4,24,64,65]. The variety of context-specific definitions of FS has also been growing in recent years, including Stable Food System [66], City Region Food Systems [10,36], and Sustainable Urban Food Systems [3,9,24,27,64].

The underlying reason for this trend of growing definitions of different varieties of FS might because that the General Assembly of the United Nations adopted the second Sustainable Development Goal (SDG2) to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture" in 2015 [18,58], emphasizing the importance of sustainability in agriculture and food systems in reaching the new sustainable development agenda.

This literature review covers not only the FS framework, but also other related frameworks for food systems' dimensions and related concepts. Of 50 frameworks, 44% (22) did not include any food system related definition, 32% (16) covered the definition of the food system, 20% (10) frameworks contained other definitions, including food literacy, climate-smart agriculture, food environment, sustainable diets, urban agriculture, etc. (Figures 8 and 9). In addition, no articles have defined the urban food system (UFS) particularly, implying a limitation in developing frameworks for UFS only. However, another concept which is closely connected to UFS, City Region Food System (CRFS) is defined by FAO as "all the actors, processes and relationships that are involved in food production, processing, distribution and consumption in a given city region that includes a more or less concentrated urban centre and its surrounding peri-urban and rural hinterland" for its CRFS programmes aligned with Urban Food Agenda, Milan Urban Food Pact, etc. [10,56]. One of the most critical points for defining food systems is defining food system boundaries. For assessing the impacts of food systems, Nesheim et al. [67] set defining systems boundaries as one part of the scoping stage right behind the problem identification; while for characterizing food systems, Gaitan-Cremaschi et al. [16] put the food system boundaries as the priority.

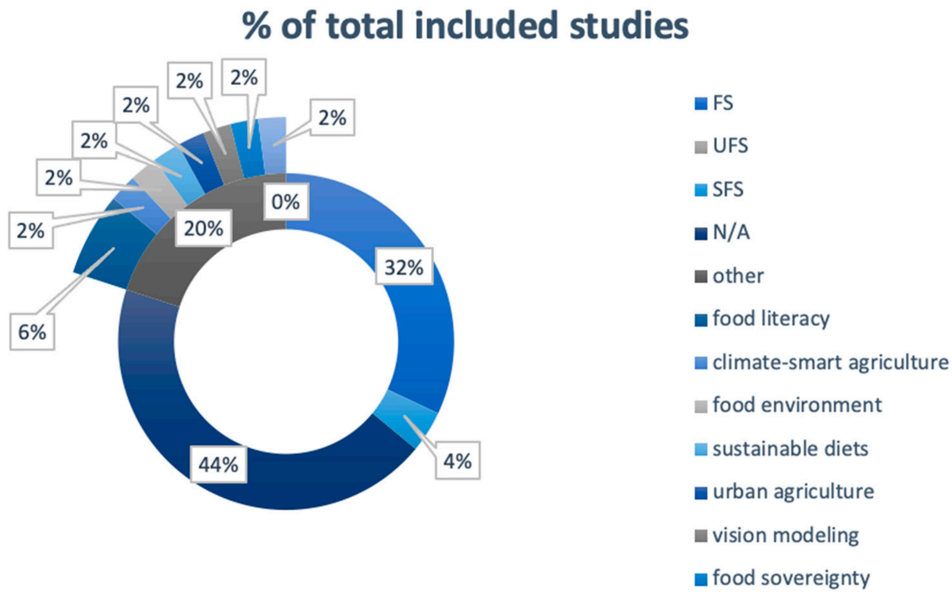

Figure 8. The definition of FS and related concepts in percentage.

