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Food mapping approaches for understanding food system transformations in rapid-growth city regions in the Global South

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The world's food systems are rapidly changing due to socioeconomic, environmental, and demographic changes, globalization, and urbanization. Urban regions connect urban food consumption with rural food production and are associated with rapid dietary transitions in developing counties. Despite urbanization being a key driver of city-regional and global food system transformations, city-regional food systems (particularly in developing countries) are under-researched. Although the importance of dynamic urban and peri-urban food systems has led to new frameworks and approaches for mapping food flows within urban regions, our study highlights both opportunities and limitations to food mapping in high-growth city regions in the Global South. We review existing approaches to food mapping using three contrasting city-regional food systems as case studies, namely, Bahir Dar (Ethiopia), Hanoi (Vietnam), and Cali (Colombia), and identify priorities for future progress. These include temporal dimensions of food access; nutritional outcomes of food flows; economic, cultural, and ethnic factors affecting consumer behavior; and how consumption of healthier foods could be enabled by decision-making throughout food supply chains. In addition, the roles of food loss and waste could also be more specifically considered. We conclude that providing a more comprehensive and nutrition-sensitive understanding of city-regional food systems can guide evidence-based interventions and activities to enable transitions to healthier, equitable, and more sustainable urban food systems.

KEYWORDS

food systems, cities, urban, peri-urban, food systems mapping, nutrition transition, decision-support

1. Introduction

Over 3.1 billion people cannot afford a healthy diet, with 691–783 million people suffering from hunger (FAO, IFAD, UNICEF, WFP, and WHO, 2023). Food systems contribute to human health, economic prosperity, and planetary health. Achieving food system transformations toward systems that are more sustainable, healthier, and equitable will require major shifts in mindsets, including the recognition of food as not just a commodity but the foundation of cultures, nutrition, livelihoods, and landscapes (Webb et al., 2020).

Globally, food systems are affected by multiple interacting threats. These include inflation, the cost-of-living crisis, rising energy prices, uneven post-COVID-19 economic recovery, conflicts (e.g., in Ukraine, Ethiopia, South Sudan, Yemen), and climate change. These are compounded by the global inequality impacting supply chains and access to food, with marginalized consumers in low-income countries bearing the brunt of ongoing food, energy, and economic crises (WFP, 2022). The FAO's Global Report on Food Crises 2022 classified nearly 193 million people as "acutely food insecure," an increase of nearly 40 million compared to 2020 (FAO and WFP, 2022).

In 2021, more than 56% of the global population resided in urban settlements, with a projected rise to 68% by 2030 (UN, 2018). The UN-Habitat (2022) defines three main classes of human settlements: cities, towns and semi-dense areas, and rural areas. Urban areas are those settlements with at least 5,000 inhabitants, while areas with at least 50,000 inhabitants are considered cities, and those with fewer inhabitants are considered towns and semi-dense areas (UN, 2018). It should be noted that these definitions may or may not correspond with politically demarcated boundaries or the perceptions of the communities that inhabit them.

Food is essential to sustain citizens in new and expanding urban agglomerations, with approximately 70% of the global food supply consumed by urban dwellers (FAO, 2019). Given the close relationship between agricultural production and food supply from hinterlands to urban areas, attempts to understand agri-food systems increasingly focus on "city regions" rather than cities *per se*. Considering a "city region" rather than a city or urban area allows for the inclusion of megacities, associated smaller towns, and the immediate rural and agricultural hinterlands that surround them. Within this broader definition, small-scale producers and their agricultural value chains can also be considered in relation to the urban centers and markets with whom they are linked (Ruaf, 2015). City-regional food systems typically encompass the production, processing, transport, retail, consumption, and waste disposal of food products within urban/peri-urban areas and their hinterland. In some cases, city-regional food systems are considered useful frameworks for promoting "sustainability" concepts such as the production potential of urban farming, self-sufficiency, and shorter supply chains (Vieira et al., 2018).

Despite the need to transition to more sustainable and resilient city region food systems, there are some limitations in the available frameworks and research methodologies to accurately measure and understand the key components and dynamics of urban food systems (Alarcon et al., 2021). These gaps are especially marked for city regions in low-income countries. For example, Zhong et al. (2021) highlight that the published research on urban food systems mainly focused on developed countries, with the USA and the UK accounting for 34.5% of all studies. In many low- and middle-income countries, a significant proportion of the food consumed in urban areas is derived from informal systems from production through to handling, preparation, and sale (Alarcon et al., 2021). Informal food systems can be associated with food safety risks and present logistical difficulties for accurate data collection for more comprehensive food system assessments (Tian et al., 2018). For more effective decision-making on urban food systems, it is crucial to have an improved and complete understanding of the structure and drivers of urban food systems globally, especially within rapid-growth urban areas in the Global South. In this study, we review the literature to answer three research questions, namely, (1) What evidence can be generated from food mapping? (2) What approaches have been used to map food systems in city region food systems? and (3) What are the major knowledge gaps in relation to food mapping efforts?

1.1. Review of concepts and approaches to food system mapping

Understanding how urban food systems can best be configured to support sustainable diets, health, and livelihoods is complex. It requires the consideration of processes that shape food systems, the relationships among them, and their outcomes and impacts of ongoing or proposed changes (Jensen and Orfila, 2021). Food system mapping represents an approach used to identify all stakeholders, institutions, goods and activities (including losses and waste), food flow levels and rates, along with policy, economic (e.g., value addition, food safety and quality, food diversity, poverty reduction, etc.), and environmental characteristics, to record the "status quo" and "dynamic change" of any food system. Food mapping tends to provide a static depiction of the basic structure and a framework to guide systematic analysis (Kiambi et al., 2018), and a time course-based food mapping can reveal rates of change and dynamics in urban food systems. Time course-based food mapping consists of measuring food system characteristics along successive time points.

Since food is a cross-sectoral, multidisciplinary subject that intersects with a wide range of urban issues, food mapping approaches aim to develop visual representations of geospatial and other sources of data to enable improved decision-making. Food mapping can be participatory, involving stakeholders across the food system (including citizen science and crowdsourcing approaches) to expose hidden disparities, strengths, and weaknesses within the food system (Sweeney et al., 2016). While static geospatially tagged "snapshots" are important, it is also necessary to understand the directional flow of food commodities from a range of dimensions. Ideally, assessments should provide a better understanding of the relative importance of each food flow component. This is important to avoid the risks of oversimplifying a food system or to avoid blind spots as a result of missing, biased, or skewed data sources (Alarcon et al., 2021).

Numerous approaches are currently used to map food systems, including participatory (Alarcon et al., 2017; Ahmed et al., 2019; Jacobi et al., 2019; Terdoo and Feola, 2021), qualitative (Batista et al., 2021), and quantitative methods. Geospatial methods frequently involve the use of geographic information systems (GIS)-based mapping software (McEntee and Agyeman, 2010; Kremer and DeLiberty, 2011; Widener et al., 2011; Jensen and Orfila, 2021), spatial analysis, and visualization including internet-based geospatial tools such as *Google Earth, ArcGIS Open Data,* and *ArcGIS Storymap*, and guides such as FAO's City Region Food System (CRFS) programme (Meenar, 2017; Blay-Palmer et al., 2018; Santini et al., 2018; Posthumus et al., 2021). In addition to static representations, geospatial analytic approaches can also be employed to analyze and communicate geospatial changes over time.

