General limitations to the current approach to urban food system frameworks

Abstract

Current studies on sustainability transitions of the food system (FS) are limited. The tools for assessing FS sustainability and enhancing FS performance are still lacking, highlighting the critical role of developing an assessment indicator framework for assisting sustainable FS transitions. This study seeks opportunities for optimizing existing food systems frameworks (FSF) that address the triple burden of malnutrition and FS sustainability. It examines FSF and other food system-related frameworks such as those related to food security, food sovereignty and so on, unveiling the general limitations of current approaches and methodologies in FSF and other related frameworks. To our knowledge, it is the first study to discuss the gaps of FSFs regarding their coverage on the food lifecycle and their representation of FS's multidimensionality. The results indicate that most FSF and related frameworks are conceptual. The most frequent limitations are no targeting audience, no coverage of food disposal stage, and no institutional/political dimension/indicators. Some have no multi-stakeholder inputs, no coverage of food input and/or food storage stages, no economic and/or nutritional dimension/indicators, while a few frameworks don't involve any statistical/empirical methods either/or quantitative indicators. Other limitations regarding language, data, and time are also identified. Finally, this study suggests developing a comprehensive multi-dimensional urban food system framework considering the full life cycle of food and combining FS-related dimensions with the five dimensions of environmental, economic, institutional, socio-cultural, and nutritional sustainability together to relieve the lifecycle and dimension gaps.

Keywords

Urban food system; food security; indicator assessment; sustainability transitions; food system.

1. Introduction

Food system (FS) issues can be describing as its unsustainability and the triple burdens of malnutrition (undernutrition, overweight, and obesity). To resolve those issues, it is widely accepted that sustainable transitions and transformations are the most optimal solution regarding the current global environmental challenges (GECs), climate change (CC) impacts, rapid urbanization, and other major planetary issues. According to El Bilali et al. (2019), three main strategies can be adopted for fostering sustainability transition of FS. They include efficiency enhancement (e.g., sustainable intensification), demand restraint (e.g., sustainable diets, reducing meat consumption), and transformation of FS (e.g., alternative food systems). However, there is a lack of clearly defined and commonly agreed intervention points that will have positive impacts on different sectors of FS to achieve sustainable diets and restrain the demand restraints (Mayton et al., 2020). Similarly, actions aiming at transforming FS and improving FS resilience also have the same difficulty determining the best time and opportunity to undertake interventions, especially when facing unexpected external shocks like the COVID-19 outbreak (Butler et al., 2021). Thirdly, it is widely recognized that actions and changes in decision-making from individuals and organizations across the whole FS are needed for promoting its transformations (Hoek et al., 2021), while the choices of available tools are very limited (Butler et al., 2021). Concerning the urgent need for major FS transformations nowadays, Clément and Ajena (2021) also stated the need to define suitable and applicable tools for assessing any proposed solutions to enhance FS has become one of the top priorities in sustainability studies.

In addition, it is argued that reaching consensus on metrics of sustainable FS (SFS) and understanding the trade-offs of FS sustainability (FSS) are vital to achieving the SFS agenda (Bene et al., 2019). Nonetheless, there is a lack of universally applied metrics system or framework of sustainable diets either (Allen et al., 2019). While the role of industries and firms in agro-food sustainability transition is also largely unexplored (El Bilali et al., 2019), so do the role of smart & resilient city drivers, circularity, carbon neutrality, and climate neutrality actions. Moreover, it can be argued that urban FS (UFS) holds the greatest opportunity for this sustainability transition of FS as cities play a vital role in driving sustainable patterns in production, consumption of goods & services (e.g., food and food systems), as well as in climate actions due to the following three reasons:

First, cities are the main drivers of CC, and at the same time, they are influenced by CC the most; this implies that cities provide a part of the solution to CC. Cities consume most of the world's food, water, energy, and other resources, and account for the largest proportion of the global GHGs, food loss and waste, and environmental pollution. Today, 55% of world's population lives in cities that only occupy 3% of the Earth's surface while consuming 70% of the world's food and 2/3 of primary energy accounting for about 70% of global CO2 emissions (FAO, 2021a), and 1/3 of all food is lost or wastes while 26% of global GHGs comes from agriculture (Poore and Nemecek, 2018).

Secondly, FS is also one of the main contributors to GHGs emissions. It is greatly impacted by CC, indicating that FS play an important role in undertaking CC actions. FS accounts for 34% of the world's total GHG emissions identified by the global database of GHG emissions from food systems (EDGAR-FOOD) for the year 2015, while agriculture and land use related activities contributed 71% of the total food system emissions, with the rest were from supply chain activities: retail, transport, consumption, fuel production, waste management, industrial processes, and packaging (Crippa et al., 2021). In *IPCC's special report on climate change,* *desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, Mbow et al. (2019) state that FS contributes to about 21-37% of global GHGs emissions from agriculture & land use to consumption through the whole food life cycle; and it is estimated to be increased by 30-40% by 2050. In detail, crop and livestock activities in farms account for 9-14%, land use (land use change, deforestation, peatland degradation) account for 5-14%, and supply chain activities account for 5-10% (Mbow et al., 2019). Moreover, besides capital, utilities, and housing, the food sector is recognized as one of the largest sectors in terms of consumption-based GHGs emissions per capita (FAO, 2021a). Resource-intensive foods, climate footprint of food production, land use for agriculture, unsustainable high-input agriculture, and monocultures have posed severe pressure on our environment, causing multiple negative climate impacts (World Resource Institute (WRI), n.d.); (Li et al., 2018). On the other hand, IPCC's report suggests that the four pillars of food security (availability, access, utilization, and stability) are all impacted by climate change, and these impacts will be continuously growing via yield declines caused by future CC with rising food prices, reduced nutrient quality and food supply chain disruptions (Mbow et al., 2019). In a meta-analysis conducted by Zougmoré et al. (2021), 70% studies indicate that CC impacts will decline crop yields by 2030s, with 50% of the studies shows different degrees of declines from 10% to 50%. Further, (Mbow et al., 2019) claim that agriculture and the food system play a vital role in dealing with CC, while coordinated action to address CC can simultaneously improve land, food security, and nutrition, and help to end hunger. It can be argued that food-climate synergy offers potential efficient and effective pathways to solve CC and food system issues at once towards sustainability.

Finally, even though cities consume about 79% of the total food produced in the world, current studies on UFS are very limited (ICLEI Circulars, n.d.), while urban food problems have been ignored in urban studies until recently, when the growing food activities in cities and their impacts is attracting more and more attention and research interest in both academia and urban practices (Maye, 2019). Before 2050, the world's total population is projected to be around 10 billion (World Resource Institute (WRI), n.d.), 68% of the world's population will live in urban regions (Wang et al., 2021), and cities will consume 80% of the total food in the world (Ellen Macarthur Foundation., 2019)(FAO, 2021b). Cities or urban areas provide a critical lens for studying sub-national dynamics, linking social & economic activities to spaces, and assessing the material & energy flows towards the lowest environmental costs and influences (Blay-Palmer and Conaré, 2018). While food supply has become a key issue of human development, the growing critical role of FS in urban areas has been amplified as urban areas have become hotspots for intensive resources (Doernberg et al., 2019). In a research project called "Rapid Planning", food systems are considered part of urban infrastructure including trans-sectional synergies between resource flows within an urban metabolism (Kasper et al., 2017), implying the potentials of handling the urban food system issues and promoting circular urban metabolism simultaneously. In the process of constructing and managing sustainable and resilient FS & UFS, cities play a strategic role since they are seen as "*progressive policymaking hotspots*" and "*new spaces for FS innovation*" (Milan Urban Food Policy Pact (MUFPP), 2020); (Doernberg et al., 2019). In food and agriculture practices, city councils and urban social movements both act as key players in food policy, including urban agriculture for mitigating CC impacts and urban heat island effects; diet-related issues to pushing cities to create strategies to build more sustainable urban foodscapes; etc. (Maye, 2019). While in the perspectives of food policy and urban studies, cities are gradually seen as a critical part of the FS, as well as a dynamic space for creativity, experimentation, and green activism, such as new forms of social innovation, governance, and sustainable transition (Maye, 2019).

Existing studies verify cities are part of the FS and play a significant role in the sustainability transition of FS. While UFSs are part of a city and part of FS as well, it can be argued that the UFS of one particular city plays a significant role for that city in the sustainable transition of FS and CC cooperation. This fact is due to the food-climate synergy and city-climate synergy based on the point of context-specific solutions to sustainability. As discussed above, it is assumed that UFS has the most significant potential in FS transition towards sustainability to resolve FS issues and CC due to several reasons.