Secondly, it can easily be seen that most other non-FS or UFS definitions are key research areas or hotspots for food system transitions, such as climate-smart agriculture, urban agriculture, sustainable diets, etc. This indicates that the focus of this study field has a wide range with a great number of varieties scattered in different areas. Indeed, Maye [43] states that urban food research is about food security and connects various areas, including social well-being, community cohesion, urban agriculture, urban food innovations, and so on. Due to the complexity of food systems, sometimes it is easier to take only a few elements or dimensions of a food system to study deeply and intensively. However, the interlacing nature of urban food system challenges needs a systematic perspective to examine the interrelatedness of the whole food chain [43]. A holistic approach is indispensable for studying and exploring potential pathways toward sustainable food system transitions. However, holistic assessments of UFS remain vastly unexplored [10]. In short, a holistic and context-specific urban food system framework with a more comprehensive definition of FS and/or UFS is needed in future studies of FS sustainable transitions. Regarding this, here we proposed an integrated new definition of UFS as "A complex urban system that comprises the entire range of actors, activities, processes, relationships, environments, generated outputs, flows and interactions that are involved in food production, processing, packaging, distribution, retail, consumption, and disposal within a given urban boundaries, including both tangible and intangible outcomes from socio-cultural, economic, ecological-environmental, institutional and political, health and nutritional dimensions". In addition, we define sustainable urban food system (SUFS) as "an urban food system that delivers food security, nutrition and well-being for all people while enable sustainability, circularity, equitability, and resilience of both food system and urban system in such a way that all the fundamental bases to generate food security, nutrition, well-being and continuous optimization and innovation of the systems for future generations are not compromised".

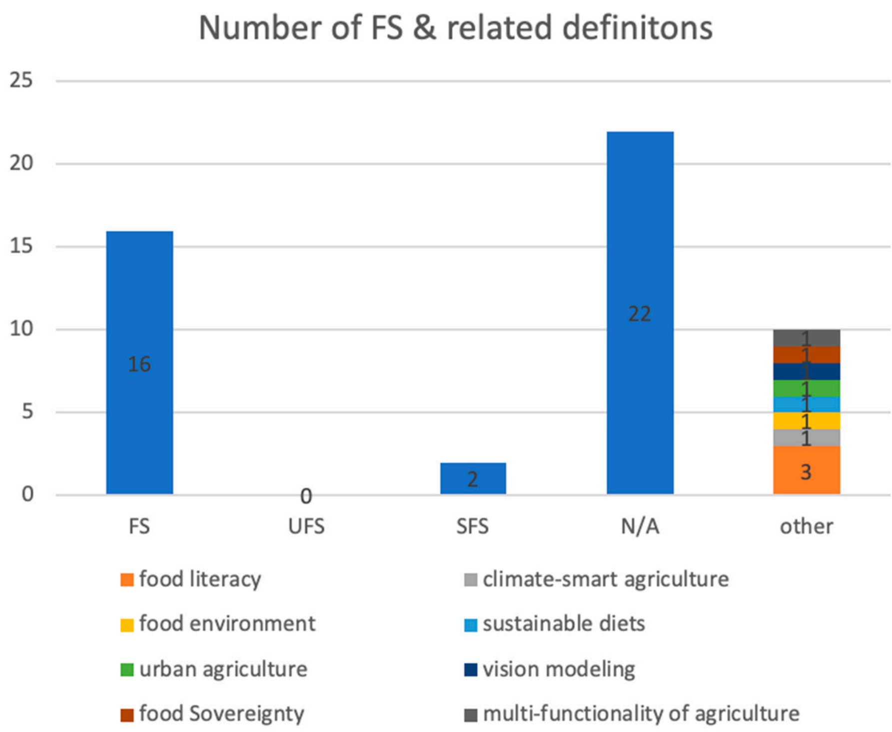

Figure 9. The definitions of FS and related concepts.

4.6. Novel Findings in the Evaluation of Current FS

Regarding FS research, several reviews have been conducted in this field of study focusing on various topics including FS drivers [29]; definitions of food security related terms and food sustainability related concepts [4,18]; FS outcomes and their discourse framings [21]; local food systems [68]; studies related to components of sustainable and resilient UFS [12]; agro-food sustainability transitions [4]; diversity of FS [16] and so on.

To our knowledge, this study is the first to use a PRISMA approach and a network analysis together to critically review the existing publications on the topic of FSF and FS-related frameworks. Secondly, it is the first to investigate not only current existing FSF but also other FS-related frameworks at the urban level, covering frameworks which are dealing with particular or multiple dimensions/aspects/issues of FS (e.g., food security, food sovereignty, sustainable diet, climate change, food security and human health nexus, etc.) rather than FSF only. Moreover, this study is also the first to connect FSF-related publications to time and space which has interpreted the trends of included frameworks regarding geographical locations, case study countries, and publication year while linking them to HIC and LMIC divisions, continent distributions, and MDG and SDG time frames as well.

Lastly, this study observes the variety of FS, SFS, and other related definitions used in the included studies, recognizing the potential optimizations in defining FS/SFS/UFS/USFS, which can be improved in future studies. In short, this study attempts to discover the trends, challenges, and need for current FS transitions toward sustainability and provides some insights with the following findings and recommendations (Table 3).