Despite the technological power of geospatial methods, limitations such as the relevance of data points, scale, cost, and feasibility can be encountered. Mapping efforts can be constrained by data availability, particularly in the Global South. Ideally, food flow mapping could be used to identify the flows and quantities of food from production and processing through to preparation, consumption, and waste, to facilitate accurate and comprehensive food system

decision-making and planning (Schreiber et al., 2021). Studies aiming to assess food flows differ substantially in terms of scale, scope, and data availability (Karg et al., 2022). In cases where secondary data (e.g., Household Dietary Diversity Scores, Census Data, National Health Surveys) are not readily available—a common occurrence in low-income countries—most food flow analyses, aside from examples such as Drechsel et al. (2007), rely on tracing food to its source through the use of market surveys (Gunasekera, 2012) or ethnographic methods (Wegerif and Wiskerke, 2017).

Some food system assessments consider the city as a focal point, or a "sink" for resources, which underappreciates the city's multi-functional roles (Karg et al., 2022). There is often a lack of differentiation among people working within food systems, power distribution, socioeconomic environment, and the regulatory bodies and financial services involved (Alarcon et al., 2021). Comprehensive analyses of food systems also require an improved understanding of value generation (including what is meant by value and different stakeholders' perceptions of value) along the food value chain, including all waste streams and negative environmental externalities associated with the particular food value chain. Hence, food mapping also needs to carefully consider the dynamic sub-systems that manage the by-products and waste disposal through the food system.

This review investigates the current status and state of food mapping to understand food systems in three contrasting rapid-growth city regions in low-income (Bahir Dar, Ethiopia), lower-middle income (Hanoi, Vietnam), and upper-middle income (Cali, Colombia) countries. In the three city regions, we sought to identify what evidence has been generated from food mapping, approaches that have been used to map food systems, and propose possible routes to address existing data and knowledge gaps.

2. Methodology

This study focuses on Bahir Dar in Ethiopia, Hanoi in Vietnam, and Cali in Colombia. These three cities were the subject of focus due to their contrasting food systems (Marshall et al., 2021) and to explore the use of food mapping in different socioeconomic contexts. The John Hopkins and GAIN Alliance Food Systems Dashboard categorizes Bahir Dar as a "rural and transitioning food system" with relatively high stunting rates and nearly no obesity. A large share of dietary energy is derived from cereals, and agriculture provides 71% of employment. In contrast, Hanoi is categorized as an "informal and expanding food system" as it has low stunting rates, a higher share of dietary energy from non-cereals, and is experiencing an increase in obesity and non-communicable diseases (NCDs). Infrastructural developments have facilitated higher rates of electricity access and there is much less agricultural employment (30%). Cali represents a "modernizing and emerging food system" with relatively high obesity rates, a high share of dietary energy from non-cereals, widespread access to electricity, and employment outside of the agricultural sector (Food Systems Dashboard, 2022).

The Google Scholar database was searched for studies relating to the research topic and research questions across all dates to July 2022, initially using combinations of keyword search terms relating to production, processing, daily food basket, distribution, retail, consumers, and food waste. The following query terms were used in a range of combinations, using Boolean operators: [Global South food systems], [Global South nutrition transition], [Global South city region food systems], [food system monitoring], [food system transformation], [food mapping], [food mapping approaches], [food mapping methods], [GIS-based food mapping approaches], [PGIS-based food mapping approaches], [internet based food mapping approaches], [Global South food mapping approaches], [Ethiopia food system], [Vietnam food system], [Colombia food system], [nutrition transition food baskets], [Ethiopian food production], [Vietnamese food production], [Colombian food production], [Ethiopian food producers], [Vietnamese food producers], [Colombian food producers], [Ethiopian food processing], [Vietnamese food processing, [Colombian food processing], [Ethiopian food baskets], [Vietnamese food baskets], [Colombian food baskets], [Ethiopian food retail environments], [Vietnamese food retail environments], [Colombian food retail environments], [Ethiopian food consumption], [Vietnamese food consumption], [Colombian food consumption], [Ethiopian food loss], [Ethiopian food waste], [Vietnam food loss], [Vietnam food waste], [Colombia food loss], [Colombia food waste].

The following keywords were also used to focus the search on the three cities and the surrounding regions of each country: [Food mapping Bahir Dar], [Food mapping Cali], [Food mapping Hanoi], [Urban food consumption], [Urban food consumption Vietnam], [Urban food consumption Colombia], [Urban food production Ethiopia], [Amhara food production], [Urban food production Vietnam], [Urban food production Colombia], [Bahir Dar daily food basket], [Hanoi daily food basket], [Cali daily food basket], [Bogotá daily food basket], [Addis Ababa daily food basket], [Da Nang daily food basket], [Bahir Dar food processing], [Addis Ababa food processing], [Hanoi food processing], [Bahir Dar food retail], [Bahir Dar food markets], [Amhara food distribution], [Hanoi food retail], [Cali food markets], [Cali food distribution].

After compiling a list of the most frequently cited food items in the daily food baskets of the three cities (Table 1) based on previous findings, the search strategy then systematically considered the supply chains of each of the food items, from production through to waste (e.g., "teff production Bahir Dar") at the city level and then at the national level. The search terms used in combination with each of the food products for Bahir Dar, listed in Table 1, were [production Bahir Dar], [processing Bahir Dar], [retail Bahir Dar], [consumption Bahir Dar], [storage Bahir

TABLE 1 Frequently cited food items in Bahir Dar (Ethiopia), Cali (Colombia), and Hanoi (Vietnam).

Bahir Dar	Cali	Hanoi
Fish (Nile tilapia and barbel), vegetables (onion, tomato, pepper, cabbage, Swiss chard, and carrot), fruits (strawberry and avocado), legumes (soybean, lupine, field pea, and broad beans), and teff.	Whole grains (rice, wheat, and corn), tubers (mainly potato and plantain), citrus fruits (oranges, tangerines, and lemons), vegetables (in part limited to tomato and onion), legumes (peas and beans), dairy products (milk and cheese), eggs, meat (chicken and beef), sugars (panela and sugar cane), and fats (palm oil and margarine)	Whole grains (rice), green vegetables (pak choy, choy sum, cabbage, broccoli, spinach, morning grow, watercress, and lettuce), vegetables (tomato, cucumber, squash, potato, and carrot), and white meat (pork and chicken)

Dar], [policy environment Bahir Dar], [food waste Bahir Dar]. The search terms used for the listed food products Cali were: [production Cali], [processing Cali], [retail Cali], [consumption Cali], [storage Cali], [policy environment Cali], [food waste Cali]. The search terms used for the food products listed for Hanoi were: [production Hanoi], [processing Hanoi], [retail Hanoi], [consumption Hanoi], [storage Hanoi], [policy environment Hanoi], [food waste Hanoi].

3. Results

A key objective of food mapping is to provide an insight into the different constituent elements, drivers, and outcomes of any given food system. In terms of knowledge generation, different mapping approaches have already been pursued in the three cities under study in this mini-review (summarized and compared in Table 2).

In Bahir Dar, there have been value chain analyses that feature a food mapping component (Yigzaw et al., 2016; Desalegn, 2018; Chen et al., 2021; Mossie et al., 2021; Wosene and Gobie, 2022). Chen et al. (2021) mapped the agri-food chains of legumes, vegetables, fruits, and fish through the collection of qualitative data from focus groups that were conducted by local partners. Some of the value chain analyses in Bahir Dar have focused on food loss and waste and tomato value chains (Yigzaw et al., 2016; Wosene and Gobie, 2022). Mossie et al. (2021) combined apple and mango smallholder farmers' participation along the value chain with food security outcomes, while Chen et al. (2021) coupled an agri-food chain mapping exercise with a literature review to provide a basis for the elaboration of an indicator-based assessment framework for assessing food system governance.