To our knowledge, not only the research on sustainability transitions of FS is minimal (El Bilali, 2019), but also research on FSS at urban and/or city level is still lacking as such kinds of studies usually measure FSS at global or national level (Carvalho et al., 2021). Besides, Butler et al., (2021) argue that there is a lack of effective and efficient tools available to identify possible interventions for improving FS resilience and opportunities of FS transformations. To fill these gaps and better support UFS sustainability transition, a long-term mitigating plan is needed to put efforts into building a comprehensive multidimensional UFS framework (UFSF) for relieving current and potential FS issues.

Thus, the aim of this literature review study is to optimize a framework for the development of FS/UFSs that tackle the triple burdens of malnutrition and FS unsustainability and explores the following research questions:

- What are the general gaps in the existing frameworks and the limitations in developing a comprehensive multidimensional UFSF?
- How can the identified gaps and challenges in the current FSFs be addressed and mitigated?

2. Literature Review

2.1 Triple Burdens of Malnutrition

Global success in reducing the prevalence of hunger and increasing nutrition has benefited from improving the efficiency and productivity of FSs (Ericksen, 2008). However, due to the specialization, standardization, and mechanization of present industrial agriculture practices (IPES-Food, 2016), our food systems have been trapped into a vicious cycle of increased production, environmental and ecosystem degradation (Benton et al., n.d.), and growing public health costs. Such factors have only been beneficial to a small portion of population (Clément and Ajena, 2021). This inability of the FSs to provide equal and equitable benefits is considered one of the four major narratives of our food system (Béné et al., 2019). Another narrative that is closely linked to this imbalance is the inability of the system to deliver a healthy diet (Béné et al., 2019), resulting in malnutrition and micronutrient deficiencies among vulnerable people. According to (Johnston et al., 2014), even though more than one billion people in the world are overweight and obese, 868 million people are suffering from hunger, and another 2 billion are suffering from micronutrient deficiencies. This phenomenon refers to the existing wide-spreading global imbalance, the so-called “triple burden of malnutrition” (Johnston et al., 2014; El Bilali, 2019; Allen et al., 2019).

Furthermore, (Downs et al., 2020) state that every country in this world is still suffering from the triple burdens of malnutrition, including overweight, obesity, undernutrition, and their coexistence, which remains the top causes of death. More specifically, coexistence of multiple burdens of malnutrition happens in 88% of countries, much of which is associated with diets high in saturated fat, sugar, highly processed foods, and meat, while being low in fibres, fruits, and vegetables (Downs et al., 2020). In fact, the triple burden of malnutrition reminds us to rethink health and nutrition as the main goals of FS (Allen et al., 2019). Johnston et al. (2014) also argue that the world is producing enough food to feed all the people for now. The true challenges for the current global FS are making the available food accessible, affordable, culturally acceptable, and nutritious. While Horton et al. (2016) state that our current FSs not only produce insufficient food but they are also unsustainable, inequitable, and not resilient in the economic, environmental, and social dimensions. Equally, the inability of the current FSs to feed the world's growing population in the future and FSs' unsustainability are recognized as major narratives about the failure of FS by Béné et al. (2019). Downs et al. (2020) also argue that feeding sufficiently and healthily an increasing population remains one of the biggest challenges in the current Anthropocentric Age. This aligns with the FSs' narratives of being unable to feed the people in the future, and to deliver a healthy diet.

Lastly, it is also highlighted that the fundamental underlying reason for the triple burdens of malnutrition is the unaffordable cost of healthy diets (FAO et al., 2020). Monoculture depending on starchy crops and lacking food production diversity can result in unhealthy diets and finally malnutrition (Li et al., 2018), and lowering the system resilience in facing uncertainties and disturbances, especially under the current circumstances of global environmental challenges, intensifying CC, the epidemic outbreaks, and other stressors. To resolve this problem, FSs transformation is needed, and it should create supportive food environments, encourage people to learn about nutrition, and stimulate behaviour changes that can lead to healthy food choices (FAO et al., 2020). At the same time, IPES-Food (2016) also suggests that a paradigm shift from industry-orientated FS to diversified agroecological systems, and climate-smart agriculture are needed for assisting FS sustainability transition. In a word, regarding to the triple burdens of malnutrition, eliminating the monoculture of food production while promoting a greater diverse FS at all scales, fostering more healthy and sustainable diet with food environments and behaviour change, and resolving all the four pillars of food security is critical.

2.2.2 Context Specific Solutions

Like all other global challenges, there are no one-size-fits-all solutions for countries to resolve the food crisis. FAO et al. (2020) argue that all potential solutions must be specifically tailored to each context which will benefit in reducing nutritious food prices, making healthy diets affordable to all, and even creating jobs in FS for vulnerable people to increase their incomes so that improve their food security. Furthermore, Waterlander et al. (2018) emphasize the complexity of FS needs to be acknowledged to find solutions for the current nutrition challenges (e.g., triple burden of nutrition) as it cannot be solved in isolation. Actions like identifying context-specific barriers, optimizing trade-offs, and making the greatest use of synergies are also suggested for policymakers for constructing strategies (FAO et al., 2020). Since those trade-offs are usually between different scales or levels of decision-making and policy-making, Ericksen (2008) argues that solutions to deal with them must be context-specific.

To be successful in FS transition towards sustainability, utilizing context-specific strategies is essential because of the heterogeneity and complexity of FSs' nature, as well as the diversity and variability of key players, priorities, and problems regarding different contexts at multiple scales such as countries, regions, cities and even districts. Since cities hold the key to food system transformations with several advantages, it can be argued that the most effective and efficient way to tackle food system issues will need to be tailored for a specific city or focus on a particular urban context. To our knowledge, not only the research on sustainability transitions of FS is very limited (el Bilali, 2019), but also research on FSS at the urban and/or city level is still lacking because such kinds of studies usually measures FSS at global or national level (Carvalho et al., 2021).

According to the Government of Canada (2017), a framework is "*simply the structure of 'a system, concept, or text'*", which can be used to describe FS and UFS. While the indicator is a single data element that can be seen as a measure of something or a snapshot of a status (Government of Canada, 2017); simplifying complex phenomena (Maclaren, 1996) such as FS activities and interactions. Hence an indicator framework can be served as a powerful assessment tool to analyse FS dynamics and assess FSS regarding different circumstances and scenarios. Moreover, the Government of Canada (2017) also claims that an indicator framework is a straightforward and succinct method to illustrate collected data and information while making it easier to indicate the relation and association between various indicators. However, based on the results of our literature review, current research on the topic of developing UFS frameworks remains greatly underexplored, not to mention the construction of the UFS indicator framework particularly.

To fill these gaps and provide more effective solutions to the FS issues, an assessment tool (i.e., to measure FSS at the urban level) is needed to help better understand the mechanism of UFS and FSS. The tool also helps support the UFS transition, calling for developing indicator frameworks specific for UFS.

This paper is structured as follows:
Section 3 describes the details of review materials and methods. Results and discussions on methodologies, limitations, and gaps of FSF and FS-related frameworks are illustrated in Section 4. Lastly, Section 5 provides a summary of the main findings and conclusions of this review, highlighting research gaps and future directions of investigation.

3. Material & Methods

The protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) was employed in this literature review, providing transparency and clearness for the whole process, which makes it easy to reproduce. An initial search was performed to identify and explore potential keywords for developing a useful review strategy, indicating that the keywords "urban food system" and "framework" rarely appeared together in the results. Hence, this search string was used: **TOPIC**: ("food system") *AND* **TOPIC**: (framework).

3.1 Literature selection

The initial research was conducted on May 19th, 2021, using the Web of Science database, which yielded 603 documents (Fig. 1). The cut-off date is Jun 18th, 2021. After the initial search, 28 more newly published articles were added, and six additional articles from the included studies' references were also included. 152 documents were excluded after screening their titles & abstracts since they didn't contain the keywords "food system" and "framework" together. Then the following inclusion criteria was applied:

1) Develop a food system framework (FSF) or FS-related framework (e.g., food security, food governance, sustainable diets and etc.);
2) Either a conceptual or practical framework using one or more methods that are replicable.

