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Integrating Nutritional and Dietary Aspects in Food Self-Sufficiency: A Systematic Literature Review of Recent Advancements

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ABSTRACT

Food self-sufficiency is central to food policy and sustainability discussions, yet traditional volume- and calorie-based metrics overlook the complexity of food systems and do not reflect actual nutritional needs of populations. This systematic review synthesizes recent developments in food self-sufficiency research, with a specific focus on how nutritional and dietary dimensions are incorporated. Using PRISMA guidelines, 55 studies were identified and categorized by geographical level, timeframe, data sources, assessment methods, and the extent of nutritional integration. Across the literature, new approaches have emerged that link domestic food production to age- and sex-specific requirements for a wide range of macro- and micronutrients. These assessments consistently reveal major shortfalls in the domestic production of many essential nutrients, particularly calcium, choline, polyunsaturated fatty acids, vitamins A and E, folate, iron, and vitamin B12. For many low- and lower-middle-income countries, international trade only partially improves national nutritional adequacy, leaving large populations vulnerable to "hidden hunger". Population growth, rising food demand, dietary changes, and environmental constraints are expected to further intensify these pressures. Addressing nutritional self-sufficiency requires context-specific strategies, including improving resource efficiency, reducing food loss and waste, diversifying domestic production toward nutrient-dense crops, promoting healthier and more sustainable diets, and using international trade in a targeted manner to close gaps in critical nutrients and food groups. Future research should focus on filling data gaps in food production and consumption at the level of individual food items and in food composition, particularly for local and traditional food items, generating more reliable food loss and waste estimates, accounting for nutritional degradation, and refining novel nutritional and dietary indicators.

1 | Introduction

Food self-sufficiency (FSS) remains a central subject within food policy and sustainable development planning. It has gained renewed importance in the current era, given the even more complex challenges of modern global food supplies and their evident failure to guarantee food security and nutrition across all countries. More specifically, the COVID-19 pandemic and the war in Ukraine have led to high levels of uncertainty in global food markets, manifested in disruptions to supply chains or volatility in agricultural and energy commodity prices (Szajner et al. 2024). As a response to those uncertainties, many countries are now reformulating their food self-sufficiency to reduce dependence on food imports from other countries and to ensure a steady domestic food supply. This shift reflects a growing recognition of FSS in a world of increasing global economic crises and geopolitical instability. Nevertheless, international trade remains essential for guaranteeing access to food that cannot be grown locally due to geographical and climatic constraints, or insufficient agricultural areas. A broader understanding of food self-sufficiency considers a range of strategies, from boosting domestic production to efficiently managing imports to strike a balance between local capabilities and global market dynamics (Clapp 2017; Godenau et al. 2020). Food self-sufficiency has been defined broadly as the extent to which a country can satisfy its food needs from its domestic production (Clapp 2017). Traditionally, it has been measured as the ratio of domestic food production to total food demand at the national level and has been mainly focused on staple foods. The basis for the calculation was the volume of food, the dietary energy supply, or the economic value of food commodities. Shortcomings of the traditional FSS assessment have been observed regarding data availability and quality, food losses and waste (FLW) consideration, and a general failure to capture the multifaceted and interconnected nature of food systems. For instance, import dependency in food systems encompasses not only food products but also the resources needed across the whole food value chain, such as fertilisers, pesticides, energy, machinery and feed. Similarly, it has been argued that the method is simplistic, as it does not consider the actual nutritional needs of populations or the socioeconomic issues related to food access (Damerau et al. 2020; Macdiarmid et al. 2018). Indeed, higher food self-sufficiency does not automatically translate into improved nutritional outcomes for the population, and calorie-based assessments can hide micronutrient deficiencies (Wassénius et al. 2023). Only a minority of the global population lives in countries that are fully self-sufficient in this sense, with many reliant on imports for key nutrients, and vulnerable to trade or geopolitical shocks (Wassénius et al. 2023). As a result, consensus is growing on the need to move toward more comprehensive FSS metrics that integrate nutritional adequacy (Chen et al. 2021) and dietary diversity alongside standard production-based indicators (Wassénius et al. 2023). The present review systematically examines the most recent advancements in food self-sufficiency research, focusing on the integration of nutritional and dietary aspects. To the best of our knowledge, this is the first review to offer insights into the transition towards a nutrition-oriented approach in the assessment of food self-sufficiency, underscoring both the opportunities and challenges for future research and policy development.

2 | Materials and Method

The review was done systematically following the PRISMA guidelines (Page et al. 2022). Papers were searched on Web of Science (WoS) and Scopus, as these are among the most comprehensive databases of peer-reviewed journals and scientific papers in environmental, agricultural, food, and nutritional sciences. In line with the review's objective, "nutri*" "food self-sufficien*", "domestic produc*" and "food balanc*" were queried as shown in the following search string:

TITLE-ABS-KEY ("nutri*") AND TITLE-ABS-KEY ("self-sufficien*" OR "food balanc*" OR "domestic produc*") AND PUBYEAR > 2009 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")).

This string was utilized in Scopus and adapted for Web of Science to align with its syntax requirements. The review was limited to original articles published between 2010 and 2024 and written in English. Furthermore, to maintain a reasonable and manageable number of articles, and in alignment with the review's scope to examine the most recent and relevant advancements in the topic of FSS, the search was constrained to the article title, abstract, and keywords (TITLE-ABS-KEY). After removing duplicates, the remaining papers were screened based on their titles and abstracts to assess their relevance to the review's objective. Subsequently, the full texts of the selected articles were thoroughly evaluated according to the following criteria focused on the clarity and rigor in the FSS definition and assessment methodology, resulting in the exclusion of:

1. studies not centered on FSS;
2. studies focused on a single crop or food group;
3. case studies with very limited geographic or population scope (e.g., case studies confined to a single farm or household); and
4. purely theoretical, and political works.

Additionally, the reference lists of the included articles were cross-checked to identify any further relevant studies for consideration. Furthermore, to reduce any publication bias and capture also relevant grey literature (Haddaway et al. 2015), we extended our search to Google Scholar. Specifically, the first 200 articles obtained through a similar search string, sorted by relevance, were carefully screened. Those that did not overlap with the articles already found in WoS and Scopus and met the eligibility criteria were included. Especially, studies evaluating national food/nutritional adequacy without distinguishing between domestic and imported food sources were excluded following criterion no. 1, as they do not provide relevant results under a FSS perspective. In fact, while they offer valuable insight into the broader nutritional security status of a population, they do not address the vulnerabilities of food systems associated with import dependence, a core aspect in FSS (Macdiarmid et al. 2018; Wassénius et al. 2023). Nevertheless, given their relevance to the broader field of food and nutrition security, some of them (Lividini and Masters 2022; Schmidhuber et al. 2018; Smith et al. 2016, 2021) were consulted and used in the discussion (Section 3) to contextualize and enrich our review findings.