In Hanoi, food mapping has typically focused on the drivers and outcomes of dietary transformations along rural–urban transects, for example, the development of food system profiles of three benchmark sites to provide a snapshot of the food system transformation, as well as the dietary outcomes of food environments. The latter is of major relevance when considering the recent surge in urbanization, "supermarketisation" of food policies, and the swathe of social media platforms and apps relating to the dietary choices of younger generations (Huynh et al., 2021; Nguyen et al., 2021).

In addition to the creation of a food system profile for Cali, consideration has been given to analyzing food flows into Cali to demonstrate its close relationship with both the surrounding production regions and the other localities that receive the same produce (Rankin et al., 2021). Chaboud and Moustier (2021) assessed the volume of food loss and waste along a tomato supply chain and analyzed the roles that supermarkets and non-supermarket channels play in contributing to food loss and waste. Following growing climate concerns, more attention is being placed on the impacts of food on the environment and the impacts of projected changes in weather patterns on food crop production (Gerbal, 2019).

In Hanoi and Cali, more advanced and comprehensive mapping approaches have been used. These include food flow analyses of different food groups, coordinating across multi-stakeholder platforms, ranking the presence of Milan Urban Food Policy Pact (MUFPP) key indicators, and using a set of metrics that highlight key challenges and offer a baseline for the measurement and monitoring of future changes. In both cities, mixed-methods approaches have also been used to map food systems. For example, combining quantitative data (static geospatial data at the neighborhood level and household surveys) with qualitative data (in-depth interviews with shoppers and expert consultations) to assess the impacts of food on the environment and the impacts of projected changes in climate patterns on the suitability of food crop production (Aronson, 2019; Burra et al., 2019; Gerbal, 2019; Huynh et al., 2021; Nguyen et al., 2021; Rankin et al., 2021; Rankin-Cortázar, 2021).

4. Discussion

There are a number of strengths associated with the food mapping activities to date in both Hanoi and Cali (e.g., the recognition of each city as a node in the food distribution network and not only a consumption point, the inclusion of non-market food sources and the informal retail sector, desirability of food among different ethnic groups, food categories households prefer to buy with a larger food budget, and important food). However, key knowledge gaps remain, including in relation to a better understanding of power dynamics, socioeconomic environments, and institutional contexts (Rankin et al., 2021). The following paragraphs summarize the gaps identified from the existing literature for each stage of the value chain in the three cities:

- *Production*: There is a general lack of recognition of the "who, what, where and how" of how agricultural production shapes nutritional outcomes of food systems of the three cities. In addition, there is a lack of data analyzing whether the seasonality of food supplies has nutritional effects on consumers and how this influences their purchasing habits (Feola et al., 2015; Le et al., 2015; Baltenweck et al., 2018; Minten et al., 2018; Gurara et al., 2021; Rankin et al., 2021).
- *Processing*: To date, mapping approaches in the three city regions have not included a detailed analysis of food processing facilities and practices. There is also a lack of consideration given to the flow of foods from local processing facilities, and how much of the food is going into the city and what is leaving (Tegegne and Ashenafi, 1998; Møller et al., 2012; Hernandez, 2020; Neela and Fanta, 2020; Cheffo et al., 2021).
- *Logistics*: Although there are data available in relation to infrastructure and transport, the possible effects of different transport distances and methods on the nutritional quality of the food arriving in the city have not been examined. The practices of more localized food transfer to informal markets and their nutritional effects could also be further explored (Gerber, 2011; Schoebitz et al., 2014; Minten et al., 2016; Yigzaw et al., 2016; Desalegn, 2018; Hansen, 2018; Chaboud and Moustier, 2021; Mejía et al., 2021).
- *Retail*: Some approaches have addressed the nutritional effects of different distribution channels. However, limited attention has been given to defining culturally accepted retail outlets, and if there are nutritional benefits associated with different outlets (Usuga et al., 2012; Guarín, 2013; Wertheim-Heck et al., 2014; Wertheim-Heck and Spaargaren, 2016; Wertheim-Heck et al., 2019; Trinh et al., 2020; Chaboud and Moustier, 2021; Mossie et al., 2021; Zaharia et al., 2021; Karg et al., 2022).
- *Consumer*: More consideration should be given to the cultural and ethical aspects of consumer choices such as the influence of religion, non-market food source practices such as kinship, and consumer differences between generations and genders. Analyses of the possible influences of modern food marketing on the food environment are currently lacking (Harris et al., 2009;

TABLE 2 Food mapping approaches to date in Bahir Dar, Hanoi, and Cali.

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Bahir Dar, Ethiopia (unless otherwise stated**)						
Wosene and Gobie (2022)	Value chain	Regional	Used both primary and secondary sources of data. Qualitative and quantitative data from primary data sources were collected using semi-structured questionnaires from farmers and the other from tomato traders.	Tomato Value chain	Mapping of tomato value chains, their roles and linkages; to identify the major tomato market channels, and analyze the structure conduct and performance of the tomato value chain in the selected districts of Bure Zuria, North Mecha, and Jabitehinan.	Lack of consideration of food losses and waste. This could include the health and nutrition outcomes of the tomatoes relating to the different market channels and their food security effects.
Desalegn (2018)	Value chain	Regional	Used both primary and secondary data sources using Participatory Value Chain Analysis with Gender, Green, and Governance Lens (PVCA+G3). Both quantitative and qualitative data collection tools were employed.	Poultry Value Chain	The study was conducted to assist actors in poultry VC to identify their business opportunities and competitive advantages and to address the shortcomings that pose a risk for their business initiatives to prosper.	Does not consider food after purchase (e.g., waste, cooking, nutritional status, storage, food safety, and quality). Limited considerations for processing practices, relevant policies, and food landscape.
Chen et al. (2021)	Value chain	Local/ Regional	Used both primary and secondary sources of quantitative and qualitative data	Agri-Food Chain Governance	A literature review on food chain governance and a mapping of current agri-food chains in the six regions provide the basis for the elaboration of an indicator-based assessment framework.	Does not consider food after consumer-level or waste.
Mossie et al. (2021)	Fruit value chains	Regional	Primary data were collected from a random sample of 384 households, 211 of which are fruit value chain participants and the rest are non-participants. Quantitative and qualitative data were gathered.	Apple and Mango Value Chains	Investigation of effects of apple and mango smallholder farmers' participation along the value chain, focusing on their household food security in north-western Ethiopia.	Limited consideration of the food policy environment and food flow after consumer purchase, including food waste and consumer profiles.
Yigzaw et al. (2016)	Fruit value chains	Local	Both qualitative and quantitative sources of primary data	Postharvest losses in the Bahir Dar fruit market	Analysis of fruit marketing practices, documenting causes and extent of postharvest losses in the Bahir Dar fruit market.	Briefly covers food production. Does not cover how the spoiled fruits are disposed/what could be done with the resulting fruit if the postharvest losses were to continue.
Minten et al. (2018) **National	Value chains	National	Secondary data sources of both qualitative and quantitative data.	Ethiopia's food systems in the past, present, and predicted future	To provide an overview of Ethiopia's food systems in the past and present, while offering predictions about future food systems based on current trends.	Limited consideration of food loss and waste, food safety practices, and the nutritional status of food.