Based on scrutiny of abstracts, 372 more documents were excluded as they don't meet the inclusion criteria. After reviewing the full text of 107 documents and applying the inclusion criteria, 50 records were included by the end of the cut-off day (Jun 18th, 2021).

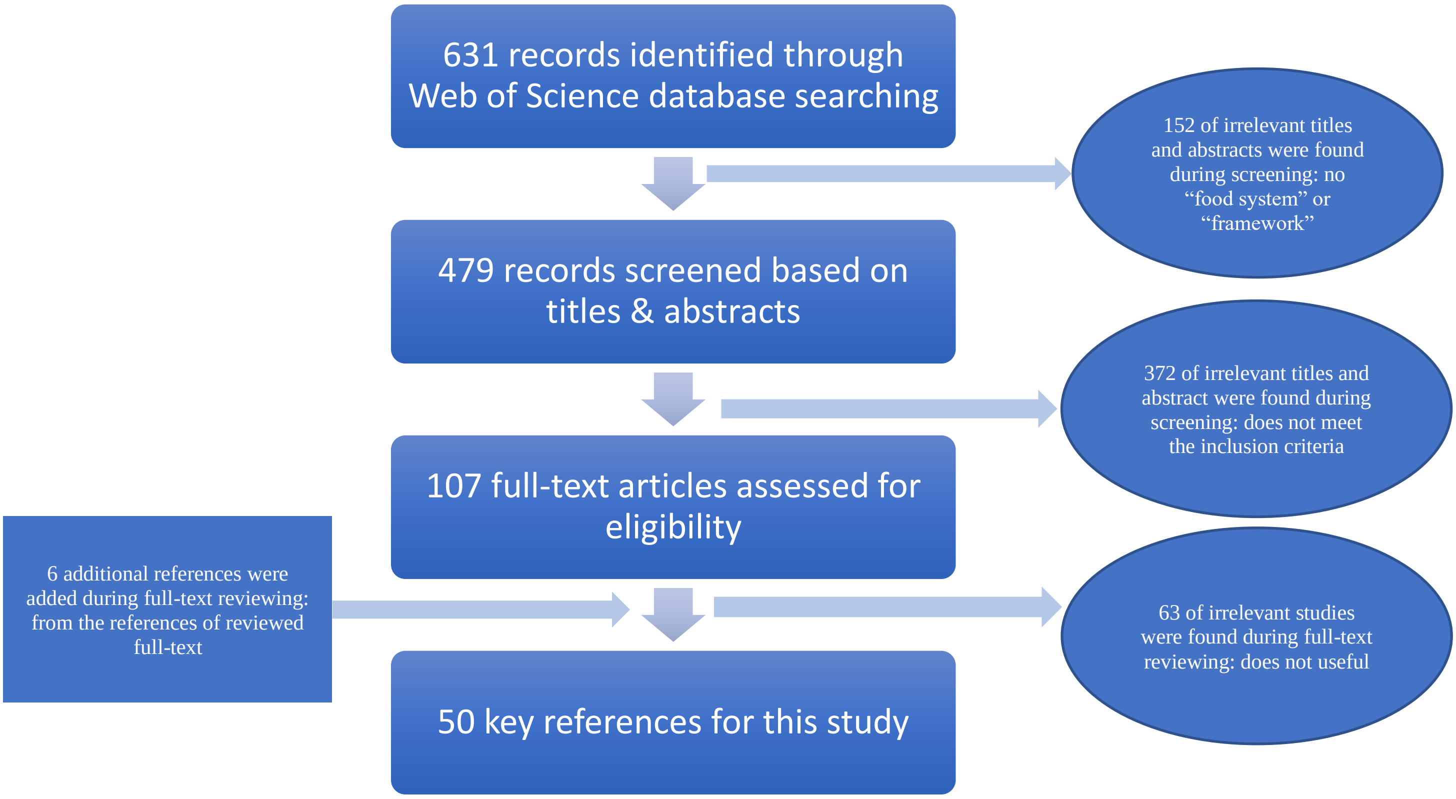

Fig. 1. Systematic review process (Source: the Authors)

3.2 Literature review and data extraction

The literature review and data extraction consist of four main steps (Fig. 2):

1) Various data related to the retrieved articles were composed in a Microsoft Excel sheet, such as types of frameworks, the configuration of frameworks, indicator features, methods used in their developments, and related limitations;
2) The collected data was read in detail and coded;
3) Another round of review was done to check the accuracy of the coded data;
4) Another round of review for additional checking/refining by considering the feedbacks received from the project team .

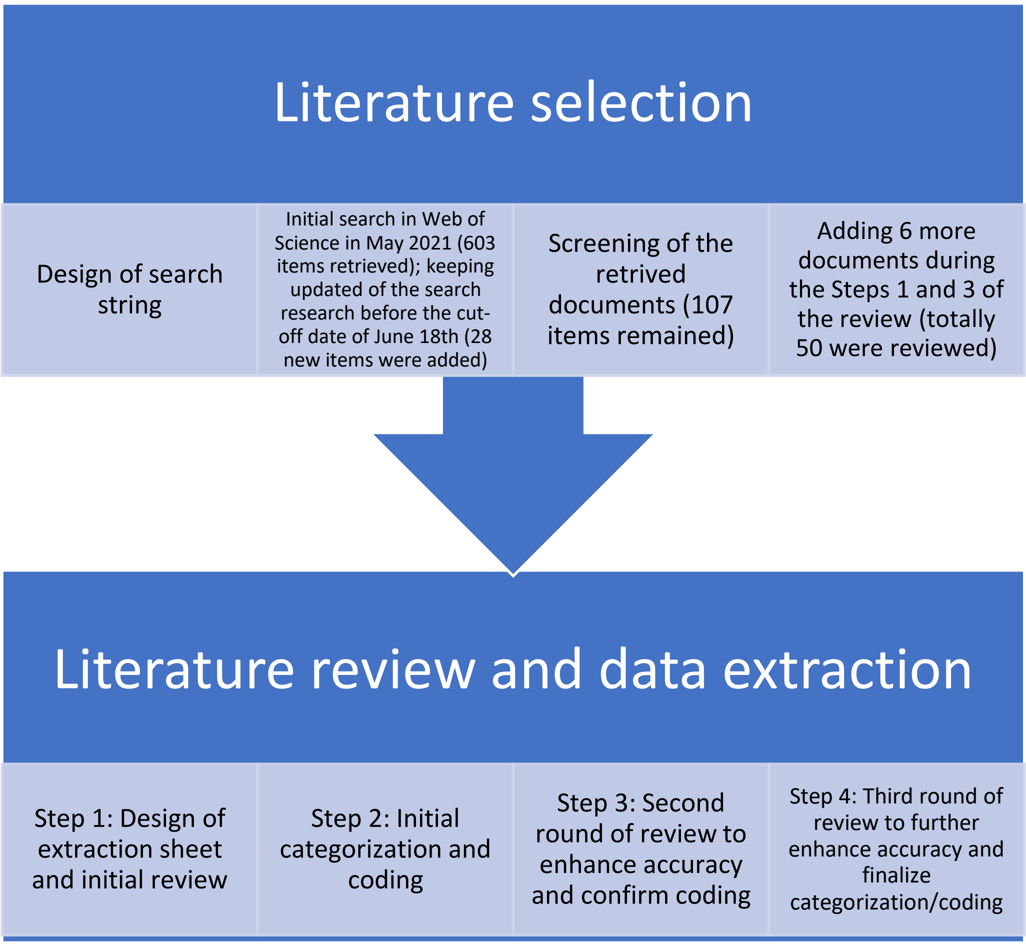

Fig. 2. Procedures for literature selection and data extraction (Source: the Authors)