The included studies were classified and analysed based on the following factors:

1. the geographical level (cross-scale, global, regional, country, subnational and local)
2. the timeframe (current/short-term analysis, historical/long-term analysis, future projections)
3. data sources (primary, secondary and mixed)
4. food self-sufficiency assessment (based on volume, dietary energy, price or monetary terms, agricultural land or nutrition); and
5. integration of nutrition and/or dietary aspects.

FSS were considered as integrating nutritional and dietary aspects only when nutritional metrics were used, and not when the FSS only accounted for volume, energy, or economic criteria. The energy-based approach was not considered a proxy for nutrition and dietary aspects because it only considers energy availability, not nutritional value. Likewise, papers that modeled and evaluated the effects of dietary scenarios (e.g., changes in food consumption composition) on FSS but did not calculate the same FSS from a nutritional perspective were not regarded as integrating the nutritional dimension. The papers were thoroughly discussed in terms of the above-mentioned classification factors, key findings, and recommendations. Special attention was given to studies that incorporated nutritional and dietary aspects. This involved analyzing the evaluated nutrients, the nutritional needs of different population groups, and the main results individually or in comparison to traditional assessments when applicable.

3 | Results and Discussion

3.1 | Overview of the Reviewed Studies

Figure 1 shows the flowchart of the systematic literature review performed. Indeed, as the result of the material collection, screening, and evaluation process, 55 studies were included in the review.

As shown in Figure 2, research output on nutritional and dietary aspects in food self-sufficiency was limited and stable from 2013 to 2017, with only one to two publications per year.

A notable increase began in 2018, reaching five publications that year and peaking at 10 in 2021. This activity level continued from 2022 to 2024, with seven to eight publications each year. Notably, nutrition-based FSS studies began to emerge from 2017, indicating a shift in research focus toward more comprehensive assessments of food systems. A possible explanation for the increase in publications since 2018 could lie in rising food price volatility, together with global health crises and geopolitical conflicts, which have exposed the systemic fragility of food systems and prompted new interest in food self-sufficiency.

For completeness, we also classified the reviewed studies by the subject area of their publishing journals (Figure 3). FSS papers covered various academic fields: 36% in agricultural and food sciences, 26% in multidisciplinary journals, 20% in social sciences, 16% in environmental sciences, and only 2% in nutrition and dietetics.

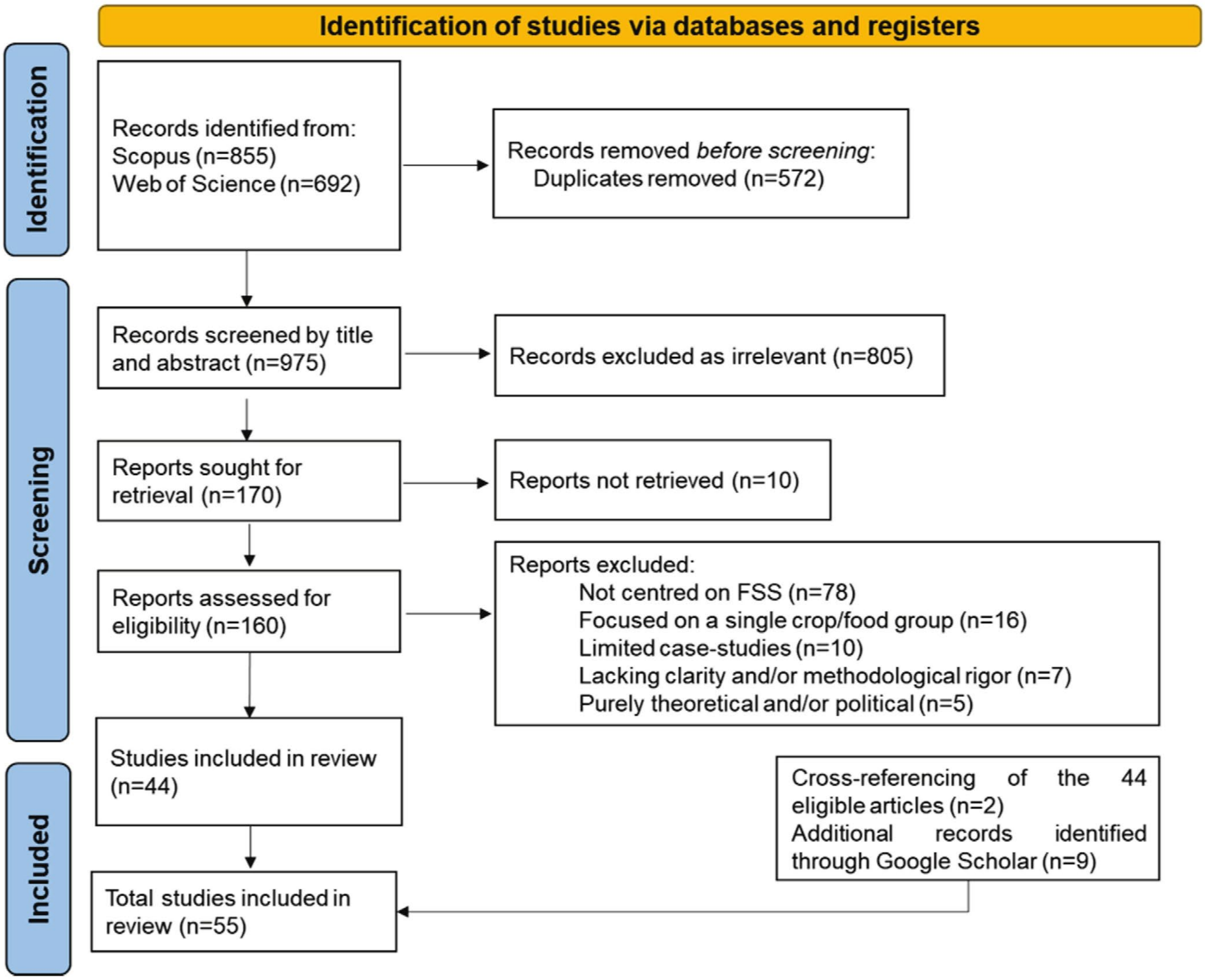

FIGURE 1 | Flowchart of the systematic literature review.

