REVIEW

Holistic approaches to assess the sustainability of food systems in low- and middle-income countries: A scoping review

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Abstract

Food systems and their sustainability have been extensively studied in high-income countries (HICs), yet less so in low- and middle-income countries (LMICs), despite their importance for global food security. In this study, we conducted a systematic scoping review to describe the extent, range, and nature of peer-reviewed literature assessing the sustainability performance of food systems in LMICs. The review revealed a recent and heterogeneous literature. From this diversity, 3 archetypes of epistemological approaches emerged, classified by their purpose: *observational*, *modeling*, and *transformative*. All 3 approaches apply existing or tailored methods to specifically study food systems, and their objectives are to observe, model, or transform different parts of the food systems towards sustainability. Gaps in the literature include inconsistent definitions of food systems and frameworks and understudied drivers of food systems sustainability. Therefore, the development of a comprehensive and systematic inventory of frameworks and their sustainability is crucial to determine the most suitable interdisciplinary methodologies for specific contexts and generate actionable knowledge for food systems transformation.

Author summary

Although food systems in low- and middle-income countries (LMICs) are significantly threatened by climate change and are more vulnerable to price increases, understanding and evaluating food systems sustainability has predominantly focused on high-income countries (HICs). Thus, we reviewed the literature assessing the sustainability performance of food systems in LMICs. This body of literature is recent, diverse, and highly represented by studies employing quantitative methods. It also can be categorized into 3 different archetypes: *observational*, *modeling*, and *transformative* approaches, each appraising the sustainability of food systems. However, our findings highlight the need for more systematic definitions of food systems and analytical frameworks for generating actionable knowledge to guide research investments and shape policies towards more sustainable food systems.

1. Introduction

A paradigm shift from food security to sustainable food systems has taken place to ensure access to healthy and sustainable diets for all [1,2] in the context of the Sustainable Development Goals. According to the High Level Panel of Experts on Food Security and Nutrition (HLPE), a food system "gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socioeconomic and environmental outcomes" [3]. This definition further includes the drivers of change and conditions (biophysical, social, economic, and political) that influence food security, environment quality, and human well-being. Therefore, rather than considering separate and unconnected elements, a food system approach encompasses the broad spectrum of activities, drivers, and outcomes across the food system, their interconnectedness and interactions, the feedback loops and tradeoffs across scales, and the actors involved in their governance [4,5].

A sustainable food system is "a food system that delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised" [6]. In accordance with this definition and prior works [3,7,8], we defined the notion of sustainability in food systems according to 4 pillars: food security and nutrition, social, economic, and environmental sustainability. Prevailing food system approaches have focused mostly on the environmental dimension [9].

Food systems in low- and middle-income countries (LMICs) face significant threats from climate change and are especially vulnerable to price increases [10]. Yet, sustainability assessments of food systems have largely focused on high-income countries (HICs) [8,11,12], with the exception of some platforms and methods based on quantitative metrics [13,14]. Furthermore, the relevance of applying methods that have been designed to understand food systems in HICs to LMICs is questionable. First, food systems in LMICs have been described as much more heterogeneous both in terms of characteristics (e.g., agricultural value added per worker, share of dietary energy from staple grains and cereals, urbanization, and supermarket density) and in terms of impacts on diets, nutrition and health, livelihoods, and environmental sustainability, as compared to food systems in HICs [15]. Second, methods designed to understand food systems in HICs often rely on standardized and homogenized data that may be difficult to generate in LMICs. For example, while Poore and Nemecek [16] were able to consolidate data on multiple environmental impacts from 119 countries in a meta-analysis, there was an overrepresentation of data from HICs and considerable unavailability of data from LMICs. Given these challenges, our interdisciplinary scoping review aims to analyze peer-reviewed literature using integrative tools and metrics to assess the sustainability performance of food systems in LMICs, describing the research landscape, highlighting gaps, and posing new research questions.

2. Methods

2.1. Type of review

Scoping reviews aim at identifying, mapping, and synthesizing available evidence within a field of interest [17,18]. The guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) statement (see S1 File) as well as some elements of the updated guideline (e.g., flowchart) from the PRISMA 2020 statement were used for the review.