4. Results & Discussions

4.1 Configuration of Food System Frameworks

Speaking of framework configurations (See Figure 3), the selected studies display a great variety and diversity. Since this paper includes twenty-eight FSFs (3, 4, 5, 6, 8, 9, 10, 16, 18, 19, 20, 22, 24, 25, 26, 27, 30, 31, 32, 35, 36, 37, 39, 40, 45, 47, 48, 50) and twenty-one other FS related frameworks (1, 2, 7, 11, 12, 13, 14, 15, 17, 21, 23, 29, 33, 34, 38, 41, 42, 43, 44, 46, 49 - See Appendix 1), the configurations of frameworks have been divided into the two types: conceptual and practical. In total, the included studies have twenty-three conceptual frameworks (4, 5, 7, 12, 13, 16, 23, 27, 28, 29, 30, 32, 33, 34, 37, 38, 39, 40, 43, 44, 45, 47, 48) and twenty-seven practical frameworks (1, 2, 3, 6, 8, 9, 10, 11, 14, 15, 17, 18, 19, 20, 21, 22, 24, 25, 26, 31, 35, 36, 41, 42, 46, 49, 50), varying from diagram illustrations to lists of methods with proposed procedures (See Appendix 1 and Table 1). Some frameworks just consist of single concept maps; some are lists of related key concepts and definitions; others are detailed assessment frameworks with indicator banks and verification process like case studies. Some even involve the improved version of the proposed frameworks. More specifically, conceptual frameworks provide virtual illustrations of ideas and concepts with graphs or diagrams or lists focusing on theoretical foundations of the food system assessment tools. Conceptualization of ideas or introducing new concepts briefly through conceptual frameworks can provide a basis for further development of practical frameworks. While practical frameworks cover not only conceptualizations but also applications in experiments, case studies or pilot assessments, and some are just building upon existing conceptual frameworks with a few improvements and/or detailed indicators. Data/results generated by applying practical frameworks serve as a part of the validation of the framework itself. It can be argued that practical frameworks provide more useful information on the application and limitation of implementing FSF and other related frameworks, while some conceptual frameworks contribute to foundations of new theories or further advanced frameworks precisely (Fig 3 and Table 1).

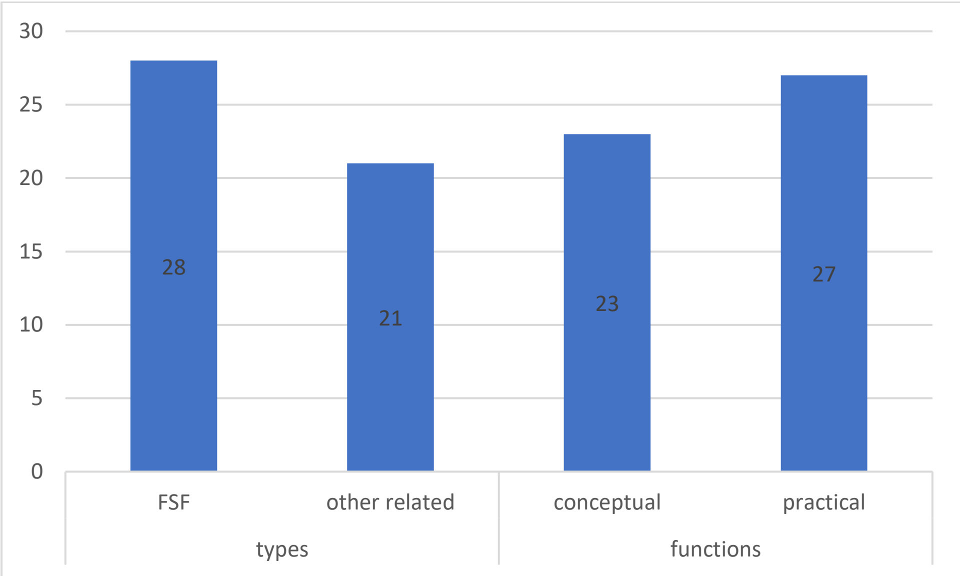

Fig. 3. Configurations of FSF and other FS-related frameworks (Source: The Authors)

Table 1. Characteristics of different types of framework configurations

Types of framework configurations	**Characteristics**
FSF	-deal with food system/urban food system/sustainable food system
FS-related Frameworks	-deal with one or more dimensions of FS framework (e.g., framework for food security, food policy, food sovereignty, food governance) -deal with some aspects of FS and/or more than just FS (e.g., framework for reducing nitrogen loads of urban food system; framework for sustainable diet; framework to study and respond the CC, food security and human health nexus)
Conceptual frameworks	-visual illustration of ideas, theories, or concepts (e.g., diagram conceptualization of proposed food system) -no empirical data or methods involved (e.g., lists of methods with proposed procedures)
Practical frameworks	-involve empirical data, methods and/or approaches (e.g., case studies, pilot assessments) -can be applied directly (e.g., indicator assessment framework)

4.2 Frameworks' Problems & Limitations

Nesheim et al. (2015, p.10-12) states that a reasonable assessment framework should:

1. Recognize effects across the full food system;
2. Consider all domains and dimensions of effects;
3. Account for system dynamics and complexities; and
4. Choose appropriate methods for analysis and synthesis.

In this literature review, the typology of framework for sustainability indicators development from Mclaren (1996) is used to analyse frameworks' problems and limitations. General limitations and problems for all frameworks can be found in Section 4.2.1. Since not all the included frameworks are assessment frameworks or contain any indicators (Table 2), additional discussions on the lifecycle gap and dimension gap of the frameworks can be found in Section 4.2.3, and 4.2.4 respectively.

4.2.1 General Problems/Limitations

Generally, the included studies have seven main limitations (See Figure 4 and Table 2). From the highest frequency to the lowest one, those limitations include no targeting audience (41), no multi-stakeholder inputs (22), no quantitative indicators (8), various data limitations (5), no statistical/empirical methods applied in the studies (4), language limitations (3), and time limitations (2). These seven types of limitations will be discussed further in the following sections.

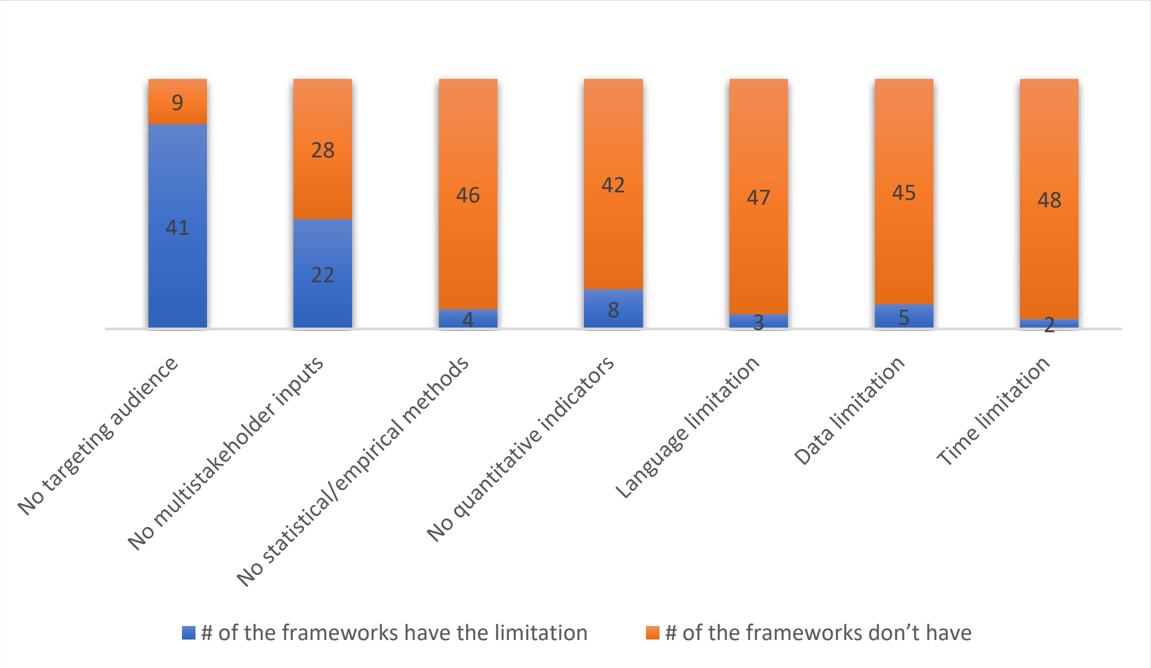

Fig. 4. General limitations of FSF and other FS-related frameworks (Source: The Authors)

Table 2. General limitations mentioned in the included frameworks

Limitation category (count)	IDs
Time limitation (2)	1,8
Data limitation (5)	3, 5 (double counting), 9 (missing data in time series data sources), 35 (survey used for data

	collection were different in different countries), 41 (data availability)
Language limitation (3)	2 (include dietary guidelines from only HICs as only those available in English), 33 (source of datasets primarily in English), 34 (English speaking coders to conduct document review)
No quantitative indicators (8)	4, 5, 10,13, 27, 30, 44, 45
No statistical/empirical methods (4)	10, 27, 30, 45
No multi-stakeholder inputs (22)	2, 4, 8, 11, 13, 14, 16, 17, 22, 23, 24, 25, 29, 30, 31, 35, 37, 40, 43, 45, 47
No targeting audience (41)	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12 ,13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, 41, 42, 44, 45, 46, 48, 49, 50