Table 3. Key Findings of this Study and Recommendations.

Key Findings	Implications and Recommendations
In the included studies, the top keywords are "sustainability", "food security", "agriculture", "food systems", "climate change", "resilience", "nutrition" and "health"; while keywords related to city/urban areas such as "urban food systems", "city", "urban" are lacking.	-constructing more FSF particularly for cities or urban areas (i.e., UFSF) for assisting SFS transitions
In the included studies, keywords related to circular principles such as "circular economy", "cradle to cradle", "closed-loop systems", "circular design", "3R/4R/5R principles" are lacking; again, nothing related to urban/city either such as "circular urban metabolism", "urban circularity", "circular city" or "zero waste city".	-developing SFS transitions strategies through the lens of circular principles -using circular drivers as indicators to assess and develop FSF, especially urban circular drivers for UFSF -combing the construction of circular cities and SFS development together
In the included studies, keywords related to smart city/smart drivers such as "smart", "smartness", "smart environment", "ICT" are lacking; again, nothing related to urban/city either such as "urban smartness" or "smart city".	-consider merging smart city construction or smart technology into the strategies and/or actions of food system transformation -use some smart drivers as indicators when developing FSF, especially urban smart drivers for UFSF -combining the construction of smart cities and SFS development together
In the included studies, keywords related to resilient city/resilient drivers is partially limited, only got "resilience", "vulnerability", again, nothing related to urban/city either such as "urban resilience" or "resilient city".	-consider utilizing resilience thinking or resilient in take interventions and actions for achieving SFS agendas -employing some resilient drivers as indicators when developing frameworks, especially urban resilient drivers for UFSF -combining the construction of resilient cities and SFS development together
The most included literature was published in 2020, while the year of 2015 ranks the second highest, also is the year of 17 SDGs establishment.	-taking advantages of existing sustainable assessment tools (SAT) to assess and enhance FS sustainability when developing FSF/UFSF -integrating some other concepts and goals with SFS agenda in practices rather than only focusing on SDG#2 zero hunger as the goal when fostering SFS (e.g., SGD#3 good health and well-being, SDG#11 sustainable cities and communities, SDG#12 responsible consumptions and production, SDG#13 climate action)
Most frameworks were developed in HIC and/or countries with higher food security level, while LMIC and/or countries with severer food insecurity issues and rapid urbanization rates only developed a few framework (e.g., countries in Asia and Africa).	-developing more FSF/UFSF for LMIC and/or countries with severer food system issues and rapid urbanization rates is needed
Only 46% of the included studies have done case studies, covering 84 different countries around the world; no community-scale case studies.	-using more case studies when developing FSF/UFSF -considering examining smaller scales (e.g., community level, individual) when undertaking case studies
Regarding continents, 48.81% case study locations were from Europe, followed by 14.29% in Asia, 11.9% in Africa same as South America, and 3.57% in South America.	-undertake more case studies in non-European regions such as Asia and Africa which have the highest food insecurity risks and worst food crisis concerns
Key drivers of food crisis among countries vary very differently (e.g., climate shocks, conflict and insecurity, displacement, economic shocks, etc.), so do the FS issues and main causes of unsustainability of FS (e.g., food wastes, change of diet patterns, etc.).	-develop context-specific solutions/frameworks for countries/regions and/or specific groups is needed for achieving food system sustainability
In the included frameworks, the most cited definition of FS is proposed by Ericksen in 2008 and the most cited definition of SFS is proposed by HLPE in 2014. Although both two definitions do not cover the food governance and/or institutional aspects, most studies use them directly while no frameworks have defined UFS except the CRFS by FAO.	-a more comprehensive definition of FS and/or UFS involving the institutional processes and food governance is needed, especially when developing FSF/UFSF

5. Summary and Conclusions

This literature review examines the trends of food system framework publications worldwide. In general, 50 publications were included. The majority were published in 2020, followed by 2015, the year of SDG's establishment, COP21, and Milan EXPO2015. The year 2019 has the third-highest number of publications. In the same year, FAO implemented its Urban Food Agenda Framework. Furthermore, the total publications of 2021 rank at fourth with eight publications for now, and the speed of a growing number of publications suggests that it will surpass last year's total amount of the trend. The US developed most of the food-system-related framework in terms of geographical location, followed by Canada, and The Netherlands. Other HICs, except China, Colombia, the Philippines, and Brazil, indicate a lack of development of food-system-related frameworks in LMIC and/or developing countries. At the same time, they are more vulnerable in the face of climate change impact, pandemic influences, and other shocks.