2.2. Framework analysis

The HLPE framework was selected for its pragmatic scheme containing the key components of food systems and highlighting how they are influenced by exogenous drivers and linked to health, sustainability, and socioeconomic outcomes [12]. Comparison of selected works was facilitated by identifying the key components of food systems—termed "entry points" by the HLPE [3]: "drivers" (macro variables affecting the food system), "components" (activities like food production, storage, distribution), and "outcomes" (impacts of these activities) (Box 1).

Box 1. Possible entry points into food systems from the HLPE framework (2017)

Drivers

1. Biophysical and environmental drivers (climate change, soil erosion, pollinator decline, groundwater for irrigation, etc.)
2. Technological drivers (production methods, innovation, technical education, etc.)
3. Political and economic drivers (food prices, GDP, land tenure, food waste policy, food policy environment, etc.)
4. Sociocultural drivers (food and agricultural traditions, women's labor and role, food policy, power relations, etc.)
5. Demographic drivers (population growth, changing age distribution, urbanization, migration, etc.)

Components

6. Food environments (food availability and accessibility, economic access, individual drivers, etc.)
7. Food supply chains (production, production-related costs, etc.)
8. Consumption behavior and preferences (at national or consumer level, etc.)

Outcomes

9. Environmental outcomes (water scarcity, GHG emissions, etc.)

10. Nutrition and health outcomes (including diet quantity, diversity, quality, and safety)

11. Socioeconomic outcomes (poverty reduction, income, implementing costs of new technologies, etc.)

The 4 dimensions of sustainability were identified for each study based on the semantic fields and indicators used by authors to assess sustainability.

To address the broad spectrum of food system research, ranging from quantitative environmental impact assessments to qualitative studies of actor perceptions and interactions, we developed archetypes of epistemological approaches based on objectives, in line with prior classifications [19,20]. Within the literature reviewed, we identified 3 approaches: (a) "*observational approaches*" measuring food system sustainability through existing or new metrics, such as a global index of sustainability or a score for different dimensions of the food system; (b) "*modeling approaches*" producing models to measure the evolution and impact of interventions at different levels of the food system to improve the outcomes and optimize the food system through scenario analysis; (c) "*transformative approaches*" enabling to test food system transformations with stakeholder involvement (e.g., policymakers, grassroots organizations, farmers) and assess their acceptance to changes.

2.3. Eligibility criteria

Studies were included in our review based on 4 inclusion criteria. The first criterion required the use of holistic and comprehensive approach to food systems, specifically approaches that considered the interdependence of different food system elements and, where feasible, encompassed the entire food system. Accordingly, selected studies were required to assess a minimum of 3 food system elements, which could include any of the "entry points" previously detailed (Box 1). The second criterion concerned the adoption of an approach or methodology capable of assessing at least 1 dimension of sustainability within food systems (food security and nutrition, environmental, economic, and social). The third criterion mandated the application of such approaches or methodologies in at least 1 LMIC (defined as low income, lower middle income, and upper middle income countries according to the World Bank 2020 income classification; see S2 File). The final criterion restricted the scope to peer-reviewed articles and book chapters published in English, without any limitations on the publication date. Exclusion criteria were as follows: (a) studies focusing exclusively on 1 or 2 food system elements (e.g., food production, food environment, consumer behavior, or diets) rather than on the food system as a whole; (b) studies utilizing approaches or methodologies assessing aspects other than the sustainability of food systems (e.g., resilience); and (c) studies focusing solely on HICs. Resilience was not considered an eligibility criterion and is viewed in this review as a distinct concept from sustainability, due to the extensive debate on whether resilience is one of the dimensions of sustainability or a concept in itself [21]. Additionally, reviews, special issue introductions, expert opinions, editorial comments, conference reports, book reviews, and manuals were also excluded from this review.