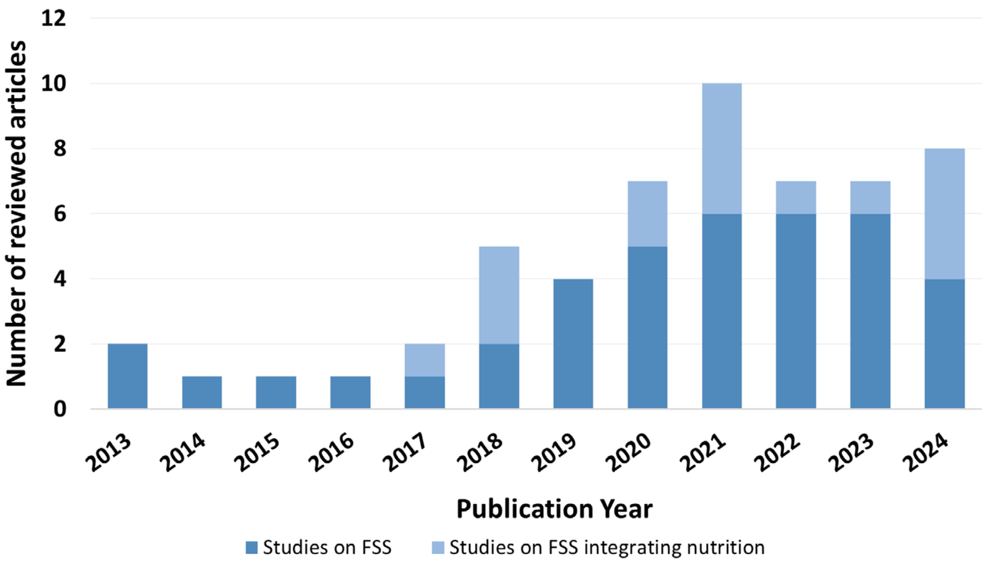

FIGURE 2 | Number of reviewed articles per publication year.

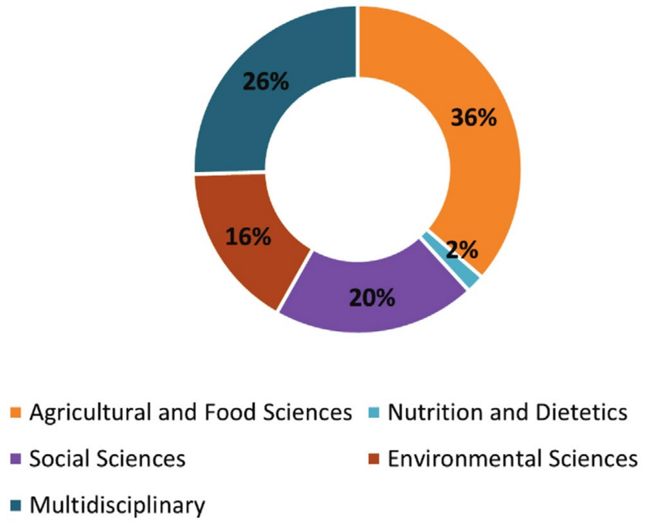

FIGURE 3 | Distribution of the reviewed articles across different subject areas, based on the publishing journals.

Table 1 presents the number of reviewed articles, which are classified according to the aforementioned factors chosen to highlight the key differences in food self-sufficiency studies. Some papers addressed multiple time periods and employed diverse methods to assess food self-sufficiency and were consequently listed under more than one category. For readers interested in retrieving the specific studies within each category, the classification table with full references is provided in the Supporting Information (Table S1). The following subsections, we discuss the similarities, differences, main results, trends, and gaps among studies, grouped by each classification factor.

TABLE 1 | Classification of the food self-sufficiency (FSS) reviewed articles.

Classification factor		Number of papers
Geographic level	Cross-scale (from global and/or world regional to country and/or local levels)	21
	Country and/ or subnational	18
	Local	16
Time frame	Current/short term	31
	Historical/Long term	22
	Future projections	12
Data Sources	Primary	2
	Secondary	42
	Mixed	11
FSS assessment	Volume	22
	Dietary Energy	18
	Agricultural land	9
	Price	1
	Nutrition	16

3.1.1 | Geographic Level

The mix of geographic levels highlights that FSS can be analysed at various scales, each of them offering valuable insights that, when combined, provide a more comprehensive understanding. For example, cross-scale studies employed large datasets (e.g., from FAO and national statistics) and/or models capable to scale up or down the results and are essential to identifying main trends in FSS. Their findings generally highlighted the vulnerabilities of modern food systems and the limited capacity for an 'absolute' FSS across the globe. Indeed, while global FSS is relatively stable and/or sufficient (Beltran-Peña et al. 2020; Porkka et al. 2013), its degree varies significantly between regions and countries (Pradhan et al. 2014; Wassénius et al. 2023), with many becoming increasingly dependent on imports (Schramski et al. 2019). These differences depend on various factors, including low agricultural productivity due to unfavorable natural and climatic conditions, as well as limited resources and other socio-economic factors (Baer-Nawrocka and Sadowski 2019). African and Asian countries showed the lowest levels of FSS, due to a combination of low agricultural productivity, climate change impacts, and rapid population growth (Beltran-Peña et al. 2020; Pradhan et al. 2014; White and Gleason 2022). In view of this, the majority of the studies have emphasized the current and future significance of international trade in fulfilling food demand and fostering global food security. However, the risks associated with heavy dependence on imports have been also well recognized (Porkka et al. 2013; Wassénius et al. 2023), such as discouraging advancements in domestic production, intensifying resource depletion, and promoting unsustainable dietary patterns. When the nutritional dimension was incorporated into the assessment, cross-scale studies corroborated the diversity in results across geographical scales and revealed additional challenges. For instance, Geyik et al. (2020) documented that while total global production can adequately provide the global human population with all nutrients except vitamin A, up to 120 countries are unable to meet their national population's dietary needs through their domestic production. Likewise, Chen et al. (2021) found that despite the overall nutritional adequacy of the total global production, most countries lack sufficient amounts of choline, calcium, polyunsaturated fatty acids, vitamin A, vitamin E, folate, and iron in their domestic food production. High-income countries produce adequate amounts of nutrients in general, while the foods produced in low-income countries, mainly comprising roots and cereal products, often lack in important micronutrients such as choline, calcium, and vitamin B12 (Chen et al. 2021). Those results were confirmed and enriched by White and Gleason (2022), whose global assessment demonstrates that current agricultural systems supply sufficient nutrients to feed the current population except for DHA + EPA and vitamin D. They also found that if the global population were scaled up to 10 billion people (i.e., an estimated future target population), there would be additional calcium, choline and vitamin E deficiencies. Moreover, countries with very low nutritional self-sufficiency are often unable to fully compensate for and overcome their domestic production deficits of key nutrients through international trade alone (Geyik et al. 2021). Geyik et al. (2021) explored the effect of international food trade on the nutritional adequacy of domestic production of 128 countries from 2013 to 2015, and found that it did not substantively improve the nutritional adequacy of most low/lower-middle income countries (~40% of the global population), with particular concerns around vitamin A and B12. This allowed the authors (Geyik et al. 2021) to suggest to policymakers to prioritize domestic production of certain nutrients that their populations lack and that can be produced with the available domestic resources, while selectively benefiting from international trade for others that they are unable to produce domestically. Similar insights were provided also from Wassénius et al. (2023), who comprehensively mapped countries' ability to meet nine key nutritional needs and additionally assessed the relationship between nutritional self-sufficiency and production diversity. Based on their results, most countries meet basic nutritional needs through domestic production, but only a third are absolutely self-sufficient, and the diversity of food production systems varies substantially (Wassénius et al. 2023). Some countries are primarily at risk from trade-related disruptions, since highly dependent on imports, while others, despite high self-sufficiency, face risks from specialization or homogenization (low diversity) (Wassénius et al. 2023).