First, for the geographical locations of case studies, the locations of 23 of them covered 84 countries across the world. More than half of them (65%) were conducted in LMICs, and only four case studies were conducted in countries affected by food crises identified by FAO. Considering continents, 41 out of 84 countries from Europe (48.81%) were covered in all the case studies, indicating that Europe has put a lot of effort into food system research such as FOOD 2030, Farm to Fork Strategy, and so on. Furthermore, it is noteworthy that only 10 African countries are included in case studies, there is also a very limited number of case studies located in Asian countries, even though Asia is the most populated continent with the second-highest level of food insecurity. Calls for developing food system frameworks in the context of African and Asian countries are essential. In the perspective of resilience thinking, different countries and/or regions have very different stressors and risks, while the causes and priorities of their food system issues vary. To classify different underlying causes and identify potential strategies, we prosed three themes in respond to food system failures towards sustainability in Figure 10 below.

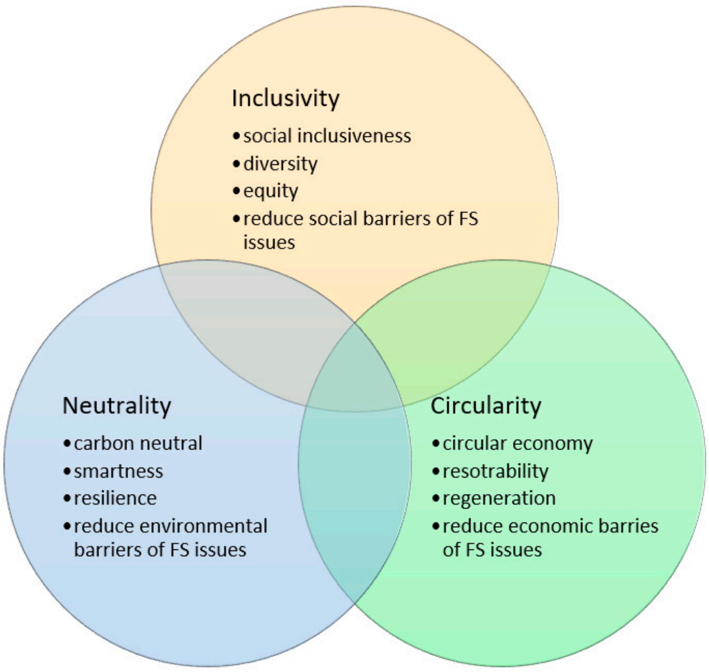

Figure 10. Three themes in response to food system unsustainability.

On the other hand, since urban food system is part of urban system, some strategies and practices of sustainable urban development can be adopted to facilitate and promote sustainable urban food system development. Since smart cities are not necessarily resilient or sustainable, resilient cities might be sustainable in some respects but not essentially smart. This suggests that smart resilient cities might be the only possibly closest and fastest pathway to sustainable food system transitions. The Urban Metabolism-Urban Sustainability-Smart Cities Nexus implies that smart cities can provide technological basis for building urban sustainability while offer platform for improving urban metabolism [69]. Optimally utilizing the infrastructure, practices, and co-benefits of smart cities constructions can boost the circularity and sustainability of both urban systems and urban food systems. In order to foster climate-resilience and reduce additional barriers of FS issues, the other optional approach besides smartness is resilience which can support food security, food system carbon-neutrality and inclusivity. Hence, it can be argued that infrastructures and actions for developing smart resilient cities can be used to foster food system sustainability. Figure 11 shows a roadmap to foster food system sustainability transitions in smart resilient cities.