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Hanoi, Vietnam						
de Haan et al. (2020)	Profile maps	Regional	Combined (i) qualitative primary collection and (ii) secondary data collection and analysis based on pre-defined key metrics.	Profiles along a rural-to-urban transect	To define three benchmark sites along a rural-to-urban transect to facilitate future high-resolution contextualized research at the subnational level, in addition to linked research at the national level.	Limited data are available for urban districts, only a few variables could be included at the district level. More data are needed at the district level for better accuracy of mapping and site selection.
Huynh et al. (2021)	Profile and food flow maps	Regional	Used both primary and secondary sources of qualitative and quantitative data	Core indicators of constituent elements and drivers of food systems: food production and supply chains, food environments, consumer behavior, drivers of food systems, diets, nutrition and health outcomes, and social, economic, and environmental outcomes.	Providing a snapshot of the food system transformation along a rural–urban transect in North Vietnam, from urban and peri-urban Hanoi to Moc Chau; to help policymakers understand existing challenges among elements of food systems.	Does not cover food loss and waste in the area. Does not consider 'true' accessibility of food due to its exclusive consideration of straight-line distances. Limited consideration of food governance.
Nguyen et al. (2021)	Profile maps	Regional	Combined primary quantitative data (static geospatial data at neighborhood level and household survey) and qualitative data (in-depth interviews with shoppers)	Food environments across an urban-peri-urban–rural gradient	Presenting a picture of the food environment in a typical emerging economy	Does not include the effects of marketing on food environments. Lack of consideration for food flows.
Huynh et al. (2021)	Profile map	Local	Used secondary qualitative and quantitative data sources	Overview of the main food system outcomes, constituent elements, and drivers	Providing a synopsis of the food system of Cau Giay district in Hanoi, an urban area in north Vietnam.	Does not consider the temporal dimension of food access.
Huynh et al. (2021)	Profile map	Local	Used secondary qualitative and quantitative data sources	Overview of the main food system outcomes, constituent elements, and drivers.	Providing a synopsis of the food system of the Dong Anh district in Hanoi, a peri-urban area in North Vietnam	Does not consider the temporal dimension of food access.
Huynh et al. (2021)	Profile map	Local	Used secondary qualitative and quantitative data sources	Overview of the main food system outcomes, constituent elements, and drivers.	Providing a synopsis of the food system of the Moc Chau district in Hanoi, a rural area in North Vietnam	Does not consider the temporal dimension of food access.

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Cali, Colombia						
Rankin et al. (2021)	Profile map	Local	Used secondary qualitative and quantitative data sources	Analysis includes different components of the food system of Cali as a city region, to understand characteristics, dynamics, and vulnerabilities	To provide a decision-making tool that helps actors in the food system in Cali, Colombia to build a common vision and roadmap to promote transformation in a sustainable way.	
Aronson (2019)	Profile maps using Monitoring Framework Indicators from the Milan Urban Food Policy Pact (MUFPP)	Local	Used primary and secondary, qualitative and quantitative, data sources on existing food systems, and health indicators for Cali, Valle del Cauca, and Colombia that were being already being measured from municipal, departmental, and national government documents.	Overview of the main food system outcomes, constituent elements, and drivers such as sustainable diets and nutrition, food production, food supply and distribution, social and economic equity, food governance, and food waste.	Providing insights for decision-makers in Cali to (a) assess to what extent metrics and mechanisms are in place to measure and track the progress of the city's food system sustainability, and; (b) identify opportunities for future action through a priority-setting methodology.	Multiple components of the city region's food systems were out of scope or lacked data such as consumer perspectives, the relationship between food sovereignty and food and nutrition security, and food asset mapping to visualize the food landscape
Chaboud and Moustier (2021)	Value chain mapping	Local	Based on primary data collected along a tomato value chain—from production to retailing—in Cali	Tomato value chain	Assessing the volume of FLW along a food supply chain (FSC) and analyzing the roles of supermarket and non-supermarket channels for dealing with food losses and waste.	Unclear whether the nutritional status of the resulting tomatoes varies as a result of different storage, transport, and distribution facilities.
Gerbal (2019)	Value chain analysis	Local	Based on secondary sources of quantitative and qualitative data	Carbon footprint and climate risk of daily food basket	A combined methodology was used to simultaneously assess the impacts of food on the environment (carbon footprint) and the impacts of projected changes in climate patterns on the suitability for food crop production, for the top five food products consumed in Cali.	Lack of consideration for food loss and waste, seasonality and affordability of daily food baskets, consumer choices, and food governance.
Santini et al. (2018) **Medellín	Food flow maps	Regional	Combined primary and secondary quantitative (static geospatial data) and qualitative data.	How much produce is entering and how much is leaving the municipal territory	To provide a decision-making tool to support local government, policymakers, and multi-stakeholder bodies to make more informed decisions to improve urban and regional food system sustainability and resilience.	

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Bahir Dar, Ethiopia (unless otherwise stated**)						
Wosene and Gobie (2022)	Mapping of tomato value chains, their roles and linkages; to identify the major tomato market channels, and analyze the structure conduct and performance of the tomato value chain in the selected districts of Bure Zuria, North Mecha, and Jabitehnan.	Data were collected from both primary and secondary sources. Primary data were collected from randomly selected 280 tomato producers and 60 traders. To improve the validity of the data, the researchers used focus group discussions and key informant interviews in two rounds with a total size of 10 participants per discussion. Secondary data were included from published articles and unpublished district reports.	The study indicates the flow of tomato production inputs from input suppliers to producers, as well as the flow of the product from farmers through different value chain actors to the consumers. There is also information flow from consumer to producer regarding the price of tomato among the value chain actors.			Lack of consideration of food losses and waste. Scope to include the health and nutrition outcomes of the tomatoes relating to the different market channels and its food security effects.
Mossie et al. (2021)	Investigation of effects of apple and mango smallholder farmers' participation along the value chain, focusing on their household food security in north-western Ethiopia.	The study used propensity score matching (PSM) to establish a causal relationship between participation in the fruit value chain and changes in household food security.	The study analyzed the food security effects of apple and mango value chain participation in north-western Ethiopia using recent data from a cross-section of smallholders, measured by household food consumption in kilocalories.			
Yigzaw et al. (2016)	Analysis of fruit marketing practices, documenting causes and extent of postharvest losses in the Bahir Dar fruit market.	The study employed both qualitative and quantitative data including sex, age, education level and length of fruit marketing experience of respondents, type of fruit being sold, type of packaging material, transportation method, storage facility, source of fruit, percentage of fruit loss, causes of fruit losses, percentage fruit loss in different seasons, possible uses of over-ripen fruits, and measures taken by respondents to reduce postharvest losses. Data were collected by questionnaire and analyzed using SPSS statistical software.	Using semi-structured questionnaires, 31 fruit retailers were randomly selected and interviewed to obtain information on their socioeconomic characteristics, fruit marketing practices, and postharvest losses.			Briefly mentions nutrition security.