Country and sub-national studies assessed FSS in the context of their national food policies or consumption patterns, and frequently evaluated transitions over time, often including future projections. They encompassed a diverse range of geographic and economic contexts, including:

- high-income countries: Switzerland (von Ow et al. 2020), UK (Macdiarmid et al. 2018), Scotland (Rathnayaka et al. 2024), Australia (Ridoutt et al. 2017), Russia (Erokhin 2017; Wegren and Elvestad 2018), Canary Islands (Godenau et al. 2020) and the European Alpine Space, for example, the high mountain region spanning the following Central and Western European countries: Austria, Switzerland, Slovenia, France, Germany, and Italy (Pecher et al. 2024).

- upper-middle income countries: China (Liang et al. 2024, 2023; Zhang et al. 2018), Ukraine (Szajner et al. 2024), Iran (Soltani et al. 2020) and Mexico (Galeana-Pizaña et al. 2018; Novotny et al. 2024, 2021);

- lower-middle income countries: India (Damerau et al. 2020; Ritchie et al. 2018), and Bangladesh (Binte Mostafiz et al. 2021; Soma et al. 2023); and

- low-income countries: Burkina Faso (Assogba et al. 2023) and Sudan (Ahmed 2020).

The scope of the studies varied depending on the country, with some focusing on the role of domestic production in ensuring food security, while others addressed specific challenges related to increasing agricultural productivity, improving food distribution, and reducing dependence on imports.

Local and regional studies were found to offer a new perspective on FSS, more closely linked to socio-cultural, environmental, and economic aspects. Indeed, they assessed the potential for local food systems, including urban and peri-urban food systems, to enhance food security and promote sustainable food production. Particularly noteworthy from a methodological perspective was the integration of foodshed analysis with FSS assessment, as evidenced in the works of Zasada et al. (2019), Vicente et al. (2021), Sylla et al. (2022) and Wang et al. (2023). For the first time, Zasada et al. (2019) developed a novel model to assess the metropolitan foodshed, and regional food self-sufficiency of Metropolitan regions, named Metropolitan Foodshed and Self-sufficiency (MFSS). Under this model, the FSS is measured as the ratio between the available and required agricultural area for regional food demand. Thus, a self-sufficiency level (SSL) of 100% would be achieved, when the complete area demand for food production can be covered within the municipal or regional boundaries. The MFSS model was adopted also by Vicente et al. (2021) and Sylla et al. (2022). Wang et al. (2023) use a similar model for assessing the foodshed and FSS in a mega-city region, including an in-depth consideration of different agricultural land types (arable, horticultural, and water), key factors not previously adequately studied. Results from these studies showed that in many urban and metropolitan areas, available agricultural land is insufficient to meet food demand, especially as populations grow or diets become more diverse.

3.1.2 | Time Frame

The studies reviewed covered a range of FSS research, looking at both short-term and long-term perspectives. Short-term assessments were predominant, examining current FSS deficits or improvements and serving as benchmarks for future change. These studies often highlighted gaps between production and demand, suggesting a dependence on imports. However, the specific findings differed depending on the geographic area and the assessment method used. Historical and long-term studies were also common and used historical data and various models/techniques to analyze trends in food production, consumption, trade, and associated FSS levels. Some researchers further incorporated scenario analysis to estimate future levels of FSS. In doing so, they made various assumptions about key drivers of change, such as population growth, climate change, food waste reduction, and dietary shifts. This future-focused analysis allowed these studies to offer policy recommendations for improving food self-sufficiency and promoting more sustainable food systems. These recommendations included:

- investing in agricultural technology and innovation to close yield gaps (Beltran-Peña et al. 2020; Ritchie et al. 2018).
- adopting sustainable water and land management to save water, prevent further land degradation, and sustain long-term productivity (Beltran-Peña et al. 2020; Kriewald et al. 2019; Vicente et al. 2021).
- diversifying production systems, especially in nutrient-dense crops, to reduce reliance on imports, increase resilience to shocks, and improve dietary diversity (Lividini and Masters 2022; Pompeu et al. 2021; Soltani et al. 2020)
- reducing FLW, and improving infrastructures to make food systems more efficient (Damerau et al. 2020; Pradhan et al. 2014; Soma et al. 2023);
- shifting diets towards less resource-intensive foods (i.e., more plant-based) to reduce pressure on the environment and align production with nutritional needs (Ridoutt et al. 2017; Soma et al. 2023).

3.1.3 | Data Sources

FSS research relies on diverse data sources, with the majority of studies utilizing secondary data (Godenau et al. 2020). The latter, such as national and international agricultural, food and trade statistics (e.g., from FAO or national agencies), are indeed easily accessible, standardized, and covering many regions and time periods. Among the others, FAO Food Balance Sheets (FBS) were largely employed. However, these datasets can lack local specificity and may mask subnational or household-level diversity (Godenau et al. 2020; Macdiarmid et al. 2018; Sylla et al. 2022). They also may not provide up-to-date or sufficiently disaggregated information to evaluate rapid changes or socio-behavioral factors (Macdiarmid et al. 2018; Ritchie et al. 2018). Usually, food consumption is estimated from these data by summing production and imports minus the sum of exports, changes in stocks, and non-food uses such as feed use, to obtain the "food available for human consumption". It is important to note that this "food available for consumption" is not a measure of actual intake: we assume that food which reaches the market is consumed in proportion to its availability, although a number of demand-side factors are known to shape real dietary patterns, such as consumer preferences, cultural food habits, affordability and broader market dynamics (Godenau et al. 2020). Other few studies used house-hold surveys (HHS) to measure actual food consumption and dietary patterns at the household level (Giller et al. 2021; Noromiarilanto et al. 2016; Novotny et al. 2021). HHS facilitates the execution of analyses at finer scales, allowing researchers to study specific regions or populations and to capture the heterogeneity in food-consumption behaviour, which may otherwise be masked by aggregate statistics (Godenau et al. 2020; Noromiarilanto et al. 2016). At the same time, they can be subject to errors due to recall bias, under-reporting, and other measurement issues (Noromiarilanto et al. 2016; Reguant-Closa et al. 2025). Differently, authors integrating the nutritional dimension refer to the recommended consumption, rather than the total food available or a population's current consumption patterns. This includes using established guidelines on recommended energy and nutrient intakes in order to determine whether domestic food production is sufficient to meet nutritional requirements. Primary data sources (e.g., those obtained by the authors through surveys, interviews, or field measurements) were rarely used (Assogba et al. 2023; Pan et al. 2024). Whether the use of primary data is feasible strongly depends on the scale. At the household or local level, it can capture context-specific dynamics, such as local agricultural practices and specific consumption patterns, that aggregate statistics tend to mask. On a national or larger scale, instead, collecting primary data across an entire population is generally too resource-intensive and logistically demanding, which likely explains why secondary data sources dominate at that level. In particular, Assogba et al. (2023) carried out structured household surveys targeting local farm households within the specific study region to collect data on household food production, consumption patterns, agricultural practices, and food security status. Similarly, Pan et al. (2024) primarily utilized field surveys and direct measurements to collect primary data on crop yields, land management practices, and other socio-economic characteristics of farming households.