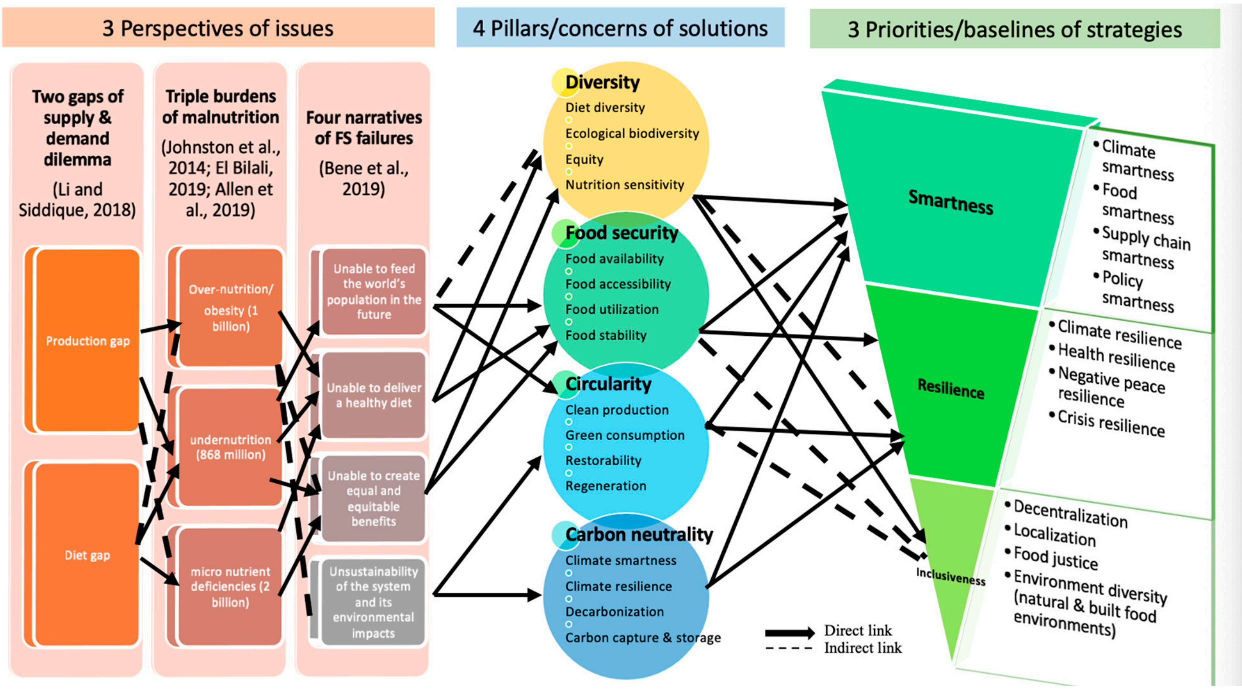

Figure 11. Roadmap to foster system sustainability transitions in smart resilient cities [the authors adapted [1,3,18,28,29]].

As for the food crisis, FAO [70] and Humanitarian Aid [31] identified conflicts, economic shocks, and extreme weather events/climate shocks as the top drivers, implying the importance of food system resilience in defeating acute food insecurity and food crisis. It is also highlighted that food supply and price across countries vary greatly, while LMICs are the most vulnerable groups regarding food price rise and healthy and balanced diets [36,54]. Thus, a more inclusive, just, and equitable food system is needed to reduce those vulnerabilities and risks.

Secondly, regarding the Millennium Development Goals (in 2000) and Sustainable Development Goals (in 2015) timeline, all the frameworks developed before 2015 were from only six developed and/or HIC, and 11 countries developed the majority of all frameworks after 2015, which is the date of the establishment of SDG#2. Only three of those 11 countries were from Asia, and none were African, unveiling the limited recognition for food system frameworks in those countries. Before 2000, only the US and UK published FSF-related papers. One key milestone was the World Summit on Food Security in 2009, the adoption of the Rome Principle for Sustainable Global Food Security. After that, the concept of a green economy and the global Zero Hunger Challenge (ZHC) was adopted at the Rio+20 Conference in 2012. The Rome Declaration on Nutrition was adopted at the Second International Conference on Nutrition in 2014. In the same year, FAO's City

Region Food System (CRFS) Programme was initialized, bringing the idea of addressing food system issues with city region and/or urban approach to the front of the world's food system research. The 17 SDGs, the Paris Agreement, and the Milan Urban Food Policy Pact were all launched in 2015. There was a growing global recognition of cities and urban regions' role in food system transitions afterward. After the adoption of the New Urban Agenda in 2016 and the creation of the Platform for Accelerating the Circular Economy (PACE) in 2018, the UN and FAO have been devoted to exploring possible approaches of urban planning in improving urban food systems through the Urban Food Agenda, Green Cities Initiative, and other associated actions.