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Minten et al. (2018) **National	To provide an overview of Ethiopia's food systems in the past and present, while offering predictions about future food systems based on current trends.	Literature review, including analysis of secondary data. Consideration of expected future developments based on assumptions of income growth, urbanization, and population growth and benchmarking Ethiopia with other countries with lower and higher GDP levels.		Assess recent evidence regarding dietary, agricultural, and supply chain transformation to provide snapshots of past and present Ethiopian food systems to add context for how future food systems can evolve. Economic growth has shown to be an important associate of change in food systems.		
Hanoi, Vietnam						
de Haan et al. (2020)	To define three benchmark sites along a rural-to-urban transect to facilitate future high-resolution contextualized research at the subnational level, in addition to linked research at the national level.	Multi-stakeholder survey and site-based data comparison to predefine three benchmark sites or populations along a rural-to-urban transect.		Stakeholder survey-based consultation and secondary data collection/analysis based on pre-defined key metrics.		Much data are not available for urban districts, only a few variables could be included at the district level for composite index. More data are needed at the district level for better accuracy of mapping and site selection.
Huynh et al. (2021)	Providing a snapshot of the food system transformation along a rural–urban transect in North Vietnam, from urban and peri-urban Hanoi to Moc Chau; to help policymakers understand existing challenges among elements of food systems.	Metrics that provide an overview of the food system's constituent elements, drivers, and outcomes.		Core indicators of constituent elements and drivers of food systems: food production and supply chains, food environments, consumer behavior, drivers of food systems, diets, nutrition and health outcomes, and social, economic, and environmental outcomes.		

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Nguyen et al. (2021)	Presenting a picture of the food environment in a typical emerging economy	Examines how the food environment varies across an urban–peri-urban–rural gradient from three sites in North Vietnam and the relationship between child undernutrition status and household consumption of processed food.	Combined quantitative data (static geospatial data at neighborhood level and household survey) and qualitative data (in-depth interviews with shoppers).	Specific features such as non-market food sources (own production and food transfers) and dominance of the informal retail sector.		Effects of marketing on food environments.
Huynh et al. (2021)	Providing a synopsis of the food system of Cau Giay district in Hanoi, an urban area in north Vietnam.	Metrics that provide an overview of the food system's constituent elements, drivers, and outcomes.		Overview of main food system outcomes, constituent elements, and drivers. Uses a set of metrics that highlight key challenges and offers a baseline for the measurement and monitoring of future changes. Builds from outcomes concerning residents' diets, nutrition and health, socioeconomic, and environment. Traces back to food supply chains, the food environment, consumer behavior, and the underlying drivers		Temporal dimension of food access.
Huynh et al. (2021)	Providing a synopsis of the food system of the Dong Anh district in Hanoi, a peri-urban area in North Vietnam	Metrics that provide an overview of the food system's constituent elements, drivers, and outcomes.		Overview of the main food system outcomes, constituent elements, and drivers. Uses a set of metrics that highlight key challenges and offers a baseline for measurement and monitoring of future changes. Builds from the outcomes concerning residents' diets, nutrition and health, socioeconomic, and environment. Traces back to food supply chains, the food environment, consumer behavior, and the underlying drivers.		Temporal dimension of food access.
Huynh et al. (2021)	Providing a synopsis of the food system of the Moc Chau district in Hanoi, a rural area in North Vietnam	Metrics that provide an overview of the food system's constituent elements, drivers, and outcomes.		Overview of the main food system outcomes, constituent elements, and drivers. Uses a set of metrics that highlight key challenges and offers a baseline for measurement and monitoring of future changes. Builds from outcomes concerning residents' diets, nutrition and health, socioeconomic, and environment. Traces back to food supply chains, the food environment, consumer behavior, and finally the underlying drivers		Temporal dimension of food access.
*Cali, Colombia (unless otherwise stated**)*						
Rankin et al. (2021)	To provide a decision-making tool that helps actors in the food system in Cali, Colombia to build a common vision and roadmap to promote transformation in a sustainable way.	The analysis includes different components of the food system of Cali as a city region, to understand characteristics, dynamics, and vulnerabilities.		Focuses on the municipality of Cali as a consumption pole, and also demonstrates a close relationship with producing areas and with other "receiving" localities that are supplied by the flow of food that transits and is redistributed through the city.		

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TABLE 2 (Continued)

References	Food mapping approach	Scale of mapping used	Data used	Mapped features of the food systems	Objective of mapping activity	Knowledge gaps
Aronson (2019)	Providing insights for decision-makers in Cali to (a) assess to what extent metrics and mechanisms are in place to measure and track the progress of the city's food system sustainability, and (b) identify opportunities for future action through a priority-setting methodology.	The presence of Milan Urban Food Policy Pact (MUFPP) key indicators in Cali's municipal initiatives ranked with a green-yellow-red "traffic lights" scheme. Indicators that were present or in agreement were marked in green, indicators partially present were marked in yellow, and indicators absent were marked in red.		The analysis examined the degree to which current indicators tracked in Cali's 2016–2019 Municipal Development Plan, the city's Climate Change Adaptation and Mitigation Plan, the city's Resilience Strategy, and the ENSIN1 survey matched the 44 Monitoring Framework Indicators from the MUFPP.		
Chaboud and Moustier (2021)	Assessing the volume of FLW along a food supply chain (FSC) and analyzing the roles of supermarket and non-supermarket channels for dealing with food losses and waste.	The study is based on primary data collected along a tomato chain—from production to retailing—in Cali		The study focused on gaining further insight into the implications of supermarket development by conducting a detailed analysis of farmers who marketed their produce using a combination of different types of buyers.		Not clear whether the nutritional status of the resulting tomatoes varies as a result of different storage, transport, and distribution facilities.
Santini et al. (2018) **Medellín	To provide a decision-making tool to support local government, policymakers, and multi-stakeholder bodies to make more informed decisions to improve urban and regional food system sustainability and resilience.	Visualizing food flow maps using GIS.		Understanding of food flows and identification of gaps/opportunities for improving food provisioning logistics.		

Authors' analysis of cited papers.

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Wertheim-Heck and Spaargaren, 2016; Kidane Meles et al., 2018; Quintero-Angel et al., 2019; D'haene et al., 2020; Mai et al., 2020; Umberger et al., 2020; Wertheim-Heck and Raneri, 2020; Wondim, 2020; Nguyen et al., 2021; Turner et al., 2022).

Across the three cities, there are knowledge gaps relating to the temporal dimension of food accessibility, considering the prominence of informal markets and the sustained presence of two major food supply seasons. In addition, there is a lack of standardized inclusion of health outcomes such as non-communicable diseases (NCDs), socioeconomic dimensions, or environmental dimensions. Decision-makers may also benefit from evidence that includes a stronger focus on the influences of marketing powers from the recent expansion of telecommunications and e-commerce platforms that manipulate the food environment (Harris et al., 2009).

In the case of Bahir Dar, little attention seems to have been given to date to the role of religion in shaping food choices, nutrition, and food supply chains. Greater consideration of the influence of Ethiopian Orthodox Christianity (which makes up 43% of the total population of Ethiopia and *circa* 90% of Bahir Dar) could inform improved understanding of food systems, along with consideration of minority religions in the city (e.g., Muslim and Protestant) (Alonso, 2015). Many religions have fasting and abstinence systems which can affect food system dynamics. For instance, in the Ethiopian Orthodox community, lay people are required to fast for 180 days (Zellelew, 2014). In addition, there has been little attention given to the inclusion of non-market food sources such as own production, wild food harvesting, and food gifts which link food availability and personal food environments (D'haene et al., 2020; Turner et al., 2020; Nguyen et al., 2021).