2.4. Information sources, search strategy, and data extraction

A structured search strategy, focusing on title-abstract-keywords, was developed to retrieve peer-reviewed articles published in English. Searches were conducted in September 2021 in Web of Science, Scopus, Medline, and Food Science Source (see S2 File). In addition, the reference lists of the studies retrieved were examined to identify other relevant studies. In line with the objectives of the scoping review, we conducted a two-stage screening process to select the studies for comprehensive review. During the first stage, titles and abstracts were examined by 2 authors (EF and EOV), leading to the identification of 84 relevant studies. Subsequently, these 84 studies were divided among 7 pairs of authors for thorough reading, evaluation according to the inclusion and exclusion criteria, and extraction of the necessary information for our analysis. All disagreements regarding eligibility and discrepancies in the extracted information were resolved through discussions within each pair and with the first author (EF).

3. Results

We retrieved 1,123 studies from the original search, of which 38 articles met our inclusion criteria and were included in the analysis (see Fig 1 and S1 Table).

3.1. An emerging and heterogeneous literature in LMICs

Studies adopting a holistic approach to assess the sustainability performance of food systems in LMICs are scarce and recent (Fig 2A): half of the articles (n = 24) were published over the last 3 years (2019 to 2021). Furthermore, less than half (46%) of the articles are co-authored by at least 50% of authors affiliated with an institution located in a LMIC (Fig 2B). In terms of geographical distribution of the studies, Latin America and the Caribbean (LAC) is the main region covered by the literature (Fig 2C), followed by East Asia and the Pacific, South Asia, sub-Saharan Africa, the Middle East and North Africa (MENA), and finally Europe and Central Asia. The literature published on LAC and East Asia and the Pacific presents a higher proportion of authors from LMICs, possibly due to stronger research institutions in these regions. In contrast, literature on South Asia, MENA, and sub-Saharan Africa features a higher number of authors from HICs.

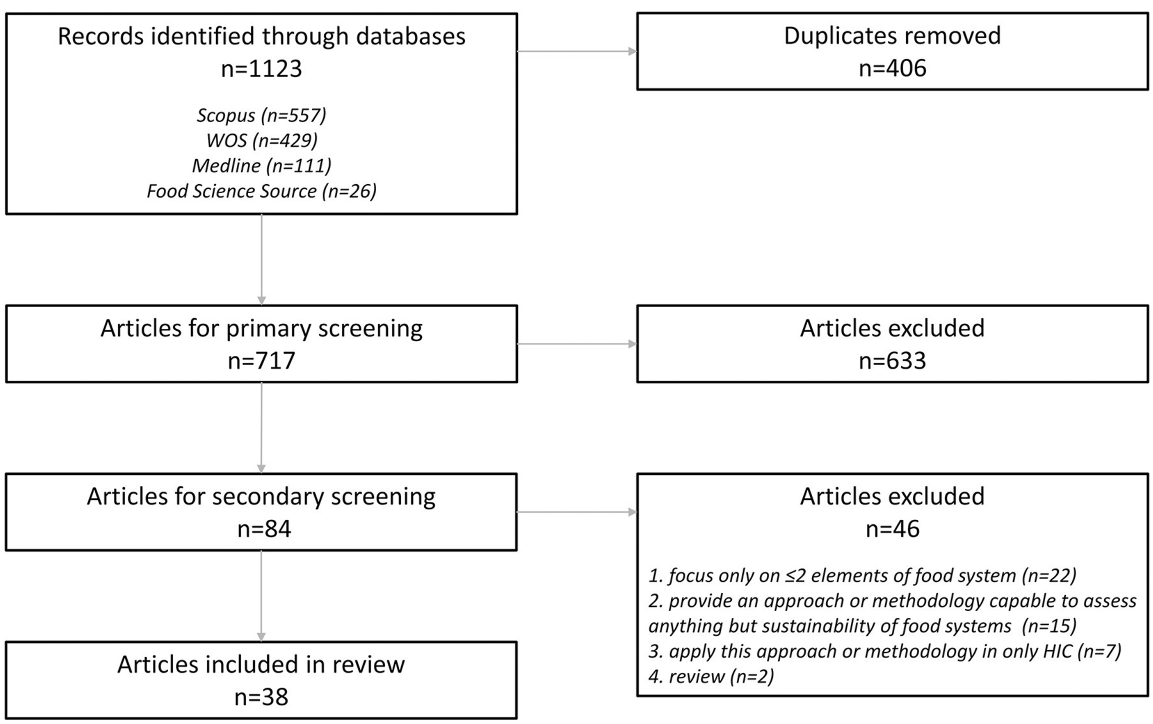

Fig 1. Systematic literature review flowchart for article selection.