Other limitations found in the literature vary differently but seem to make only very mild impacts on the results of framework development, or the impacts can hardly be assessed. For example, Ahmed et al. (2019, p. 13) claims that one of their research's limitations was "the equal prioritization of the ecological, economic, socio-cultural/political, and human health dimensions and sub-dimensions of sustainability"; thus, making it very hard to quantify the impact of this limitation on the proposed framework. A potential way of resolving this shortcoming is to use weighted values. Ahmed et al. (2019)'s framework has the same problem as well. They also did not apply any weighting to the different elements of their framework. Some other limitations are related to levels or scales (Bizikova et al., 2016); lack of holistic consideration in their own frameworks, such as marine food supply (Cadillo-Benalcazar et al., 2020); FS governance (Ericksen, 2008); insufficient meta-analysis (Chen and Antonelli, 2020); biases generated through the rating and aggregation of results by an expert panel (Jacobi et al., 2020); unsolved larger spatial variation (Ma et al., 2019); small sample size of survey (Park et al., 2020); Logistical and resource constraints (Samaddar et al., 2020). For more details, see Appendix 1.

4.2.1.1 No Targeting Audience

One major limitation of most studies identified in this literature review is no targeting audience. In total, there are 41 frameworks either not considering specific targeting audience or not clarifying their targeting audience (See Table 2). In the urban sustainability reporting process, identifying targeting audience is a step of its scoping stage, providing the preliminary background and idea for setting temporal and time boundaries (Maclaren, 1996). Moreover, it's also argued by (Maclaren, 1996) that both the number and form of indicators depend greatly on the sociodemographic features and other characteristics of targeting audiences. For instance, scientists/experts may prefer, and demand highly detailed and advanced indicator sets, which can sometimes be very hard for non-professionals to understand and adopt. On the other hand, as FS issues greatly vary differently according to different countries and regions, even cities and communities, which calls for developing context-specific frameworks to solve FS issues and promote FS sustainability. Moreover, lacking target audience in included frameworks reflects another aspect of lacking context-specific FSFs since audience-specific framework can also be seen as a type of specification regarding to targeting conditions, scenarios, or FS issues. In sum, identification of targeting audience is important for setting frameworks boundaries and developing context-specific solutions. Therefore, future FS frameworks are suggested to clarify targeting audience for better further implementation.

4.2.1.2 No Multi-stakeholder inputs

Multi-stakeholder participation can provide various benefits in the field of assessment development, decision-making process, sustainability studies, etc. However, only a few studies examined in this literature review have employed multi-stakeholder inputs. Twenty-two studies have no multi-stakeholder inputs during their framework development stages (See Table 2). Multi-stakeholder inputs can serve as an interactive bridge between bottom-up and top-down approaches, giving different perceptions from various standpoints and perspectives, as well as minimizing the potential biases generated by limited sight and information gap from single and/or simple source/s. According to Mclaren (1996), multi-stakeholder input is a distinguishing feature of sustainability indicators different from other kinds of indicators. The underlying reason is that the concept of sustainability is naturally value-laden and context-sensitive. It is suggested to consider more multi-stakeholder inputs when designing the framework development process and choosing methodologies.

4.2.1.3 No Quantitative Indicators

Some included frameworks have no quantitative indicators (See Table 2), creating further potential constraints and disadvantages of the proposed food system frameworks. However, most of these frameworks are conceptual, and can be improved before practical implementation. Quantitative indicators produce outcomes in the form of numbers while qualitative indicators generate data in form of texts (Garbarino et al., 2009). Using quantitative indicators makes it easier to compare the results straightforwardly and present the outcomes more intuitively. An assessment framework relying on qualitative indicators alone will reduce its practicability and limit its applicability. For developing future FSF, utilizing an appropriate combination of both quantitative and qualitative indicators is suggested.

4.2.1.4 Data limitation

Five analysed studies have discussed their data limitations (See Table 2), including double-counting, missing data in time series, data sources, the survey used for data collection were different in different countries, and limitations in data availability. Most data limitations are caused by practical difficulties or force majeure factors, it's very hard to make any changes or improvements. Nevertheless, some data limitations could be prevented to some degree with careful selection of indicators.

4.2.1.5 No Statistical/Empirical Methods

Lacking statistical analysis or empirical methods is another limitation of the included studies (See Table 2). One main underlying reason for this limitation is that they do not have quantitative indicators, preventing them from having useful data to undertake any statistical analysis. Another reason is probably due to the fact they are conceptual frameworks, and the authors only focused on the conceptualizations not the validations and/or applications. However, experiments and/or statistical analysis are essential to testify and validate the proposed assessment framework. Meanwhile undertaking various types of analysis with different focuses can provide inclusive information for specific questions, for example, relationships between different indicators. In order to prevent this kind of limitation in the future development of FSF, eliminating the limitation on no quantitative indicators is a key step, and engaging statistical/empirical methods with a theoretical foundation in the process of framework development is also recommended.

4.2.1.6 Language Limitation

Speaking of language limitations, only three studies have addressed this issue (See Table 2). It can be affirmed that this type of limitation is usually ignored when discussing methodology limitations in FSF development. More specifically, all the mentioned language limitations are due to the single use of English ,including dietary guidelines from only HICs as only those available in English, source of datasets primarily in English, and English-speaking coders to conduct document review. However, it is assumed that most of the existing frameworks have the same situation or similar issues due to various limitations and constrains such as the availability of data sources in different languages other than English, the researchers' language level in different languages, language popularity, and distributions in study countries/areas, and so on. To minimize the negative effect of language limitation, improving data accessibility and availability and engagement of multilingual researchers and data sources might be a possible solution.

4.2.1.7 Time Limitation

There are only two frameworks that recognized time limitations in their studies (See Table 2). Due to the time constraints, Ahmed et al. (2020) designed their questionnaires to evoke only yes/no responses for undergoing a rapid assessment while more details could be lucubrated if time allows. Moreover, Butler et al. (2021) state that all their research teams have difficulties in extracting an enormous volume of information and data within a concise timeframe. It can be argued that time limitations greatly constrain the utility of any proposed FSF and the choice of approaches. Again, like language limitation, time limitation can only be partially resolved or mitigated. Potential strategies include a better program/research plan for the framework development, greater time management, constant coordination of the timeframe regarding the rate of progress, etc.

4.2.3 Framework Lifecyle Gap

In total, twenty frameworks considered the elements the FS activities or stages of the food value chain (FVC). As illustrated in Table 3, all of them covered the production/growing stage, 85% covered distribution of food, followed by consumption and/or cooking (80%), processing and/or packaging (75%), and retailing/marketing (60%). The rest stages of FVC were rarely considered by the authors, including disposing/waste (40%), food storage and/or food environment (35%), and farm level/input/origin of source (30%).

Table 3. Framework's coverage of food system activities and their proportion compare with total number of studies (Source: the authors)

ID	Farm level/input/origin of source	Production/growing	Processing and/or packaging	Distribution/transportation/logistics	Storage/storage to food environment	Retailing/marketing/trade/wholesale	Consumption/preparation/cooking	Disposing/wastes and/or food loss
1		X		X	X		X	X
6		X	X	X	X	X		
13	X	X		X	X	X		
16		X	X	X		X	X	
17	X	X	X	X				
21		X		X	X			
22	X	X	X	X			X	X
23		X	X	X		X	X	
24		X	X	X	X	X	X	X
26		X	X		X	X	X	

29	X	X	X	X	X	X	X	
30		X		X			X	
31		X	X			X	Household*	
33		X	X	X			X	X
35		X	X	X		X	X	X
38		X	X	X		Selection*	X	X
39	X	Post-harvest*	X	X		X	X	X
41	X	X				X	X	
43		X	X	X			X	
47		X	X	X			X	X
% of total	30%	100%	75%	85%	35%	60%	80%	40%

Note: yellow boxes represent the stages/activities that are not covered in the framework.