Another approach was using mixed data sources, combining secondary data with targeted primary data, and it allowed researchers to validate secondary data with local realities.

The integration of the nutritional dimension into FSS assessments represents a significant methodological advance, but it also requires more extensive data collection and careful matching. To conduct a nutritional self-sufficiency analysis, researchers need detailed food composition datasets (providing macronutrient and micronutrient profiles for different foods), demographic breakdowns (to apply life-stage-specific nutritional requirements), nutritional requirements, or data on actual dietary patterns, and sometimes even factors on nutrient bioavailability (especially on indispensable amino acids, iron, and zinc (Smith et al. 2021)). This added complexity introduces new challenges and a possible greater degree of uncertainty.

Some of the most cited issues comprise:

- *Classification and aggregation issues*: Production statistics are typically reported by broad food commodity groups, whereas food composition databases may classify items more specifically (by species, subspecies or food type), as nutrient content can vary widely based on these aspects. To deal with this, it is often necessary to aggregate or average the nutrient content of different subspecies or foods within a commodity group. This has been done either by simple averaging or by weighting according to actual consumption or purchasing patterns in the country. A significant methodological advancement in this field was introduced by Smith et al. (2016), who developed the Global Expanded Nutrient Supply (GENuS) model by expanding FAO's 98 broad food categories into 225 individual food items and matching them to regional FCDBs.
- *Variability in food composition and data gaps*: the nutrient content of food varies by region, climate, season, agricultural practices, post-harvest handling, and food composition datasets may be incomplete or unrepresentative of domestic food quality (for instance, missing local varieties and traditional foods that are frequently consumed in high quantities or provide a large proportion of particular nutrients).
- *Accounting for FLW*:
    - Assessing FSS requires translating production quantities into the food actually available for consumption. Between food production and consumption, food is lost or wasted at multiple stages of the supply chain. Not accounting for such losses can inflate the apparent consumption and overestimate the nutrients available to populations. In our review sample, the majority of the studies do not correct for FLW at all, either explicitly acknowledging the lack of relevant data as the main reason or implicitly by not mentioning any adjustment; some studies relied on regional estimates based on FAO (2011) report on global food losses and waste, which provides commodity-specific waste percentages broken down by supply chain stage and world region; and only a smaller set of studies used country-specific food waste data. Where FLW corrections are applied, they are typically applied to food mass rather than to nutrients: a percentage is subtracted from the production quantity, and the remaining mass is then converted into nutrients using food composition tables. This approach assumes that the lost portion has the same nutrient profile as the edible product, which is rarely the case. The waste may consist of peels, shells, bones (and similar fractions) which can be either more or less nutrient-dense depending on the food item, and the nutrients considered. Despite the high uncertainty of FLW data, no sensitivity analyses that evaluate the effect of varying FLW coefficient on food consumption/nutrient availability estimates were found in the literature.

Based on the above, the use of mixed data, integrating macro-level and micro-level information, is recommended to enhance the reliability and relevance of the assessment. Furthermore, careful considerations are needed when integrating the nutritional dimension, with major attention to data aggregation, matching, and gap filling, and re-examination of data quality of both consumption and waste figures.

3.1.4 | FSS Assessment

Each FSS assessment method has strengths and limitations:

- Volume-based FSS is simple and relies on readily available data. However, it fails to capture nutritional quality and needs. For this reason, we suggest this method only for baseline and preliminary assessments, or when data on dietary energy or nutritional composition is limited.
- Energy-based FSS can reveal potential caloric self-insufficiency, but it does not reveal gaps in micronutrients supply. Moreover, it may inadvertently favor high-calorie staple crops while neglecting the contribution of nutrient-dense foods.
- Price-based FSS provides insights into food security from an economic perspective (Godenau et al. 2020). However, it is sensitive to price fluctuations and does not integrate nutritional aspects. Godenau et al. (2020) is the only reviewed study to incorporate this aspect and measured self-sufficiency in the Canary Islands across three parallel metrics (volume, dietary energy, and economic value based on annual retail prices). Results diverged significantly by metric: 52.4% by volume, 29.6% by energy, 35.3% by economic value. The higher rate by volume was mainly due to the high-water content of locally produced fresh fruits and vegetables as well as the water added during processing of imported food inputs, while the lower energy-based and price-based ratios reflected the concentration of calorie-dense and higher-value products in imports.
- Land-based FSS incorporates spatial and environmental dimensions of food production. However, it can oversimplify the complexity of food systems by focusing just on land area, is highly dependent on the yield assumptions and data fed into the model, and does not address nutritional adequacy (Zasada et al. 2019).
- Nutrition-based FSS marks a significant advance by directly linking FSS to nutritional adequacy, and providing a more holistic measure of food security (Wassénius et al. 2023). However, it requires more data and is methodologically complex (Smith et al. 2021)

In terms of results' variations, global volume/energy-based metrics generally indicate that the world can produce enough quantities of food, or sufficient calories to meet present energy needs (Beltran-Peña et al. 2020; Porkka et al. 2013). Land-based studies at the global and/or regional level demonstrate that, while there is theoretically enough agricultural land, its distribution is strongly uneven, and environmental sustainability becomes a limiting factor for future land use expansion (Pecher et al. 2024). Indeed, food systems already exert significant impacts on land use, and it would be preferable to pursue increases in food self-sufficiency within the existing utilized agricultural area rather than through land expansion (Pecher et al. 2024). Proposed strategies include changes in cropping patterns or partial intensification, although intensification also raises environmental concerns (Pecher et al. 2024). Nutrition-based studies reveal that most countries (including many low-income and import-dependent regions) face significant shortfalls in the domestic production of key nutrients/food groups, and they may be unable to entirely compensate for these gaps through international trade (Geyik et al. 2021). Other studies, although not belonging to the nutrition-based FSS group, evaluated the effects of dietary shifts scenarios on FSS. For example, the potential effects on FSS of diets that reduce meat consumption and include more plant-based foods (Soltani et al. 2020), vegetarian diets (Sylla et al. 2022), and diets that rely solely on domestic consumption (Zasada et al. 2019) have been studied.

Across the different FSS methods, we argue that land-based and even more nutrition-based assessments represent methodological advancements over conventional approaches. Indeed, the former are increasingly relevant in the context of sustainability and climate change, and the latter are transformative in their own nature by aligning the assessment of self-sufficiency with public health objectives. In addition, given that the economic dimension remains also largely underexplored, a new frontier could be the integration of nutritional and economic and/or price-based indicators to identify tradeoffs between nutritional adequacy and the economic cost of domestic food.

3.1.5 | Nutritional and Dietary Aspects in FSS

The nutritional and dietary dimensions of food self-sufficiency were addressed in the literature through several related but distinct concepts, such as nutritional adequacy (NA), nutritional self-sufficiency (NSS), dietary quality, and healthy diets. To avoid confusion, we clarify these terms in Table 2.