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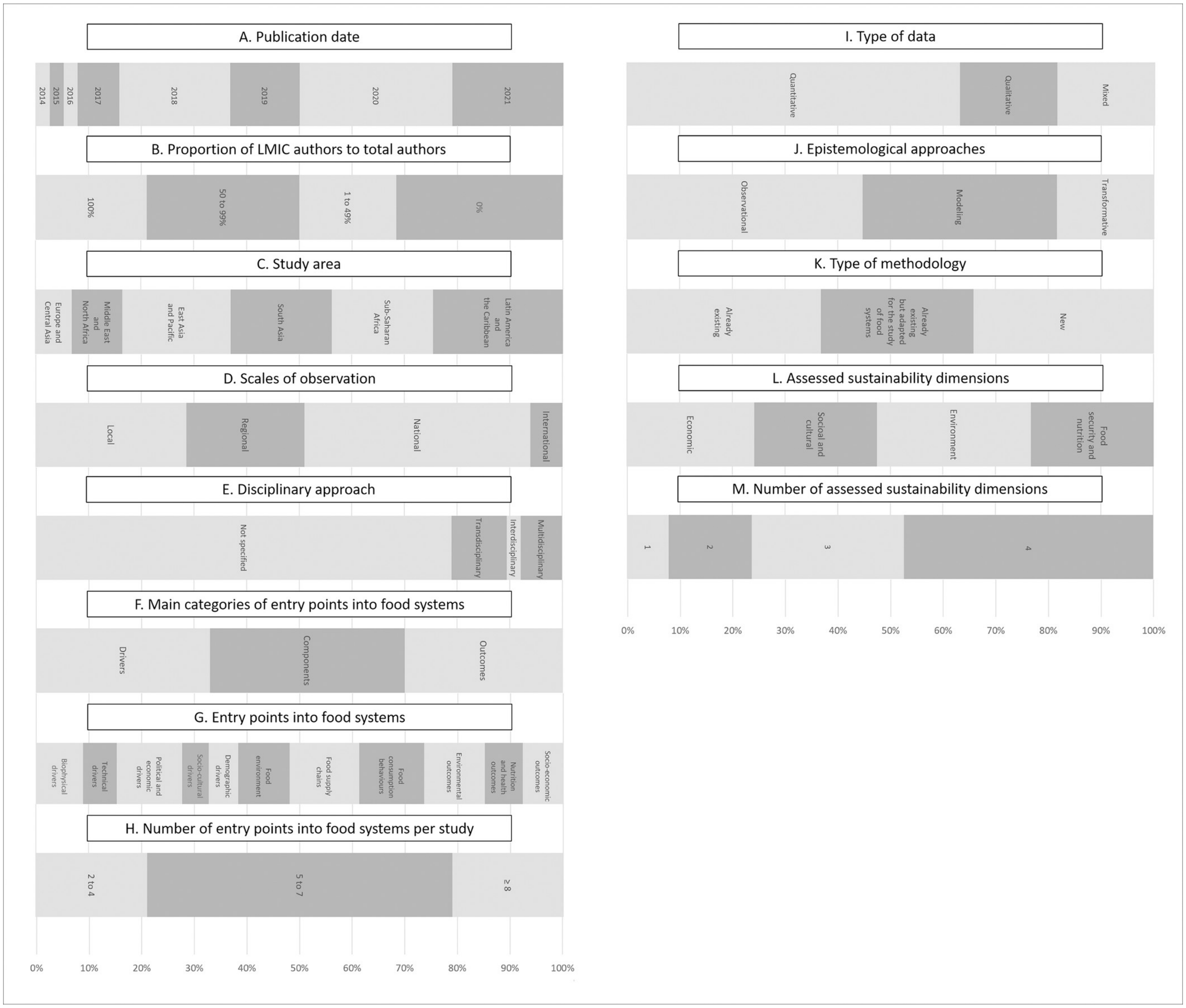