However, the resource input or food at the farm level can be embedded in the production and/or growing stage when conducting assessments. Sometimes, the definition of these stages is not clear and it is hard to separate one from another. It seems more efficient to consider them as one individual phase of food activities located one stage ahead of the processing phase. Furthermore, there re not many materials and energy flows or interactions during the static status of food storage stages. Food storage can happen in any of those three stages: distribution, retailing, and consumption, so it is challenging to set the boundaries or partition criteria. Thus, it might not be essential to consider food at the farm level and food storage separately when constructing dimensions of FS frameworks for food activities. Thirdly, in order to put forward to build a comprehensive multidimensional UFSF for relieving current and potential FS issues, a circularity/sustainability perspective is essential, it requires the consideration of the full life cycle of food which means the terminal stage of food's life cycle should be also covered. To achieve this, it is critical to consider the disposing phase and/or food loss/waste in future framework development.

4.2.4 Framework Dimension Gap

In the literature review, the goals of most FSF or FS-related frameworks was to promote SFS or to support FSS transitions while the four main dimensions of sustainable development involve environmental, economic, social, and institutional and the inherent value of food is nutrition. As a result, most of them considered environmental, economic, social, and nutritional dimensions since (2, 3, 4, 9, 10, 14, 15, 22, 24, 28, 33, 34, 36, 37) (See Table 4).

More specifically, seven frameworks directly use "environmental dimension" (9, 14, 22, 24, 28, 36, 37), while others adopt environment & ecosystems (15, 34), environmental impact (33), environmental integrity (4), ecosystem integrity (10), ecological dimension (2), water use & agrobiodiversity (3). For the economic dimension, four studies use it directly (2, 9, 14, 24, 36). In contrast, others include various economic-related dimensions such as household food cost & price volatility (3), creation of human welfare (4), agronomic (9), markets, trade, and value chains for economic growth (15). For the social dimension, only three studies use it directly (9, 22, 24) or in terms of social integrity (10), social equity (4), social value (23, 43). Four frameworks consider sociocultural & political as one dimension (2, 14, 15, 24) while others adopt sociocultural (28) or socio-political (33) alone or socio-economic (37). In a multi-scale analytic framework for characterizing the FSS, the demographic dimension is also considered besides the social dimension (9). It indicates that combining social aspects with cultural and/or political aspects is the most popular way to construct FS or FS-related frameworks, especially when dealing with a sustainability-related goal.

No frameworks utilize institutional dimension, but they do adopt related dimensions/domains including governance (36, 49); policy (37, 50); agrarian policies & civil society organization (41); leadership & partnerships, community & services (7); responsibilities (27); and rights (27). Since intuitional dimension plays an essential role in sustainable development, it can be argued that considering institutional dimension in developing UFSF is critical to reaching the goal of FS & UFS sustainability transitions.

Lastly, since food provides nutritional value and supports human health, the nutritional dimension cannot be ignored when developing frameworks for FS & UFS. The literature review illustrates that four studies use health or human health as one of their frameworks' dimensions (2, 14, 24, 28) as well as other similar health-related dimensions, including human health integrity (10), health & wellbeing (36). Two frameworks cover the nutritional dimension solely (9, 33), while another two frameworks consider nutrition and health together as one dimension (15, 34); others involve dietary diversity and nutrition adequacy (3). In a word, it can be argued that employing the four dimensions of environmental, social-cultural, economic, and nutritional might be the optimal option when developing a domain-based framework (DBF) or goal-based framework (GBF) for UFS.

On the other hand, for some FS-related frameworks which only focus on one or two aspects of FS such as food security (the four pillars of food security include food accessibility, food availability, food utilization & food stability), food sovereignty (41), or food literacy (38, 44); they conceptualize and characterize in a different perspective. In detail, those FS-related frameworks involve several additional dimensions including food accessibility (3, 12, 23, 33, 43); food availability (3, 12, 23, 43), food utilization (23, 43); food security & agriculture (15, 34); agriculture (25); food acceptability (3); food affordability (12, 43); food infrastructure (10); food production (33, 43); food loss & waste (33); food & water safety (33); food process & distribution (33, 43); food consumption (33, 41). As we can see, these additional dimensions from the FS-related framework all focus on "food" to some extent, dealing with food security issues, the triple burdens of malnutrition and other FS narratives. This implies that those dimensions could be used when developing an issued-based framework (IBF) for UFS.

Moreover, other additional infrequent or unique dimensions/aspects/domains found in the literature review contain three parts of vulnerability (exposure, sensitivity & resilience) (3); five domain of FS (Leadership & partnerships; traditional & local food production; food businesses; buildings, public places & transport; and community & services) (7); four types of food skills (knowledge, access, values, belief & culture, 12); four dimensions of effects (quantity quality, distribution & resilience, 24); three levels for the entering point of food choice intervention (eating occasions, dishes & ingredients, 42); three domains of food literacy competencies for youth (functional competencies, relational competencies & systems competencies, 44); four components of food resilience (robustness, redundancy, flexibility & resourcefulness, 45); five aspects of urban agriculture (food supply, value export, leisure agriculture, resource agglomeration & food governance, 49); six categories of food sovereignty (access to resources, productive models, commercialization, food consumption & the right to food; agrarian policies & civil society organization, and gender, 41); and even technological and other factors (37). Those considerations/dimensions could be used as an extra reference for further development of the preliminary UFSF.

Table 4. Framework's coverage of different dimensions and their proportion compared to the total number of studies (Source: the authors)

ID	Environmental /ecological	Economic	Social/ cultural	Institutional/ political	Nutritional /health	Other
2	ecological	X	Social cultural & political		Human health	
3	*Water use, agrobiodiversity	household food cost, price volatility			dietary diversity, nutrition adequacy	//the indicators were organized into the 3 components of vulnerability: exposure, sensitivity, and resilience
4	the maintenance of the environmental integrity of the resource	the creation of human welfare	the pursuit of social equity			*the 4th dimension is often superimposed on these three and involves TIME and the IDEA that sustainability of today should NOT be achieved at the cost of the sustainability of tomorrow.
5						3 key components of food security: food accessibility, availability, and acceptability.
7						5 FS domains: (i) Leadership and partnerships; (ii) Traditional food and local food production; (iii) Food businesses; (iv) Buildings, public places, and transport; (v) Community and services
9	X	economic, agronomic	social, demographic		X	technical
10	ecosystem integrity		social integrity		human health integrity	food infrastructure
12						2 spheres of FL: 1. Community Food Security (CFS): local FS, programs, access, availability, affordability; and 2. food skills: knowledge, access, values, beliefs, culture
14	X	X	social cultural & political		human health	
15	environment and ecosystems	markets, trade, and value chains for economic growth	social cultural & political		nutrition and health	agriculture and food security
22	X	X	X			
23						Food security outcomes are grouped into 3 components:

						(i)Availability: production, distribution, exchange; (ii) Access: affordability, allocation, preference; and (iii) Utilisation; nutritional value, social value, food safety
24	X	X	X		health	4 dimensions of effects: quantity, quality, distribution, and resilience
27						//5D principles of Redistribution: Decolonization, Decarbonization, Diversification, Democratization, and Decommodification; 5R principles of Regeneration: Relationality, Respect, Reciprocity, Responsibilities, and Rights.
28	X	socioeconomic	sociocultural		health	agriculture
33	(8) environmental impact		(7) socio-political context		(6) nutrition	8 domains: (1) food production, (2) food processing and distribution, (3) food loss and waste, (4) food access and consumption, (5) food and water safety
34	environment and ecosystems	markets and value chains	sociocultural & political		health and nutrition	food security and agriculture
36	X	X		governance	health & wellbeing	
37	X		socio-economic	policy		technological, and other factors
38						*3 LITERACY DIMENSION: functional literacy, interactive literacy, critical literacy
40						CC mitigation, CC adaptation
41						*6 food sovereignty's categories: 1) access to resources; 2) productive models; 3) commercialization; 4) food consumption and the right to food; 5) agrarian policies and civil society organization, and 6) gender.
42						//3 levels for the entry point of the intervention in the GSR framework: 1. eating occasions, 2. dishes, and 3. ingredients.
43						3 critical dimensions of food security: 1. availability (production, distribution, exchange) 2. accessibility (affordability, allocation, preference) 3. utilization (nutritional, value, food safety, social value)
44						3 domains of food literacy competencies for youth: (1) Functional Competencies: Confidence and Empowerment with Food; (2) Relational Competencies: Joy and Meaning through Food; and (3) Systems Competencies: Equity and Sustainability for Food Systems within the framework,