Among the others, NA was the key way and/or metric through which the reviewed studies integrated the nutritional dimension, and identified, for each context, the nutrients whose domestic production should be encouraged and those for which imports remain essential to meet requirements (Chen et al. 2021). Table 3 provides a summary of the main methodological aspects (e.g., whether NA or other indicators were measured, the nutrients accounted for, and other choices) and key results from studies integrating the nutritional and dietary aspects.

A first finding is the considerable variation in terms of number of nutrients considered by the different authors, which ranged from 2 (protein and fat) to 23, as in the case of Damerau et al. (2020) and Chen et al. (2021). These latter studies have expanded the nutrient profile considerably, which is undoubtedly a positive development as it enables us to grasp micronutrient shortfalls which would have been otherwise invisible. The list of nutrients varied considerably across the 15 studies:

- Protein was included in nearly all studies (14), followed by energy, vitamin A, folate (B9), iron, and zinc (11), and vitamin B12 (10).
- Calcium and vitamin C appeared in roughly half of the studies (8), followed by fat, vitamin B2, and vitamin B6 (7).
- Fiber, potassium, selenium, vitamins E and K, and carbohydrates were captured in only 4 studies, and manganese in 3.
- Vitamin D, choline, omega-3 fatty acids (EPA/DHA/ALA/LA), PUFAs, and vitamin B5 were each included in only 2 of 15 studies, and iodine was the least represented nutrient overall, appearing only in Atzori et al. (2024)

It is noteworthy that some of the underrepresented nutrients are ones with well-documented and widespread dietary inadequacy, and for which import dependence can be quite high in some contexts. For instance, this applies to nutrients

TABLE 2 | Concepts and terminology from studies integrating nutritional and dietary aspects into FSS.

Key concepts	Definition
Nutritional Adequacy (NA)	The extent to which food nutrient supply meets population-level nutrient requirements. NA can be assessed either on total food supply (domestic production plus imports) or on domestic production alone.
Nutritional Self-Sufficiency (NSS)	NA is assessed with respect to domestic production alone. In the reviewed studies, NSS was also computed by some authors as an aggregated score, measuring the overall extent to which domestic production meets multiple population nutrient requirements or food groups (Wassénius et al. 2023; Ridoutt et al. 2017)
Dietary Quality	Diet quality is a multidimensional concept linked to health outcomes, which entails both nutritional adequacy, food groups diversity, and the moderation of some components (foods, nutrients or other compounds) which are linked to detrimental health effects (e.g., sodium, added sugars, saturated fats, etc.). In the reviewed papers, it was assessed via indices such as the Alternative Healthy Eating Index (AHEI) (Damerau et al. 2020)
Healthy Diets	Different definitions of healthy diets exist. FAO & WHO (2024) defined them as diets that are adequate, diverse, balanced and moderated. In most countries, the national healthy diet is operationalised through food-based dietary guidelines. In the reviewed papers, healthy diets were conceived as diets with high AHEI (Damerau et al. 2020) or indeed diets adherent to national dietary guidelines (Ridoutt et al. 2017) or more broadly as nutritionally adequate and diversified diets.

TABLE 3 | Summary of studies integrating the nutritional/dietary dimension.

References	NA	Other indicators	Key methodological aspects	Main results
Geyik et al. (2020)	✓		6 nutrients (Energy, Protein, Vitamins A, B9, B12, Iron, Zinc); 7 food groups; age- and sex-specific daily recommended nutrient intakes with further adjustments for demographics, mineral bioavailability, and physical activity.	While global production can adequately provide nutrients except vitamin A, up to 120 countries have inadequate domestic production, highlighting uneven global nutrient access and hidden hunger risks.
Chen et al. (2021)	✓	Population Share with Adequate Nutrients (PAN)	24 nutrients (Energy, Protein, Fiber, PUFAs, Vitamins A, C, B1, B2, B3, B5, B6, B9, B12, E, K, Choline, Calcium, Copper, Iron, Magnesium, Manganese, Phosphorus, Potassium, Selenium, Zinc); 11 food groups; age- and sex-specific daily recommended nutrient intakes.	Despite adequate calorie production in most countries, domestic production of choline, calcium, and vitamin A is often inadequate in most countries, as well as the domestic production amounts of PUFAs, vitamin B9, and iron barely meet their respective requirements.
Geyik et al. (2021)	✓		6 nutrients (Energy, Protein, Vitamin A, B12, B9, Iron, Zinc); 8 food groups; age- and sex-specific daily recommended nutrient intakes; Values less than 1 indicate inadequate supply, further classified as: low adequacy (0.85–1.0), and very low adequacy (< 0.85).	Higher-income countries achieve adequate nutrition through domestic production and imports, while most low-income countries remain nutritionally deficient despite trade participation. Global nutrient flows mainly occur among middle and high-income countries, leaving lower-income countries relying heavily on cereal imports from few trade partners.
White and Gleason (2022)	✓		23 nutrients (Energy, Protein (total and essential amino acids), Fats (EPA, DHA, ALA, LA fatty acids), Vitamins A, B1, B2, B3, B4, B6, B9, B12, C, D, E, K, calcium, copper, iron, magnesium, potassium, phosphorus, selenium, zinc); 11 food groups; age- and sex-specific daily recommended nutrient intakes.	Agricultural systems can theoretically provide enough nutrients to feed 10 billion people, except for calcium, choline, DHA + EPA, vitamins B4, D, E. Even where production is adequate, distribution barriers, trade flows, and within-country disparities lead to segments lacking essential nutrients
Wassénius et al. (2023)	✓	Nutritional Self-Sufficiency score (NSS); Food Diversity metrics (taxonomic diversity, and H-index)	9 nutrients (Carbohydrates, Protein, Fat, Vitamins A, B9, Calcium, Iron, Zinc, and a Proxy Category for other micronutrients) (e.g., Fruits and vegetables (400 g/day)); 8 food groups; average adult daily requirements for each nutrient; the total NSS ranges from 0 to 9, indicating how many nutrient sufficiency levels are fulfilled by domestic production; taxonomic diversity measures the total number of different food items produced, and H-index reflects how many of those items each contribute to calories in the national diet.	While 127 countries (87% of the global population) achieve high potential self-sufficiency (≥ 6 nutrients), only 41 countries (33.5% of the population) are fully self-sufficient. Fruit and vegetable production are often lacking in self-sufficient nations.