As food systems are subject to rapid change over space and time, understanding how to monitor and measure dietary and market transformations, in particular, transitions to modern retail outlets and changes in consumer preferences, to better target nutrition-related outcomes is crucial to promote resilient, inclusive, and sustainable food systems (Allen et al., 2018).

5. Conclusion

This mini-review provides an overview of research relating to food system mapping, using three emerging city regions as a basis for assessing current knowledge and gaps.

To better understand food mapping and how it relates to understating food systems, power dynamics, socioeconomic environments, and institutional contexts (e.g., regulatory bodies and financial services) ideally need to be differentiated (Alarcon et al., 2021). In particular, understandings of what is meant by 'value' and how it can be generated, particularly through food and waste usage, may need to be tailored to reflect different stakeholders' perceptions. Food mapping needs to carefully consider the dynamic sub-systems that manage the by-products and waste disposal throughout the food system. Many nutrition-sensitive approaches to food systems have focused on rural development, especially with commodity-specific short, local value chains that do not capture interactions among value chains or more complex urban and international food systems (Alarcon et al., 2021).

To transition food mapping as a diagnostic tool from providing snapshot views of static data to a more dynamic and nutrition-sensitive food mapping approach, nutrition could be considered at all stages of value chains to better integrate healthier foods into city-regional food systems decision-making. Analysis of food processing practices can generate valuable insights into agricultural supply chains and the extent of processed (including so-called ultra-processed) foods supplied and consumed within urban areas. Consideration of the infrastructure, transport services, and logistics of urban food systems can provide a food flow lens on foods arriving in cities. Given the links between food losses and waste, lack of access to nutritional foods by marginalised consumers, and the inter-relationship with sustainability issues, including climate change, it is important to include an analysis of the disposal of food within the city boundaries to promote the re-circulation of nutrients and calories, including the more sustainable and circular disposal of organic waste (Cattaneo et al., 2021).

Taking a food mapping approach to analyze the food systems of the three cities provides insights into the "status quo" of each city region's food system. Our analysis of existing studies highlights limitations relating to the temporal dimensions of access to food, the nutritional outcomes of food flows, the cultural and ethical factors of consumer behavior, and how healthy foods could be better integrated into decision-making at every stage of the food supply chain (including relating to food loss and waste).

Nutritionally deficient diets and access to nutritious foods are not simply the result of personal consumer choices but reflect the consequence of food system policies, distributive justice, distribution networks, infrastructure, research and development, information and awareness, and consumer preferences. We consider that efforts to provide a more comprehensive and dynamic nutrition-sensitive understanding of the dynamics of the city region's food systems can guide interventions and activities that can enable transitions to healthier, equitable, and more sustainable food systems.

Author contributions

CS, ML, and PM conceptualized mini-review, which was drafted by HL and SM, and successively revised by all authors prior to submission. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Ahmed, S., Haklay, M., Tacoli, C., Githiri, G., Dávila, J. D., Allen, A., et al. (2019). Participatory mapping and food-centred justice in informal settlements in Nairobi Kenya. *Geo: Geogr. Environ.* 6:e00077

Alarcon, P., Dominguez-Salas, P., Fèvre, E. M., and Rushton, J. (2021). The importance of a food systems approach to low and middle income countries and emerging economies: a review of theories and its relevance for disease control and malnutrition. *Front. Sustain. Food Syst.* 5:642635. doi: 10.3389/fsufs.2021.642635

Alarcon, P., Fèvre, E. M., Murungi, M. K., Muinde, P., Akoko, J., Dominguez-Salas, P., et al. (2017). Mapping of beef, sheep and goat food systems in Nairobi—a framework for policy making and the identification of structusral vulnerabilities and deficiencies. *Agric. Syst.* 152, 1–17. doi: 10.1016/j.agsy.2016.12.005

Allen, T., Heinrigs, P., and Heo, I. (2018). *Agriculture, food and jobs in West Africa* Geneva: OECD.

Alonso, E. B. (2015). *The impact of culture, religion and traditional knowledge on food and nutrition security in developing countries* Geneva: OECD.

Aronson, S. (2019). *Cali's food systems: A diagnostic synthesis to determine priority action areas for sustainable food systems*. Cali: International Center for Tropical Agriculture.

Baltenweck, I., Thinh, N. T., Nga, N. T. D., Hung, P. V., Nhuan, N. H., Huyen, N. T. T., et al. (2018). Assessing competitiveness of smallholder pig farming in the changing landscape of Northwest Vietnam. ILRI Research Report.

Batista, L., Dora, M., Garza-Reyes, J. A., and Kumar, V. (2021). Improving the sustainability of food supply chains through circular economy practices–a qualitative mapping approach. *Manag. Environ. Qual. Int. J.* 32, 752–767. doi: 10.1108/MEQ-09-2020-0211

Blay-Palmer, A., Santini, G., Dubbeling, M., Renting, H., Taguchi, M., and Giordano, T. (2018). Validating the city region food system approach: enacting inclusive, transformational city region food systems. *Sustainability* 10:1680. doi: 10.3390/su10051680

Burra, D. D., Thi Huong, T., Duong, T. T., Huynh, T., Haan, S. D., Sánchez, A., et al. (2019). *Vietnam food systems: summary of available data and Vietnam data profile annex*.

Cattaneo, A., Sánchez, M. V., Torero, M., and Vos, R. (2021). Reducing food loss and waste: five challenges for policy and research. *Food Policy* 98:101974. doi: 10.1016/j.foodpol.2020.101974

Chaboud, G., and Moustier, P. (2021). The role of diverse distribution channels in reducing food loss and waste: the case of the Cali tomato supply chain in Colombia. *Food Policy* 98:101881. doi: 10.1016/j.foodpol.2020.101881

Cheffo, A., Mehedi, M., and Wubie, A. (2021). Value chain analysis of fish production and marketing from Lake Tana Ethiopia. *GSJ* 9, 180–193.

Chen, Q., Knickel, K., Tesfai, M., Sumelius, J., Turinawe, A., Isoto, R., et al. (2021). A framework for assessing food system governance in six urban and Peri-urban regions in sub-saharan Africa. *Front. Sustain. Food Syst.* 5:763352. doi: 10.3389/fsufs.2021.763352

D'haene, E., Vandevelde, S., and Minten, B. (2020). Fasting, food, and farming: Evidence from Ethiopian producers on the link of food taboos with dairy development. *Int. Food Policy Res. Inst.*

de Haan, S., Huynh, T., Duong, T. T., and Rubin, J. (2020). Defining the benchmark research sites (rural to urban transect) in Vietnam. [n.p.] CGIAR: Vietnam, 32 p.

Desalegn, P. (2018). Poultry value chain in West Amhara. Commissioned by Programme for Agro-Business Induced Growth in the Amhara National Regional State, 1–24.

Drechsel, P., Graefe, S., and Fink, M. (2007). *Rural-urban food, nutrient and virtual water flows in selected West African cities*. Colombo: IWMI.

FAO (2019). FAO Framework for the Urban Food Agenda. Rome: FAO.

FAO, IFAD, UNICEF, WFP, and WHO (2023) "*The state of food security and nutrition in the world 2023. Urbanization, AgriFood systems transformation and health diets across the rural-urban continuum*". Rome, FAO.

FAO and WFP (2022). 2022 Global Report on Food Crises.