Additionally, when constructing definitions of food systems and urban food systems, several authors directly adopted what Ericksen [20] proposed, while its major drawbacks regarding the exclusion of the institutional processes and food system governance have not been tackled. Other definitions were mostly developed for sustainable food systems focusing on sustainability and food security. However, no definition of urban food system was found in the included studies, but a very close definition is City Region Food System (CRFS) proposed by FAO [10,56]. This trend highlights the lack of comprehensive, compact, and clear definition for urban food systems particularly. On the other hand, some articles defined other concepts such as climate-smart agriculture (CSA), urban agriculture, food sovereignty and food environment, showing a great variety and mix of study subjects in food system research. To deal with the complexity of food systems, it can be argued that a successful food systems transformation towards sustainability will be achieved only if a holistic approach with a systematic perspective is applied.

In sum, most included studies were published after 2015 and mostly originated from HIC/developed countries. For case studies, most case studies were conducted in LMICs. While in terms of a number of countries and continents, most case studies were conducted in European countries. Furthermore, the most popular definition of food system was proposed by Ericksen [20]. There is no specific definition developed for the urban food system in included studies, except FAO [56]'s city region food system (CRFS) [10]. For developing food system frameworks, more consideration should be given to LMICs in Africa and Asia, and the framework needs to be context specific with clear definitions of UFS/FS.

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Appendix A

Appendix A.1 Locations of Case Studies (23 in Total)

ID	Author	Country Types	Location of Case Studies	Continent of Case Study Countries and Their Accounts
1	Ahmed et al. [71]	LMIC	Yunnan & Guizhou Provinces, China	Asia (1)
2	Ahmed, Downs & Fanzo [72]	HIC, LMIC	Australia, Brazil, the Grenadines, Grenada, Qatar, Netherlands, Nordic Countries, St. Vincent, Sweden, Thailand, the United Kingdom, and the United States.	
5	Biehl et al. [30]	LMIC	Baltimore City, Maryland, USA	
6	Bizikova et al. [73]	LMIC	10 communities in Honduras and 10 communities in Nicaragua	North America (2)
8	Bulter et al. [74]	LMIC	11 countries: the Philippines, Indonesia, Timor-Leste, Papua New Guinea (PNG) and seven Pacific Island Countries (PICs)	Asia (3), Oceania (8)
9	Cadillo-Benalcazar, Renner & Giampietro [2]	HIC	Oceania (1), Asia (2), Europe (4), North America (4), South America (1)	Europe (29)
15	Downs, Payne & Fanzo [26]	LMIC	North America (1)	Asia (1)
17	Fagioli et al. [75]	HIC	the main countries producing olive oil in the EU (Greece, France, Italy, Portugal, Spain)	Europe (5)
18	Flores & Villalobos [76]	HIC	the metropolitan areas of Phoenix, Arizona and Albuquerque, New Mexico, USA	North America (1)
19	Gaitan-Cremaschi et al. [16]	HIC	vegetable food systems in Chile	South America (1)
20	Guarnaccia et al. [64]	HIC	Sicily, Italy	Europe (1)
21	Halbe & Adamowski [77]	HIC	Southwestern Ontario, Canada	North America (1)
22	Heller & Keoleian [78]	HIC	US food system	North America (1)
25	Jackson et al. [79]	LMIC	the extremely remote Bedamuni tribe of Western Province, Papua New Guinea (PNG)	Oceania (1)
26	Jacobi et al. [19]	LMIC	Kenya (Laikipia, Nyeri and Meru Counties) and Bolivia (Santa Cruz Department)//6 FS types regarding to case studies: agro-industrial, domestic-indigenous, agroecological, agro-industrial, regional, local	Africa (1), South America (1)
31	Ma et al. [49]	LMIC	*China	Asia (1)
32	Marshall [63]	LMIC	*a research project examining the challenges faced by Cambodian cattle-owning smallholders in accessing value chains for premium-priced beef. (Cambodia)	Asia (1)