Fig 2. Description of the studies included in the review. (**A**) Shares of studies per year. (**B**) Shares of studies by LMIC authors as a proportion of total authors. (**C**) Shares of studies by study area. (**D**) Shares of studies by scales of observation used in the data. (**E**) Shares of studies where interdisciplinarity was declared. (**F**) Shares of studies by main category of entry points into food systems (drivers, components, outcomes). (**G**) Shares of studies by entry point into food systems (see Box 1). (**H**) Shares of studies by number of entry point into food systems. (**I**) Shares of studies by type of data (quantitative, qualitative, and mixed). (**J**) Shares of studies by epistemological approach (observational, modeling, and transformative). (**K**) Shares of studies by type of method (existing methodology, methodology adapted to the study of food systems, and new methodology). (**L**) Shares of studies assessing each dimension of sustainability. (**M**) Shares of studies by the number of dimensions of sustainability they assessed.

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While 20% of the literature adopts a multi-scale approach (predominantly local, regional, and national, or national and international scales), most studies focus on a single scale ($n = 29$). This scale is primarily national (Fig 2D), with an occurrence of 55% when combined with other scales and 37% when considered alone. Finally, only one quarter of authors specify that their approach incorporates multiple disciplines, specifically transdisciplinarity ($n = 4$), interdisciplinarity ($n = 1$), or multidisciplinarity ($n = 3$) (Fig 2E). Therefore, most articles do not specify their disciplinary approach despite a declared intention to assess food systems.

3.2. A comprehensive, though incompletely defined, food systems assessment

Only methodologies adopting a holistic approach to food systems were considered. The review indicates that most studies (*n* = 27) mention a food system framework, although its definition varies across the studies: some authors provide an original definition with varying levels of detail, while others cite an existing definition (for example, 6 studies refer to the HLPE framework) without clearly specifying the entry points examined. In contrast, one third of the studies (*n* = 11) make no reference to a food system framework, and 6 of these focus specifically on a Water-Energy-Food nexus [22–27].

We identified the entry points into food systems by examining the detailed variables reported in the studies, based on the HLPE [3] framework and its classification into 3 categories: (a) *drivers*; (b) *components*; and (c) *outcomes*.

Among the reviewed studies, food system *components* are slightly more evaluated (Fig 2F) than the drivers and the outcomes. Regarding *drivers*, the studies mainly refer to eco-political and bio-physical factors. As expected, environmental *outcomes* are the most frequently studied (Fig 2G). Most articles (*n* = 22) employ an approach encompassing 5 to 7 potential entry points (Fig 2H) (Box 1). One fifth (*n* = 8) of the studies includes 2 to 4 entry points in their analysis and another fifth (*n* = 8) examines at least 8 entry points.

3.3. A typology of approaches to appraise the sustainability of food systems

The vast majority of studies (*n* = 24) apply a quantitative method to assess the sustainability of food systems, one fifth (*n* = 7) relies on a combination of quantitative and qualitative methods, and another one fifth (*n* = 7) uses qualitative methods alone (Fig 2I). These methods serve distinct purposes. We classified the studies according to the 3 mentioned archetypes of epistemological approaches. Approximately half of the studies (*n* = 17) were categorized as *observational approaches*, two fifths (*n* = 14) as *modeling approaches*, and one fifth (*n* = 7) as *transformative approaches* (Fig 2J). Each archetype is illustrated in S3 File.

Compared to the *observational approaches*, the *modeling* and *transformative* approaches present a share of at least 50% LMIC authors, possibly because they require methodologies tailored to specific cases. Interdisciplinarity is reported more frequently in *observational* and *transformative* approaches than in *modeling approaches*. The predominance of quantitative methods is significant in both *observational* and *modeling* approaches, while it is entirely absent in the *transformative approaches*. We examined the propensity of the approaches to innovation by classifying the studies into 3 groups: (a) *existing methodologies* (*n* = 14); (b) *existing methodologies adapted to the study of food systems* (*n* = 11); and (c) *new methodologies* (*n* = 13) (Fig 2K). This classification reflects the authors' descriptions of their methods. These 3 categories are applied in a comparable manner. The *existing methodologies adapted to the study of food systems* category includes methodologies that were initially developed in different disciplines and fields of research, and then specifically adapted for food systems research. *New methodologies* were developed for studies using *observational* (*n* = 5) and *modeling* (*n* = 5) approaches, facilitating the creation of novel metrics with numerous indicators to measure different dimensions of sustainability [28–31]. In addition, *new methodologies* have also been developed for modeling food systems (*n* = 5) [24,32,33]. *Transformative approaches* are proportionally slightly more inclined towards innovation (*n* = 3), as they require a multi-stakeholder perspective for initiating the transformation of food systems in several steps at both the grassroots and stakeholder levels [34–36]. Furthermore, the studies categorized under *existing methodologies adapted to the study of food systems* examine the 4 dimensions of sustainability in a higher proportion than those in the category *new methods*, which cover fewer dimensions.