Feola, G., Agudelo Vanegas, L. A., and Contesse Bamón, B. P. (2015). Colombian agriculture under multiple exposures: a review and research agenda. *Clim. Dev.* 7, 278–292. doi: 10.1080/17565529.2014.934776

Food Systems Dashboard (2022). Food Systems Dashboard Country Profiles [Online]. Available at: https://foodsystemsdashboard.org/ (Accessed 22 June 2022).

Gerbal, L. (2019). Assessing the carbon footprint and climate risk of most consumed food products in Cali, Colombia Methodological development of a decision support tool.

Gerber, J. (2011). From farm plot to cooking pot: regional and local fruit and vegetable commodity chains supplying Hanoi Vietnam.

Guarín, A. (2013). The value of domestic supply chains: producers, wholesalers, and urban consumers in Colombia. *Dev. Policy Rev.* 31, 511–530. doi: 10.1111/dpr.12023

Gunasekera, J. (2012). *Report of the food flow mapping: Kesbewa urban area*. Colombo, Sri Lanka: Janathakshan Guarantee Ltd.

Gurara, M. A., Jilo, N. B., and Tolche, A. D. (2021). Modelling climate change impact on the streamflow in the upper Wabe bridge watershed in Wabe Shebele River basin, Ethiopia. *Int. J. River Basin Manag.* 21, 181–193. doi: 10.1080/15715124.2021.1935978

Hansen, A. (2018). Meat consumption and capitalist development: the meatification of food provision and practice in Vietnam. *Geoforum* 93, 57–68. doi: 10.1016/j.geoforum.2018.05.008

Harris, J. L., Pomeranz, J. L., Lobstein, T., and Brownell, K. D. (2009). A crisis in the marketplace: how food marketing contributes to childhood obesity and what can be done. *Annu. Rev. Public Health* 30, 211–225. doi: 10.1146/annurev.publhealth.031308.100304

Hernandez, R. L. M., (2020). *Sustainable food system profile –Vietnam*. Hanoi, Vietnam: SFSCountry Profiles. CIAT.

Huynh, T. T. T., Pham, T. M. H., Duong, T. T., Hernández, R., Trinh, T. H., Nguyen, M. T., et al. (2021). *Food systems profile-along a rural-urban transect in North Vietnam*.

Jacobi, J., Wambugu, G., Ngutu, M., Augstburger, H., Mwangi, V., Zonta, A. L., et al. (2019). Mapping food systems: a participatory research tool tested in Kenya and Bolivia. *Mt. Res. Dev.* 39, R1–R11.

Jensen, P. D., and Orfila, C. (2021). Mapping the production-consumption gap of an urban food system: an empirical case study of food security and resilience. *Food Secur.* 13, 551–570. doi: 10.1007/s12571-021-01142-2

Karg, H., Bouscarat, J., Akoto-Danso, E. K., Heinrigs, P., Drechsel, P., Amprako, L., et al. (2022). Food flows and the roles of cities in west African food distribution networks. *Front. Sustain. Food Syst.* 6:857567. doi: 10.3389/fsufs.2022.857567

Kiambi, S., Alarcon, P., Rushton, J., Murungi, M. K., Muinde, P., Akoko, J., et al. (2018). Mapping Nairobi's dairy food system: an essential analysis for policy, industry and research. *Agric. Syst.* 167, 47–60. doi: 10.1016/j.agsy.2018.08.007

Kidane Meles, D., Lemma, D. T., and Ndemo, D. E. (2018). The status and contribution of urban agriculture to household consumption, Employment and Income in Bahir Dar City Administration, Amhara Regional State, Ethiopia.

Kremer, P., and Deliberty, T. L. (2011). Local food practices and growing potential: mapping the case of Philadelphia. *Appl. Geogr.* 31, 1252–1261. doi: 10.1016/j.apgeog.2011.01.007

Le, T. H., Le, P. H., Nguyen, H. T., Nguyen, T. G., Le, T. T. X., Nguyen, T. K. C., et al. (2015). Changes of food expenditure and food consumption of people living in Ba Vi District, Hanoi, Vietnam from 1999 to 2013. Health.

Mai, T. M. T., Pham, N. O., Tran, T. M. H., Baker, P., Gallegos, D., Do, T. N. D., et al. (2020). The double burden of malnutrition in Vietnamese school-aged children and adolescents: a rapid shift over a decade in Ho Chi Minh City. *Eur. J. Clin. Nutr.* 74, 1448–1456. doi: 10.1038/s41430-020-0587-6

Marshall, Q., Fanzo, J., Barrett, C. B., Jones, A. D., Herforth, A., and Mclaren, R. (2021). Building a global food systems typology: a new tool for reducing complexity in food systems analysis. *Front. Sustain. Food Syst.* 5:746512. doi: 10.3389/fsufs.2021.746512

Mcentee, J., and Agyeman, J. (2010). Towards the development of a GIS method for identifying rural food deserts: geographic access in Vermont, USA. *Appl. Geogr.* 30, 165–176. doi: 10.1016/j.apgeog.2009.05.004

Meenar, M. R. (2017). Using participatory and mixed-methods approaches in GIS to develop a place-based food insecurity and vulnerability index. *Environ Plan A* 49, 1181–1205. doi: 10.1177/0308518X16686352

Mejía, G., Granados-Rivera, D., Jarrín, J. A., Castellanos, A., Mayorquín, N., and Molano, E. (2021). Strategic supply chain planning for food hubs in Central Colombia: an approach for sustainable food supply and distribution. *Appl. Sci.* 11:1792. doi: 10.3390/app11041792

Minten, B., Dereje, M., Bachewe, F. N., and Tamru, S. (2018). *Evolving food systems in Ethiopia: Past, present and future*.

Minten, B., Tamru, S., Engida, E., and Kuma, T. (2016). Transforming staple food value chains in Africa: the case of teff in Ethiopia. *J. Dev. Stud.* 52, 627–645. doi: 10.1080/00220388.2015.1087509

Møller, H., Vold, M., Schakenda, V., and Hanssen, O.J. (2012). Mapping method for food loss in the food processing industry. Summary report.

Mossie, M., Gerezgiher, A., Ayalew, Z., and Elias, A. (2021). Food security effects of smallholders' participation in apple and mango value chains in North-Western Ethiopia. *Agric. Food Secur.* 10, 1–15. doi: 10.1186/s40066-021-00310-z

Neela, S., and Fanta, S. W. (2020). Injera (an ethnic, traditional staple food of Ethiopia): a review on traditional practice to scientific developments. *J. Ethnic Foods* 7, 1–15. doi: 10.1186/s42779-020-00069-x

Nguyen, T., Pham Thi Mai, H., van den Berg, M., Huynh Thi Thanh, T., and Béné, C. (2021). Interactions between food environment and (Un) healthy consumption: evidence along a rural-urban transect in Viet Nam. *Agriculture* 11:789. doi: 10.3390/agriculture11080789

Posthumus, H., Bosselaar, J., Brouwer, H., De Steenhuijsen Piters, C., BodnáR, F., Newton, J., et al. (2021). "the food systems decision-support toolbox: a toolbox for food system analysis". Wageningen Centre for Development Innovation).

Quintero-Angel, M., Mendoza, D. M., and Quintero-Angel, D. (2019). The cultural transmission of food habits, identity, and social cohesion: a case study in the rural zone of Cali-Colombia. *Appetite* 139, 75–83. doi: 10.1016/j.appet.2019.04.011

Rankin, S., Hurtado, L.J., Bonilla Findji, O., Mosquera, E. E., and Lundy, M. (2021). *Perfil del Sistema Alimentario de Cali, ciudad-región*.