ID	Author	Country Types	Location of Case Studies	Continent of Case Study Countries and Their Accounts
35	Melesse [80]	LMIC	4 LMICs: Ethiopia, Bangladesh, Nigeria and Vietnam	Africa (3), Asia (1)
36	Moragues-Faus [59]	HIC	Cardiff and Bristol, UK	Europe (1)
42	Samaddar et al. [81]	LMIC	2 states in India (Odisha and West Bengal)	Asia (1)
48	Verger et al. [82]	HIC, LMIC	*food systems in the south of France and Tunisia, two completely different areas concerning the diet-agriculture-environment nexus	Europe (1), Africa (1)
49	Wang et al. [5]	LMIC	Chengdu, China	Asia (1)
50	Zougmore, Laderach & Campbell [83]	LMIC	3 countries in Africa: Ghana, Mali, Niger	Africa (3)

Appendix A.2 Some Definitions of Food System and Sustainable Food System

References	Definition of FS
Ericksen [20]	FS (Food systems) comprise a set of activities and outcomes ranging from production through to consumption, which involve both human and environmental dimensions
Ericksen [37], p.234–235	The interactions between and within bio geophysical and human environments, which determine a set of activities; the activities themselves (from production through to consumption); outcomes of the activities (contributions to food security, environmental security, and social welfare) and other determinants of food security (stemming in part from the interactions).
Tendall et al. [57] (p.18)	FS are social-ecological systems, formed of biophysical and social factors linked through feedback mechanisms, which comprise the activities involved in food production, processing and packaging, distribution and retail, and consumption [31]
Bizikova et al., [73] (p.398)	the process, required inputs and generated outputs involved in feeding a population including growing, harvesting, processing, packaging, transporting, marketing, consuming and disposing of food
Allen et al. [3] (p.957)	FS: complex social-ecological systems involving multiple interactions between human and natural components. *SFS (Sustainable Food System): provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come, with minimal negative impact to the environment; encourages local production and distribution infrastructures; makes nutritious food available, accessible, and affordable to all; is humane and just, protecting farmers and other workers, consumers, and communities provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come, with minimal negative impact to the environment; encourages local production and distribution infrastructures; makes nutritious food available, accessible, and affordable to all; is humane and just, protecting farmers and other workers, consumers, and communities
Carlsson et al. [65] (p.2)	*SFS: [deliver] food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised [9].

References	Definition of FS
Verger et al., [82] (p.2)	Two different definitions of FS: (i) chains of activities from food production ("the farm") to consumption ("the fork"), including processing, packaging, distribution and retail, which are influenced by many political, economic, socio-cultural, and environmental factors (ii) complex socio-ecological systems that involve cross-level and cross-scale interactions between human and natural components and major social outcomes, such as ecosystem services, social welfare and food security
Banerjee & Hysjulien, [66] (p.155)	*Stable FS: the general stability of the food production system while masking ongoing tensions resulting from fluctuating food prices, regulatory failures in food safety standards, and growing hunger and deprivation around the world.
Blay-Palmer et al. [10] (p.3)	*City Region Food Systems (CRFS): the complex network of actors, processes and relationships to do with food production, processing, marketing, and consumption that exist in a given geographical region that includes a more or less concentrated urban centre and its surrounding peri-urban and rural hinterland; a regional landscape across which flows of people, goods and ecosystem services are managed [37]
FAO [56]	FS: encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded. SFS: a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised. This means that: (i) It is profitable throughout (economic sustainability); (ii) It has broad-based benefits for society (social sustainability); and (iii) It has a positive or neutral impact on the natural environment (environmental sustainability).
El Bilali et al. [4] (p.5)	*SFS: a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised
Gaitán-Cremaschi et al. [16] (p.2 & p.7)	FS are generally conceived as the network of actors and activities that interact with one another, with an ecological, social, political/cultural, and economic environment. Beyond the actors involved directly in these activities (growing, processing, distributing, consuming, and disposing of foods, from provision of inputs to waste and recycling [21, IPES-Food, 2005)), FS also comprise the structural conditions (e.g. rules, standards, policies,) and dedicated agents (e.g. actors in public and private organizations such as extension services and research) that support daily operation as well as continuous optimization and innovation of the systems.
Ma et al. [49] (p.1386)	FS consists of an interrelated set of compartments, perceived as a "pyramid" with four main components: crop production (including the root-able soil layer), animal production (including managed aquaculture), food processing and retail, and households. These components are connected through flows of energy, carbon, and nutrients and virtual resources, i.e., water and land.
Jacobi et al [19] (p.1)	FS are networks of actors and activities involved in food production, processing and storage, retail and trade, and consumption. These networks include direct or indirect interactions with natural source base, governance context, and flow of information and services [37]
Raza et al., [84] (p.2)	FS involve people that initiate or inhibit change in the system, as well as the social, political, economic and technological environment in which food systems-related activities take place
Guarnaccia et al., [64] (p.1)	*SFS: a FS that delivers food security and nutrition for all people in such a way that the economic and environmental basis to generate food security and nutrition for future generation is not compromised [24]
Giudice, Caferra & Morone [9], (p.11)	*SFS: increasing or maintaining agricultural yields and efficiency while decreasing the environmental burden on biodiversity, soils, water and air; reducing food loss and wasted; and stimulating dietary changes towards healthier and less resource-intensive diets [62]
Butler et al., [74], (p.38)	all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socioeconomic and environmental outcomes