3.4. Dimensions of sustainability and their metrics

We have listed a wide range of indicators (Box 2) identified in the literature to measure the 4 dimensions of sustainability in food systems as defined by the FAO [6], namely food security and nutrition, economic, social, and environmental sustainability. For example, the environmental dimension encompasses not only greenhouse gas (GHG) footprints but also considers water quality and scarcity. Additionally, soil quality, land use, biodiversity, and, more recently, pesticide use and food waste are progressively incorporated into sustainability analyses. The food security dimension includes variables related to food, nutritional intake and diversity, access to food, food consumption budgets, perceptions of food security, and more broadly, health, access to land, water, and energy resources. Similarly, the social dimension is covers a range of topics such as equity and inclusion dynamics, population and socioeconomic dynamics, and governance influencing equitable access to production and food. In contrast, dietary and consumption habits, consumer preferences, and food norms receive minimal attention. Finally, the economic dimension is mainly analyzed through the impact of food system activities on the economy and livelihoods. The studies included in our review address the 4 dimensions of food systems sustainability comprehensively, with a slight emphasis on the environmental dimension (Fig 2L). Nearly half of the studies (n = 18) examine all 4 dimensions, 11 studies focus on 3 dimensions, 6 studies on 2 dimensions, and 3 studies on only 1 dimension (Fig 2M).

Box 2. Semantic fields to assess the dimensions of sustainability (FAO, 2014) in food systems

Food security and nutrition

Access to food (n = 17); dietary intakes (n = 14); access to resources like land, water, and energy (n = 10); health indicators (n = 6); dietary diversity (n = 5); food consumption budgets (n = 4); price food index (n = 3); nutritional quality of foods (n = 2); and food security perception (n = 1).

Environmental

Water quality, use, and degradation (n = 20); GHGEs (n = 14); energy and land use (n = 13); biodiversity and its drivers (n = 9); soil quality, use, and degradation (n = 7); use of contaminants and materials (n = 6); waste (n = 6); investments in environmental degradation control and legislation (n = 4); and perception (n = 3).

Social

Governance (n = 12); equity and inclusion dynamics (n = 9); access to land, natural resources, and markets (n = 8); population dynamics (n = 7); socioeconomic dynamics (n = 4); dietary norms (n = 2); and animal welfare (n = 2).

Economic

Impact on the economy such as GDP and import dependency (n = 11); impact on productivity and income from agricultural/food activities (n = 9), impact on livelihoods, socioeconomic status, and welfare (n = 10); and impact on consumption such as GDP per unit of energy use (n = 3).

Table 1. Entry points into food systems, approaches, and dimensions of sustainability assessed across included studies.

	Number of studies per number of dimensions of sustainability assessed				Average number of entry points assessed
	1 dimension	2 dimensions	3 dimensions	4 dimensions	
Observational	1 (6%)	1 (6%)	6 (35%)	9 (53%)	6.5
Modeling	2 (14%)	4 (29%)	5 (36%)	3 (21%)	6
Transformative	0	2 (29%)	0	5 (71%)	5.9

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3.5. Specific approaches for distinctive understandings of food systems sustainability

To better understand how approaches differ in their assessment of food systems sustainability, we cross-referenced the entry points into the studied food systems with the approaches and the sustainability dimensions (Table 1).