(Continues)

TABLE 3 | (Continued)

References	NA	Other indicators	Key methodological aspects	Main results
Atzori et al. (2024)	✓		15 nutrients (Vitamins A, B1, B2, B6, B9, B12, C, D, E, K, Copper, Iodine, Iron, Selenium, Zinc); 8 food groups; nutrient intakes also for particular subgroups, i.e., under-five children and the adult population.	94% of Small Island Developing States (SIDS) fail to meet recommended thresholds for key food groups and none meet the recommended intake for all the micronutrients, with large regional disparities resulting in both undernutrition and overnutrition.
Macdiarmid et al. (2018)	✓		13 nutrients (Energy, Protein, Fat, Saturated Fat, Carbohydrates, Free Sugars, Fiber (Non-Starch Polysaccharides, NSP), Vitamins A, B12, B9, C, Calcium, Iron, Zinc); 14 food groups; age- and sex-specific daily recommended nutrient intakes in each year to take account of demographic changes over time; both lower limit (required) and upper limit (for nutrients where excess is undesirable).	The UK's food supply ensures national-level adequacy for most nutrients, but not for fiber and carbohydrates. Reliance on imports for some critically important micronutrients (iron, zinc, vitamins A, and C) remains significant. Diversity has increased (due to imports), but domestic production for fruit and vegetables is proportionally very low.
Ritchie et al. (2018)	✓		3 nutrients (Energy, Protein, Fat); protein content was adjusted for protein quality using FAO digestibility factors; 6 food groups; metrics have been normalised to average per person per day availability using UN population figures and prospect data; the assumed distribution of supply of each macronutrient using the FAO's preferred log-normal distribution and India-specific coefficient variation (CV) factor of 0.26 was estimated.	India cannot achieve food and nutritional self-sufficiency for its population through domestic production and efficiency improvements alone. Even under the most ambitious self-sufficiency scenarios, the majority of the population would remain at risk of malnutrition.
Damerau et al. (2020)	✓	Alternative Healthy Eating Index (AHEI)	24 nutrients (Protein, Fat, Carbohydrates, Fiber, Vitamins A, C, E, K, B1, B2, B3, B5, B6, B9, B12, Choline, Calcium, Copper, Iron, Magnesium, Manganese, Potassium, Selenium, Zinc); 12 food groups; Requirements adjusted by sex/age, using household survey and global dietary databases, and EARs for adequacy; AHEI is used as dietary quality index directly linked to disease risk.	India actually faces significant micronutrient gaps and a low AHEI, but shifting current food systems toward the modeled optimized supply would markedly improve both nutritional adequacy and health benefits, while improving environmental sustainability.
Rathnayaka et al. (2024)		Nutritional Supplies	Volume-based food self-sufficiency was accompanied by the calculation of the per capita annual supply of 3 nutrients (Energy, Protein, Fat) from each food group; 4 food groups; per capita calculations are based on the total Scottish population each year, without distinction between subgroups.	Scotland exhibits high to very high self-sufficiency levels in barley, oats, potatoes, lamb, beef, dairy, and eggs. While the study does not directly measure nutritional adequacy, the high supplies of energy, and macronutrients from key food groups suggest a strong contribution toward dietary requirements.

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TABLE 3 | (Continued)

References	NA	Other indicators	Key methodological aspects	Main results
Pompeu et al. (2021)	✓		20 nutrients (Energy, Protein, Carbohydrates, Fiber, Vitamins A, B1, B2, B3, B6, B9, B12, C, Calcium, Copper, Iron, Magnesium, Manganese, Phosphorus, Potassium, Zinc); 62 crops and 5 animal products; age- and sex-specific daily recommended intakes, also projected to 2060.	Brazil's domestic agricultural production is more than sufficient to meet current and future calorie and nutrient needs from a production standpoint, providing very high nutritional adequacy for almost all nutrients and population groups. However, diets highly restricted in animal products require specific attention to vitamins B12 and A.
Ridoutt et al. (2017)		Nutritional Production Sufficiency Index (NPSI)	For each food group, the Nutritional Production Sufficiency Index (NPSI) is computed as the ratio of domestic production to domestic demand, and the resulting value is capped at 1 to indicate full self-sufficiency. The six capped scores are then summed, yielding a total NPSI that can vary between 0 (no domestic production of any food group) and 6 (domestic production meets or exceeds domestic demand for all six food groups). The design of the NPSI recognizes that excess supply of one food group does not substitute for deficit in another in a complete diet.	While Australia has historically benefited of strong nutritional self-sufficiency, it is now on a trajectory of modest but steady decline. By 2050, vegetable demand would significantly increase following the Australian Guide to Healthy Eating and domestic production would satisfy only ~62% of that need. Similar shortfalls are projected for grains and seafood.
Zhang et al. (2018)		Support Capacity, and External Dependence	3 nutrients (Energy, Protein, Fat); protein adjusted for quality; multiple foods across two main categories, that is, vegetable foods, and animal foods; "Support capacity" was calculated as population that can be fed by the available energy, protein, super protein and fat; "External dependence" was calculated as the share of the population whose nutritional needs are met by imported foods.	China achieved self-sufficiency only after 2007; before then, significant portions of the population had inadequate intake of protein, superior protein, and fat. Imports were key for meeting nutrition goals, especially for fat and high-quality protein.
Novotny et al. (2021)	✓	PAN	14 nutrients (Energy, Protein, Vitamins A, B2, B3, B6, B9, B12, C, Calcium, Iron, Magnesium, Phosphorus, Zinc); local food groups, including MILPA; total nutrients produced were divided by total annual population requirements, expressed as % of population served per nutrient.	Milpa systems produced more volume of food per area compared to the other systems. The milpa also produced all the nutrients and vitamins (except for B12) required to feed at least 2 persons ha-1. Monocultures of maize lacked vitamins A, B9, B12, and C, and the common bean lacked vitamins A, B12, and C. However, decreased labor, crop yield limitations, and declining use of diversified cropping threaten food and nutritional self-sufficiency.
Novotny et al. (2024)	✓		13 nutrients (Energy, Protein, Vitamins A, B2, B3, B6, B9, B12, C, Calcium, Phosphorus, Iron, Magnesium, Zinc); local individual crops and mixed systems; daily recommended nutrient intakes only for adults (31–50 age).	Nutritional self-sufficiency for energy, protein, and most micronutrients can be achieved with current production systems, primarily by maintaining or optimizing diverse cropping systems such as MILPA, but additional interventions are needed to ensure sufficiency for vitamins A and C.

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TABLE 3 | (Continued)

References	NA	Other indicators	Key methodological aspects	Main results
Cui et al. (2024)	✓		3 nutrients (Carbohydrates, Protein, Fat); A distinction for high-quality protein was made; 9 food groups; age- and sex-specific daily recommended nutrient intakes.	While total local food production in the Urumqi Metropolitan Area (UMA) can for now meet caloric needs, food self-sufficiency in terms of balanced nutrition and diversity is insufficient and declining, because of rising nutritional needs, changing diets, and slow adaptation of food production system.

Note: References in orange, blue, and green are cross-scale, national and subnational, and local studies, respectively.
Abbreviation: NA, nutritional adequacy.

found mainly in marine fish (iodine, EPA and DHA, vitamin D), which landlocked countries cannot produce domestically, or nutrients primarily found in animal products (vitamin D, choline), whose domestic availability is shaped by the scale and productivity of national livestock sectors. Fiber's low representation is also unexpected given its commonly inadequate intake and the global consensus on its essential role in healthy diets (Veronese et al. 2025).