Appendix A.3 Publications Included in the Systematic Review [2,3,5,9,10,12,16,17,19–21,26–30,37,41,45,47,49,55,57,59,63–65,67,71,72,74–100]

ID	Author	Year	Country of First Author	Location of the Framework Developed
1	Ahmed et al.	2020	USA	USA
2	Ahmed, Downs and Franzo	2019	USA	USA
3	Allen et al.	2019	France	France
4	Bene et al.	2019	Colombia	Colombia
5	Biehl et al.	2018	USA	USA
6	Bizikova et al.	2016	Canada	Canada
7	Brimblecombe et al.	2015	Australia	Australia
8	Bulter et al.	2021	Australia	Australia
9	Cadillo-Benalcazar, Renner and Giampietro	2020	Spain	Spain
10	Carlsson et al.	2017	Sweden	Sweden
11	Chen and Antonelli	2020	Italy	Italy//the proposed framework developed from Eertmans et al. (2001)@Belgium
12	Cullen et al.	2015	Canada	Canada
13	Dora et al.	2021	UK	UK
14	Downs et al.	2020	USA	USA
15	Downs, Payne and Fanzo	2017	USA	USA
16	Ericksen	2008	UK	UK
17	Fagioli et al.	2017	Italy	Italy
18	Flores and Villalobos	2018	USA	USA
19	Gaitan-Cremaschi et al.	2019	The Netherlands	The Netherlands
20	Guarnaccia et al.	2020	Italy	Italy
21	Halbe and Adamowski	2019	Canada	Canada
22	Heller and Keoleian	2003	USA	USA
23	Ingram	2011	UK	UK//derived from Ericksen's framework (2008 b)@UK
24	Institute of Medicine & National Research Council	2015	USA	USA
25	Jackson et al.	2020	Australia	Australia
26	Jacobi et al.	2020	Switzerland	Switzerland
27	James et al.	2021	Canada	Canada
28	Johnston et al.	2014	USA	USA
29	Kanter et al.	2015	Chile	Chile
30	Lambrou et al.	2021	USA	USA
31	Ma et al.	2019	China	China
32	Marshall	2015	Australia	Australia//adapted from McGinnis and Ostrom (2014)@USA
33	Mayton et al.	2020	USA	USA
34	Mazac et al.	2021	Finland	Finland
35	Melesse	2020	The Netherlands	The Netherlands//adapted from Ericksen (2008 b)@UK
36	Moragues-Faus	2019	UK	UK
37	Paloviita et al.	2016	Finland	Finland
38	Park et al.	2020	Korea	Korea
39	Raza et al.	2020	Italy	Italy
40	Rosenzweig et al.	2020	USA	USA

ID	Author	Year	Country of First Author	Location of the Framework Developed
41	Ruiz-Almeida and Rivera-Ferre	2019	Spain	Spain//categories and attributes for the analysis of FS from a food sovereignty perspective at the international level are adapted from Ortega-Cerdà and Rivera-Ferre (2010)@Spain
42	Samaddar et al.	2020	Philippines	Philippines//adapted from Cuevas et al. (2017, 2021) @ Philippines
43	Schnitter and Berry	2019	Canada	Canada
44	Slater et al.	2018	Canada	Canada
45	Tendall et al.	2015	Switzerland	Switzerland
46	Termeer et al.	2018	The Netherlands	The Netherlands
47	Turetta, Bonati and Sieber	2021	Brazil	Brazil
48	Verger et al.	2018	France	France
49	Wang et al.	2021	China	China
50	Zougmore, Laderach and Campbell	2021	The Netherlands	The Netherlands

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