Rankin-Cortázar, S. (2021). Colombia: Cali and Palmira. Building knowledge basis to understand the food system, players and enabling environment with a city region perspective.

Ruaf, F. (2015). A vision for city region food systems: building sustainable and resilient city regions.

Santini, G., Miller, S., and Dubbeling, M. (2018). *City region food system tools and examples*. Rome, Italy: FAO.

Schoebitz, L., Nguyen, V. A., Tran, H. H., Dang, T. H., and Strande, L. (2014). *RRR-project from research to implementation component 1–waste supply and availability report–Hanoi*.

Schreiber, K., Hickey, G. M., Metson, G. S., Robinson, B. E., and Macdonald, G. K. (2021). Quantifying the foodshed: a systematic review of urban food flow and local food self-sufficiency research. *Environ. Res. Lett.* 16:023003. doi: 10.1088/1748-9326/abad59

Sweeney, G., Hand, M., Kaiser, M., Clark, J. K., Rogers, C., and Spees, C. (2016). The state of food mapping: academic literature since 2008 and review of online GIS-based food mapping resources. *J. Plan. Lit.* 31, 123–219. doi: 10.1177/0885412215599425

Tegegne, M., and Ashenafi, M. (1998). Microbial load and incidence of Salmonella spp. in Kifto, a traditional Ethiopian spiced, minced meat dish. *Ethiop. J. Health Dev.* 12, 135–140.

Terdoo, F., and Feola, G. (2021). Rapid participatory system mapping builds Agri-food system resilience: evidence from Nigeria. *Afr. Geogr. Rev.* 40, 63–75. doi: 10.1080/19376812.2020.1761410

Tian, X., Geng, Y., Sarkis, J., and Zhong, S. (2018). Trends and features of embodied flows associated with international trade based on bibliometric analysis. *Resour. Conserv. Recycl.* 131, 148–157. doi: 10.1016/j.resconrec.2018.01.002

Trinh, H. T., Dhar, B. D., Simioni, M., de Haan, S., Huynh, T. T. T., Huynh, T. V., et al. (2020). Supermarkets and household food acquisition patterns in Vietnam in relation to population demographics and socioeconomic strata: insights from public data. *Front. Sustain. Food Syst.* 4:15. doi: 10.3389/fsufs.2020.00015

Turner, K. L., Idrobo, C. J., Desmarais, A. A., and Peredo, A. M. (2022). Food sovereignty, gender and everyday practice: the role of afro-Colombian women in sustaining localised food systems. *J. Peasant Stud.* 49, 402–428. doi: 10.1080/03066150.2020.1786812

Turner, C., Kalamatianou, S., Drewnowski, A., Kulkarni, B., Kinra, S., and Kadiyala, S. (2020). Food environment research in low-and middle-income countries: a systematic scoping review. *Adv. Nutr.* 11, 387–397. doi: 10.1093/advances/nmz031

Umberger, W. J., Rupa, J. A., and Zeng, D. (2020). Understanding food westernisation and other contemporary drivers of adult, adolescent and child nutrition quality in urban Vietnam. *Public Health Nutr.* 23, 2571–2583. doi: 10.1017/S1368980020001354

UN (2018). "*The World's cities in 2018-data booklet*". New York: Department of Economic and Social Affairs.

UN Habitat (2022). *World Cities Report 2022: Envisaging the future of cities*. Nairobi, Kenya: United Nations Human Settlements Programme, pp. 41–44.

Usuga, M. L. R., Jaimes, W. A., and Suarez, O. E. (2012). Coordination on agrifood supply chain. In Proceedings of World Academy of Science, Engineering and Technology World Academy of Science, Engineering and Technology (WASET).

Vieira, L. C., Serrao-Neumann, S., Howes, M., and Mackey, B. (2018). Unpacking components of sustainable and resilient urban food systems. *J. Clean. Prod.* 200, 318–330. doi: 10.1016/j.jclepro.2018.07.283

Webb, P., Benton, T. G., Beddington, J., Flynn, D., Kelly, N. M., and Thomas, S. M. (2020). The urgency of food system transformation is now irrefutable. *Nat. Food* 1, 584–585. doi: 10.1038/s43016-020-00161-0

Wegerif, M. C., and Wiskerke, J. S. (2017). Exploring the staple foodscape of Dar Es Salaam. *Sustainability* 9:1081. doi: 10.3390/su9061081

Wertheim-Heck, S. C., and Raneri, J. E. (2020). Food policy and the unruliness of consumption: an intergenerational social practice approach to uncover transforming food consumption in modernizing Hanoi Vietnam. *Globa. Food Security* 26:100418. doi: 10.1016/j.gfs.2020.100418

Wertheim-Heck, S., Raneri, J. E., and Oosterveer, P. (2019). Food safety and nutrition for low-income urbanites: exploring a social justice dilemma in consumption policy. *Environ. Urban.* 31, 397–420. doi: 10.1177/0956247819858019

Wertheim-Heck, S. C., and Spaargaren, G. (2016). Shifting configurations of shopping practices and food safety dynamics in Hanoi, Vietnam: a historical analysis. *Agric. Hum. Values* 33, 655–671. doi: 10.1007/s10460-015-9645-4

Wertheim-Heck, S. C., Vellema, S., and Spaargaren, G. (2014). Constrained consumer practices and food safety concerns in H anoi. *Int. J. Consum. Stud.* 38, 326–336. doi: 10.1111/ijcs.12093

WFP, F. (2022). "Hunger hotspots. FAO-WFP early warnings on acute food insecurity: June to September 2022 outlook". (Rome: FAO).

Widener, M. J., Metcalf, S. S., and Bar-Yam, Y. (2011). Dynamic urban food environments: a temporal analysis of access to healthy foods. *Am. J. Prev. Med.* 41, 439–441. doi: 10.1016/j.amepre.2011.06.034

Wondim, Y. A. (2020). Gender dimension on the living conditions of poor household heads in Sefene-Selam Sub-City, Bahir Dar, Ethiopia. *Int. J. Risk Conting. Manag.* 9, 30–62. doi: 10.4018/IJRCM.2020100103

Wosene, G., and Gobie, W. (2022). Value chain analysis of tomato: the case of bure, Jabitehinan and north Mecha districts of Amhara regional state, Ethiopia. *J. Agric. Food Res.* 7:100272. doi: 10.1016/j.jafr.2022.100272

Yigzaw, D., Habtemariam, A., Teshome, D., and Amare, H. (2016). Assessment of fruit postharvest handling practices and losses in Bahir Dar, Ethiopia. *Afr. J. Agric. Res.* 11, 5209–5214. doi: 10.5897/AJAR2016.11731

Zaharia, A., Diaconeasa, M. C., Maehle, N., Szolnoki, G., and Capitello, R. (2021). Developing sustainable food Systems in Europe: National Policies and stakeholder perspectives in a four-country analysis. *Int. J. Environ. Res. Public Health* 18:7701. doi: 10.3390/ijerph18147701

Zellelew, T. B. (2014). Meat abstinence and its positive environmental effect: examining the fasting etiquettes of the Ethiopian orthodox church. *Critic. Res. Relig.* 2, 134–146. doi: 10.1177/2050303214535002

Zhong, Q., Wang, L., and Cui, S. (2021). Urban food systems: a bibliometric review from 1991 to 2020. *Foods* 10:662. doi: 10.3390/foods10030662