Observational approaches, predominantly quantitative, provide a more comprehensive view of food systems, with an average of 6.5 entry points. Among these, approaches examining at least 8 entry points [14,28,29,37,38] are qualified as holistic. The *observational approaches* also account for the majority of studies assessing all 4 dimensions of sustainability ($n = 9$). In comparison, the *modeling* approaches cover on average 6.0 entry points, with 2 studies encompassing at least 8 entry points [23,39]. These models typically address 2 or 3 dimensions of sustainability, and less commonly, all 4 dimensions, as in the case of Medina-Santana and colleagues [27].

Lastly, *transformative approaches*, implemented through qualitative or mixed methods, present a less comprehensive overview of the food systems, averaging 5.9 entry points. Only 1 study examines at least 8 entry points into the food system [40], but these approaches more frequently consider all 4 dimensions of sustainability ($n = 5$; Table 1) [36,40–44].

4. Discussion

To the best of our knowledge, this is the first systematic scoping review describing the extent, range, and nature of peer-reviewed literature assessing the sustainability performance of food systems in LMICs. We identified a limited selection of articles ($n = 38$), most of which were quite recent. Nevertheless, this body of literature is already rich in terms of geographical coverage and methodological approaches. Notably, we discerned 3 archetypes of epistemological approaches within this corpus: observational, modeling, and transformative approaches, with the first being the most prevalent. These archetypes differ in terms of the entry points and the number of sustainability dimensions they address. However, despite these general differences, each archetype exhibits relative heterogeneity.

In a time marked by rapidly expanding research into food systems, especially concerning sustainability, our review identified only a modest number of articles. This shortage of relevant papers can be attributed to the application of a food system lens, which considerably narrows the scope of relevant literature; for example, only 15% of studies dealing with sustainable diets and the consumption of fruits and vegetables "used a comprehensive food system lens" [45]. Focusing specifically on LMICs, in contrast to Sirdey and colleagues [20], further accounts for the limited number of articles.

The literature displays a wide range of methodologies (equivalent to the number of studies) utilized to assess the sustainability of food systems in LMICs, similar to 2 other reviews [19,45], which also noted a predominance of quantitative methods (50% and 85%, respectively). We managed to categorize this methodological diversity into 3 archetypes of epistemological approaches, which are somewhat consistent with the typology developed by Sirdey and colleagues on articles covering the whole world [20]: *observational approaches* match their "type 1" (methodologies based on quantitative metrics, mostly at national scale, aimed at international comparisons), *modeling approaches* match their "type 2" (quantitative methods based on systemic models) while *transformational approaches* match their types 3 and 4 (participatory methods mostly at city-region level and multicriteria methods combining quantitative and qualitative indicators at different geographical scales).

Like Brouwer and colleagues, who identified a wide variety of definitions of food systems and conceptual frameworks [12], we observed that most studies ($n = 27$) referred to various food systems frameworks. Consequently, we found that almost a third of the articles did not mention any conceptual framework. This absence of clear concepts and frameworks hinders the comparability of this body of literature. Furthermore, we observed that the vast majority of studies did not specifically mention whether interdisciplinary or transdisciplinary approaches were used, despite the fact that addressing fundamental societal challenges, especially those related to sustainability, demands more than a single disciplinary perspective and should be tackled using interdisciplinary and/or transdisciplinary approaches [46,47].

Contrary to other literature reviews, where the environmental dimension was more extensively studied than the other sustainability dimensions [9], our review reveals a body of literature that offers more balanced coverage across these dimensions, employing a diversity of metrics and indicators. However, there is a noticeable disparity in how these metrics and indicators are used, with some being only marginally applied. For example, the use of pesticides and food waste are rarely considered in the environmental dimension, similar to food prices and food budgets in the food security and nutrition dimension, and the costs of food system activities in the economic dimension. Moreover, the literature reveals a general knowledge gap regarding demand elasticity in relation to food prices and across socioeconomic groups, as indicated by key indicators such as household budgets and consumptions, and generally associated with sociodemographic drivers [19], such as the number of people in a household to feed. Additionally, this body of literature fails to consider the cultural drivers of consumption, despite their important role in food security, such as gender and age hierarchies in food distribution or gender roles in food purchasing and preparation. This disparity in the use of these metrics and indicators could indicate overlooked areas in food systems research, likely stemming from a lack of interdisciplinary and/or transdisciplinary approaches.