						"Food literacy competencies for young adults"
45						a FS's resilience can be broken down into 4 components: (i) ROBUSTNESS, (ii) REDUNDANCY (iii) the FLEXIBILITY and thus RAPIDITY (or the FS reactivity) (iv) RESORUCEFULNESS and ADAPTABILITY,
49						5 main aspects of urban agriculture: (1) Food supply; (2) value export; (3) leisure agriculture; (4) resource agglomeration; and (5) food governance.
50						// 4 interlocking action areas for food systems reconfigurations: 1. Reroute farming and rural livelihoods to new trajectories; 2. De-risk livelihoods, farms, and value chains, 3. Reduce emissions through diets and value chains and 4. Realign policies, finance, support to social movements, and innovation
% of total	50%	39%	43%	7%	39%	86%

Note: yellow boxes represent the dimensions that are not covered in the framework

As illustrated in Table 4, the results indicate that when constructing FSF or FS-related frameworks, most studies (86%) divided their frameworks' dimensions regarding FS-related concepts (e.g., food security, food literacy) or others rather than referring to the pillars of sustainability development (SD). Since food provides nutrition and supports human health, some studies (39%) also utilized them as one dimension. In addition, 50% of the included frameworks considered environmental/ecological dimensions, 43% considered social/cultural dimensions, 39% covered economic dimensions, and only 7% covered the institutional/political dimensions. In order to develop a framework for enhancing FS performance and promoting FSS, it's necessary to involve four pillars of SD when dividing dimensions. Thus, it is suggested to integrate FS-related dimensions with others such as environmental, social-cultural, economic, institutional, and nutritional dimensions in the future development of FSF and/or UFSF.

5. Summary & Conclusions

In sum, no targeting audience is the most frequent general limitation of existing FSF and other related frameworks (82%), followed by no multi-stakeholder inputs (44%), no quantitative indicators (16%), various data limitations (10%), no statistical/empirical methods (8%), language limitation (6%), and time (4%). It can be affirmed that targeting audience and multi-stakeholders are usually ignored during the development stages of those frameworks. Considering indicators when constructing frameworks is also important as it provides the basis for using empirical approaches to testify applicable frameworks in the form of case studies, pilot assessments and so on.

Speaking of framework configurations, among 28 FS frameworks and 21 FS-related frameworks, 23 are conceptual frameworks while 27 are practical; 20 considered the elements FS activates or stages of FVC. Except the production/growing stage, distribution of food, consumption and/or cooking processing and/or packaging and retailing/marketing, there is limited coverage in disposing of waste, food storage and/or food environment, and farm level/input/origin of source, implying a research gap there.

As for frameworks' general problems & limitations, it can be categorized into seven types, respectively, 41 frameworks have no targeting audience (82%), 22 with no multi-stakeholder inputs (44%), eight has no quantitative indicators (16%), five with various data limitations (10%), four didn't use any statistical/empirical methods in the studies (8%), three studies state they have language limitations (6%) and two have time limitations (4%).

In conclusion, regarding the limitations and constraints, considering the full life cycle of food and combining FS-related dimensions with the five dimensions of environmental, economic, institutional, socio-cultural, and nutritional dimensions together are suggested to relieve the lifecycle gap and dimension gap, respectively. Other recommendations and suggestions regarding each type of limitation discussed in this paper can be found in Table 5.

Table 5. Suggestions for resolving the limitations of FSF development (Source: the authors)

Limitations	**Implications & Suggestions**
No Targeting Audience	-set clear frameworks boundaries -develop context-specific frameworks -clarify targeting audience at the beginning
No Multi-stakeholder inputs	-consider more multi-stakeholder inputs when designing the framework development process and choosing methodologies
No Quantitative Indicators	-utilize an appropriate combination of both quantitative and qualitative indicators
Data limitation	-careful selection of indicators use reliable and stable data source
No Statistical/Empirical Methods	-use quantitative indicators -conduct statistical analysis -undertake case studies/pilot assessments
Language Limitation	-improve data accessibility and availability -engage multilingual researchers and data sources if possible
Time Limitation	-better program/research plan -improve time management -constant coordination of the timeframe regarding to the rate of progress
Lifecycle Gap	-consider the full life cycle of food in the framework (i.e. cover the disposing phase and/or food loss)
Dimension Gap	integrating FS-related dimensions with others such as environmental, social-cultural, economic, institutional, and nutritional dimensions in future development of FSF and/or UFSF

Appendix

Appendix 1. FSFs and FS related frameworks

ID	Author	Year	Framework	Configuration
1	Ahmed et al.	2020	Food environment typology framework for evaluating effects of COVID-19 pandemic on FS resilience	Practical (diagram illustration + a set of interview questions)
2	Ahmed, Downs & Fanzo	2019	An integrative framework to evaluate sustainability in national dietary guidelines	Practical (*Indicator for sustainability dimension scores)
3	Allen et al.	2019	SFS	Practical (*Indicator)
4	Bene et al.	2019	To support the transition toward SFS	Conceptual (table of drafting a plan for actions)
5	Biehl et al.	2018	a framework for conceptualizing FS vulnerabilities	Conceptual
6	Bizikova et al.	2016	*for assessing FS's resilience in the context of CC	Practical (diagram illustration + a series of "checklists" and criteria)
7	Brimblecombe et al.	2015	a useful framework to facilitate collective appraisal of the FS and identify opportunities for FS improvement in Indigenous Australian remote communities	Conceptual
8	Bulter et al.	2021	FS shocks	Practical (diagram illustration + 10 steps & questions)
9	Cadillo-Benalcazar, Renner & Giampietro	2020	a multi-scale integrated analysis of the factors characterizing the sustainability of FS	Practical (diagram illustration + input-output analysis+ *indicators of "embedded" or "virtual" environmental services. e.g., water footprint, land footprint
10	Carlsson et al.	2017	FS sustainability	Practical (diagram illustration + *indicator)
11	Chen & Antonelli	2020	food choice	Practical (diagram illustration + table of factors influencing

				individual food choice)
12	Cullen et al.	2015	*a framework that situates food literacy at the intersection between community food security and food skills	Conceptual (with diagram illustration)
13	Dora et al.	2021	an interdisciplinary conceptual framework for waste utilization practices that contribute towards the triple-bottom-line (TBL) in FS	Conceptual (with diagram illustration)
14	Downs et al.	2020	Food environment	Practical (diagram illustration + table of food environment key elements+ table of a methodological approach with potential methods for measuring different elements of the food environment based on type)
15	Downs, Payne & Fanzo	2017	*a policy analysis framework for examining the components of a sustainable diet	Practical (diagram illustration + table of key components of a sustainable diet + criteria)
16	Ericksen	2008	a framework for studying the multiple interactions of broadly defined FSs with global environmental change and evaluating the major societal outcomes affected by 3 interactions: food security, ecosystems services and social welfare	Conceptual (with diagram illustration)
17	Fagioli et al.	2017	*a multiple criteria framework to assess the level of multi-functionality along the entire food value chain	Practical (*Indicator)
18	Flores & Villalobos	2018	*a modelling framework for the strategic design of local fresh-FS	Practical (diagram illustration + yield approximation functions)

19	Gaitan-Cremaschi et al.	2019	*a framework based on the Multi-Level Perspective on Socio-Technical Transitions, objected to characterize the diversity of FS in view of sustainable transitions	Practical (diagram illustration + table of steps and related methods and sources of information for classifying FS)
20	Guarnaccia et al.	2020	SFS (a bioregional strategic framework for a SFS in Sicily 2030)	Practical (diagram illustration + *indicator)
21	Halbe & Adamowski	2019	*an innovative methodological framework for vision design and assessment (VDA) to analyse the sustainability of future visions on multiple scales with consideration of ecosystems services, and to test their plausibility based upon expert and local knowledge (3 designs of a SFS were analysed and tested)	Practical (diagram illustration + *indicator)
22	Heller & Keoleian	2003	FS sustainability through a life cycle perspective	Practical (*Indicator)
23	Ingram	2011	*a framework for structuring dialogues aimed at enhancing food security	Conceptual (diagram illustration)
24	Nesheim et al.	2015	framework for assessing effects of the FS	Practical (diagram illustration + *indicator)
25	Jackson et al.	2020	*a food system causal disaster vulnerability framework within the Bedamuni tribe of Papua New Guinea	Practical (table illustration + *indicator)
26	Jacobi et al.	2020	food sustainability	Practical (*Indicator)
27	James et al.	2021	a framework for food systems transformation after COVID-19	Conceptual (table of examples for the strategic policy framework “5Ds of Redistribution”:

				Decolonization, Decarbonization, Diversification, Democratization, and Decommodification)
28	Johnston et al.	2014	sustainable diets	Conceptual (diagram illustration)
29	Kanter et al.	2015	*a conceptual framework for understanding the impact of agriculture and FS policies on nutrition and health	Conceptual (diagram illustration)
30	Lambrou et al.	2021	A global food systems framework for pandemic prevention, response, and recovery	Conceptual (diagram illustration)
31	Ma et al.	2019	SFS (modelling framework for analysing the effects of changes in the food production-consumption system of China whose results linked to 8 SDGs.)	Practical (diagram illustration + *indicator)
32	Marshall	2015	a socio-ecological systems (SES) framework for FS research	Conceptual (diagram illustration + table of attributes of SES(T) framework)
33	Mayton et al.	2020	a conceptual framework for sustainable diets that is locally relevant to Vietnam using a process that is generalizable to other developing countries	Conceptual (diagram illustration + list of unique metrics for sustainability of diets)
34	Mazac et al.	2021	Sustainability in food-based dietary guidelines (FBDG) framework with 5 core domains: health and nutrition, food security and agriculture, markets, and value chains, sociocultural and political, and environmental and ecosystems	Conceptual (diagram illustration)
35	Melesse	2020	FS	Practical (diagram illustration + *indicator)
36	Moragues-Faus	2019	a sustainability assessment framework to evaluate FS performance in UK cities	Practical (diagram illustration + *indicator)
37	Paloviita et al.	2016	*FS vulnerability	Conceptual (table of the FS vulnerability matrix)

38	Park et al.	2020	two-dimensional food literacy conceptual framework	Conceptual (diagram illustration)
39	Raza et al.	2020	FSF for children & adolescents	Conceptual (diagram illustration)
40	Rosenzweig et al.	2020	A framework enabling integrated CC solutions from production to consumption	Conceptual
41	Ruiz-Almeida & Rivera-Ferre	2019	food sovereignty	Practical (diagram illustration + *indicator)
42	Samaddar et al.	2020	the "gastronomic systems research" framework to a target population of low-to-middle income households to capture the diversity and cultural drivers of food choice and its nutritional implications in race-based diets in 2 states in India	Practical (diagram illustration + expert elicitation analysis)
43	Schnitter & Berry	2019	*an analytical framework to study and respond to the CC, food security and human health nexus	Conceptual (diagram illustration + table of potential vulnerabilities & Primary elements)
44	Slater et al.	2018	* a food literacy framework for youth transitioning to adulthood	Conceptual (diagram illustration)
45	Tendall et al.	2015	FS resilience	Conceptual (diagram illustration)
46	Termeer et al.	2018	*a diagnostic framework for FS governance arrangements	Practical (table of five principles for FS governance arrangements + *indicator)
47	Turetta, Bonati & Sieber	2021	*Community food systems (CFS) (for combating threats to FS in neglected territories)	Conceptual (diagram illustration)
48	Verger et al.	2018	SFS, for rethinking FS toward sustainable consumption and production modes	Conceptual (diagram illustration)
49	Wang et al.	2021	developed an indicator framework tailored to Chengdu’s conditions and city objectives, for in-depth evaluation and monitoring of local urban agriculture by themes,	Practical (*Indicator)

50	Zougmore, Laderach & Campbell	2021	food system transformation framework	Practical (diagram illustration + table of determinants of adoption of CSA practices)

Appendix 2. Research methods of included FSF & FS-related frameworks

Main Research Methods		Methods Classification	IDs	Total account	Category account
Literature review (LR)		N/A	4,5,6,7,11,12,13,14,15,16,18,20,28,29,32,33,34,35,36,37,38,41,43,44,50	25	LR:25
Case studies (SC)		N/A	1,2,5,6,8,17,18,21,26,35,49(*pilot in-depth assessment),50	12	CS:12
Participatory approaches	Workshops	Multi-stakeholder	26	1	Workshops :3
	Expert workshops	Top-down	33(national experts),36(*practitioners)	2	
	Consultation with experts	Top-down	6,39, 49(*experts and local authorities)	3	Expert consultation:3
	Discussion within experts	Top-down	2 (study group),8 (the Reference Committee),27(inter-disciplinary working group)	3	Discussion: 4
	Discussion within working group	Multi-stakeholder	12 (*working group consisted of community dietitians, academics, students, and community food activists)	1	
	Interviews with stakeholders	Multi-stakeholder	5,49(structured interviews)	2	Interviews: 10
	Interviews with experts	Top-down	8,25	2	
	Open-ended interviews with national-level decision-makers	Top-down	33	1	
	Semi-structured interview with key local informants/stakeholders	Multi-stakeholder	6,19,25,26	4	
	Focus group interviews	Multi-stakeholder	38	1	
	Meetings within experts	Top-down	5 (*the working group included 13 municipal agencies, seven emergency food non-profits, three state and federal agencies, and the CLF),23,36(*academics & practitioners),42	4	Meetings: 6
	Meetings with stakeholders	Multi-stakeholder	7,25	2	
	Focus groups	Multi-stakeholder	6	1	

	Field observations	Bottom-up	14,19,25	3	3
	Interactions with field experts during workshops, symposium, and conferences	Top-down	14	1	
	Classroom experiences teaching graduate students on the topic of food environments	Bottom-up	14	1	
	Expert surveys/questionnaires	Top-down	19 (with a six-point Likert scale)	1	Surveys/questionnaries:5
	Stakeholder survey/questionnaires	Multi-stakeholder	20,26 (with a five-point Likert scale),38(pilot survey with a four-point Likert scale),48	4	
	Participant observation	Multi-stakeholder	25,26	2	2
	Participatory modelling with causal loop diagrams	N/A	21	1	
	Multi-stakeholder participation	Multi-stakeholder	8	1	
	Seasonal calendars, Venn diagrams	N/A	6	1	
	Analytic Hierarchy Process (AHP): to determine the indicator weight	N/A	49	1	
Delphi methods	Delphi methods: iterative process	Top-down	1,3	2	Delphi methods:8
	Delphi methods: focus-group feedback sessions	Top-down	3,6	2	
	Delphi study: a Delphi survey/questionnaires	Top-down	3, 38(with the content validity ratio test)	2	
	Delphi methods: a modified Delphi inquiry process	Top-down	10	1	

	Delphi technique incorporating Semi-structured, in-depth telephone interviews with experts	Top-down	44	1	
Other types of methodologies/techniques/statistical analysis	The SMART (Specific, Measurable, Accessible, Reliable, Timed) criteria for selecting indicators	N/A	36	1	Other methods: 28
	garden and disaster transect walks	N/A	25	1	
	an iterative process of drafting and modification	N/A	29	1	
	Analysis of variance (ANOVA)	N/A	2	1	
	Pairwise comparison tests	N/A	2	1	
	Geo-graphic information system (GIS) mapping	N/A	5	1	
	Multi-criteria mapping (MCM) technique based on the "multi-Criteria Mapper" computer program	N/A	48	1	
	Input Output Analysis (IOA)	N/A	9	1	
	Correlation analysis	N/A	41	1	
	Co-occurrence matrices	N/A	42	1	
	Root-cause analysis	N/A	13	1	
	The Multiple Criteria Decision Aiding (MCDA) methodology	N/A	17	1	

	Back-casting analysis	N/A	20	1	
	A functional organizational analysis	N/A	21	1	
	FCM (fuzzy cognitive mapping)	N/A	21	1	
	the food-chain: NUFER (Nutrient flows in Food chains, Environment, and Resource use)	N/A	31	1	
	Scenario analysis	N/A	31	1	
	the Monte Carlo method (to assess the uncertainty)	N/A	31	1	
	Qualitative content analysis	N/A	34	1	
	Cross-concept comparison	N/A	34	1	
	Multi-criteria mapping techniques	N/A	48	1	
	Life cycle assessment (LCA)/perspecti ve	N/A	22,24	2	
	Life cycle inventories	N/A	26	1	
	Livelihood inventories	N/A	6	1	
	A principal component analysis based on polychronic correlations on the Likert-scale data in psych package in R (fa.poly function)	N/A	26	1	
	Exploratory Factory Analysis (EFA), Bartlett's test of sphericity and total variance explained, Cronbach's	N/A	38	1	

	alpha, Linear regression analyses (LRA)				
	Nutritional analysis	N/A	42	1	

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