Some limitations of this review must be mentioned. First, the scope and interdisciplinarity of this review posed challenges for including and analyzing data from studies that were highly heterogeneous in objectives and methods. To overcome these challenges, we assembled an interdisciplinary team representing various disciplinary fields. We also attempted to balance seniority in research, gender, and geographical origin, although there is room for improvement in this specific aspect. Second, we focused on peer-reviewed articles written in English, excluding articles in other languages and documents like conference proceedings and reports. Given the emerging nature of this field and its growing interest, it can be presumed that a range of gray literature in different languages exists, which future systematic reviews should consider. While this methodological choice reduced the number and diversity of methods we could cover, we assume it did not alter our results regarding the archetypes of epistemological approaches. Third, we opted to use a single conceptual framework to analyze the 38 articles in this review, choosing the HLPE framework, the most cited among the studies reviewed. Although using a single framework simplifies study comparison, it may obscure certain study characteristics not encompassed by the HLPE framework and complicate the transposition of a study's characteristics into this framework. For example, in Water-Energy-Food nexus studies, energy costs derived from water use in food production can be considered both a food system *component* and an *outcome*, based on various economic costs related to water production [23,28]. Nonetheless, we encountered few difficulties with the HLPE framework and assume that employing a different food system framework (or frameworks) would not significantly change the main results presented here.

Several directions for future research can be drawn from this review. First, we noted either a lack of clarity in the frameworks used in the literature or heterogeneity in the frameworks mobilized, both of which are problematic for the comparability of the literature. Echoing Brouwer and colleagues [12], it would be most useful to harmonize existing tools under a commonly agreed systems approach. For this purpose, the results of this review and other studies providing an overview of methodologies to assess the sustainability of food systems can be used. Second, we observed partial coverage of the sustainability dimensions, either by the number of dimensions assessed or by unevenness in the use of metrics and indicators within each dimension. Better coverage of these dimensions is achievable through a dialogue between methods and disciplines. For example, *modeling approaches* could encompass more sustainability dimensions, such as sociocultural or political dimensions, by adopting *participatory modeling* approaches to the food system [48] to shape food policy and effect systemic change. Another example is that mixed methods applied to *transformative approaches* are mostly sequential [49,50], yet they can also be designed to simulate possible behavioral changes identified by qualitative surveys. However, embracing the full complexity of the food systems' components and activities, in relation to drivers, interactions, and (un)sustainable outcomes, remains quite challenging. The study of food systems in LMICs is further complicated by unequal research capacities. The global distribution of research capacity is highly uneven, to the detriment of LMICs, with inequalities historically rooted since colonial times, current funding priorities of national governments, the lack of stable scientific institutions, or brain drain [51]. Moreover, these inequalities may persist in North-South collaborations, with disparities between researchers from HICs and those from LMICs in terms of fundraising and expenditure, grant recipients as principal investigators, and the manner in which data collected in LMICs is generally analyzed and published by researchers from HICs [52].

5. Conclusions

We synthesized methodological approaches for assessing the sustainability of food systems in LMICs and found a small but heterogenous corpus. We identified 3 archetypes that evaluate the sustainability of food systems: *observational*, *modeling*, and *transformative* approaches. Combined, these 3 archetypes have the potential to capture the complexity of food systems and support transformation towards a sustainable food system, i.e., one that enhances human nutrition, social and economic welfare, while respecting cultural and natural environments. However, guiding investments in research for transformative food systems requires a more systematic definition of food systems and frameworks, as well as a more comprehensive definition of sustainability, as a starting point for possible comparison of food systems sustainability across contexts. We hope that the results of this study will significantly contribute to the promotion of inter- and transdisciplinary research to build sustainable food systems, the development of policy guidelines, and the formulation of relevant recommendations at the regional level.

Supporting information

S1 Table. Characteristics of the 38 articles included in the review.
(XLSX)

S1 File. PRISMA Checklist.
(DOCX)

S2 File. Terms used when searching papers in Scopus, Web of Science, Medline, and Food Science Source.
(DOCX)

S3 File. Illustrations of the 3 archetypes of epistemological approaches.
(DOCX)

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