Beyond the number and types of nutrients included, also nutrient quality is important. Only a few studies (4, in total) have corrected mineral and protein content for their digestibility and bioavailability, respectively. Protein quality, in particular, would need more investigation, especially when protein supply comes mainly from plant-based sources. Similarly for fats, the distinction between saturated, monounsaturated, and polyunsaturated fatty acids is quite relevant for health (Garnås 2025), but the majority of the studies considered just total fat content. With regard to nutritional recommendations, instead, most of the studies were consistent in weighting requirements based on the distribution of age and sex of the population. Macdiarmid et al. (2018) further differentiates between lower limits (required) and upper limits (for nutrients where excess is undesirable).

Another relevant aspect regards the aggregation of the multiple nutrient adequacy ratios into a single metric/score. This has been done in our review sample only by Wassénius et al. (2023), who proposed the nutritional self-sufficiency (NSS), ranging from 0 to 9, indicating how many of the nutrients sufficiency thresholds are exceeded by domestic production. If the national production exceeded the sufficiency limits for each of the nine nutrients, the country would receive a score of nine; if production exceeded the limits for eight nutrients, the score would be eight, and so on. The NSS was then divided into four ordinal categories, based on thresholds at 3, 6, and 9 nutrients fulfilled. Two major limitations of this approach deserve attention. The set of nutrients is limited to 8, plus "fruit and vegetables" used as a proxy for other micronutrients, whereas many other essential nutrients of public health importance are not accounted for. Thus, a country may score high while remaining dependent on imports for nutrients not included in the assessment. In addition, the thresholds that define low, medium, high, and complete self-sufficiency are not set based on any dietary or health-based evidence. Future NSS assessments would benefit from improved aggregation methods, drawing on methodological choices established in the broader nutrient profiling literature (Fulgoni et al. 2009; Reguant-Closa et al. 2024). These may include averaging nutrient adequacy ratios into a composite score rather than relying on a simple count of thresholds met, as well as two further methodological choices (Green et al. 2023): capping nutrients supplied in excess (adequacy ratio > 1) so that surpluses in one nutrient cannot offset shortfalls in others, and weighting nutrients according to their national/regional health relevance (for instance, considering whether they are usually deficient, or overconsumed) rather than treating all of them as equally important. Green et al. (2023) show that such methodological choices can substantially affect the resulting adequacy assessment, and the same logic applies directly to NSS.

From Table 2, it is also possible to note that few authors utilize additional indicators, such as the Population Share with Adequate

Nutrients (PAN) (Chen et al. 2021), the AHEI index (Damerau et al. 2020), and food diversity metrics (Wassénius et al. 2023). The PAN was computed by following a population-weighted estimated average requirement (EAR) "cut-point" approach, which assumes a lognormal distribution of per capita available nutrient levels within a country constructed by the mean per capita produced amount and the coefficient of variation (CV) of each nutrient (Chen et al. 2021). The AHEI score is based on total intakes of vegetables, fruit, whole grains, sugar-sweetened beverages, nuts and legumes, red and processed meat, trans fats, long-chain ω–3 fatty acids, polyunsaturated fatty acids, sodium, and alcohol. Greater adherence to the AHEI is associated with a lower risk of several non-communicable diseases, and it was used to assess current and future dietary quality from domestic production (Damerau et al. 2020). Taxonomic diversity and production diversity (H-index) were used instead to measure the food production diversity (Wassénius et al. 2023) and disclose the benefits and/or risks for countries when they produce many and diverse foods or concentrate production on a relatively limited set of foods.

In terms of results, the reviewed studies documented that the nutrients most commonly not provided sufficiently by domestic production are calcium, choline, PUFAs, vitamin A, vitamin E, folate (vitamin B9), iron, and B12. Generally, low-income and lower-middle-income countries face the most severe nutritional deficits, often lacking multiple micronutrients simultaneously, while higher-income countries typically achieve adequate availability of nutrients through a combination of domestic production and significant imports. However, they can have structural gaps in domestic production of key food groups, most commonly fruit and vegetables.

Interestingly, five studies investigated nutritional self-sufficiency under future scenarios, each focusing on different nutrients, food groups, and geographic contexts. Ritchie et al. (2018) assessed India's domestic capacity to meet macronutrient needs (calories, digestible protein, and fat) in 2011, projecting to 2030 and 2050. Scenarios varied supply-chain food losses and crop yields while keeping diets constant. Even the most ambitious scenario left 62% and 56% of the population below caloric and protein requirements by 2050, leading the authors to recommend complementing domestic production with trade and diversifying diets away from carbohydrates.

Damerau et al. (2020) also focused on India but adopted an optimization approach that maximizes national supply of 20 minerals and vitamins under regional land and water constraints across five agroclimatic zones and 36 crops. They found that India has the resource capacity to meet or exceed micronutrient requirements, but only if 77% of cropland and 85% of irrigation water currently allocated to cereals are reallocated toward legumes, vegetables, fruit, and nuts. In Australia, Ridoutt et al. (2017) examined food-group self-sufficiency from 1995 to 2050 by computing a Nutritional Production Sufficiency Index (NPSI) that compares domestic production to domestic demand for six essential food groups: vegetables, fruits, dairy products, proteins, grains, and oils. The NPSI declines from 5.93 to 4.86 by 2050, with vegetable and seafood production covering only 62% and 20% of demand, respectively. Similarly, Cui et al. (2024) evaluated the gap between locally produced food and residents' consumption of calories and macronutrients in the Urumqi Metropolitan Area in northwestern China from 2000 to 2020. Total caloric production met demand throughout, but macronutrient gaps widened over time, with fat and protein shortfalls reaching 104.6% and 43.1% of consumption by 2020. Finally, Pompeu et al. (2021) analyzed Brazil's self-sufficiency for calories, macro- and micronutrients from 1988 to 2017 and projected to 2060 under four diet scenarios: business-as-usual, no beef, lacto-ovo vegetarian, and vegan. They found that Brazil produced enough calories to feed on average 115% of its population, and that 2017 agricultural land without expansion remains sufficient to feed 105% of the projected 2060 population under current dietary patterns. Under a vegan scenario, only 14.5 Mha would be needed (approximately 5% of the actual land used for agriculture), although the analysed crops are nutritionally poor both in vitamin A and B12. Across these five studies, the metric of nutritional adequacy varies as well as scenario assumptions. Nevertheless, with the exception of Brazil, projected adequacy tends to decline under business-as-usual scenarios, as population growth and dietary patterns push demand beyond projected production. In particular, studies that hold dietary patterns constant and test only supply-chain loss reductions and yield improvements, specifically Ritchie et al. (2018) and Ridoutt et al. (2017), project nutritional shortfalls that cannot be closed without dietary or trade-based adjustments. By contrast, studies that incorporate structural changes such as dietary and cropping systems' changes, specifically Damerau et al. (2020) and Pompeu et al. (2021), find that current resource bases can sustain or improve nutritional adequacy.

4 | Future Directions

Based on the findings, gaps and opportunities identified in this review, we outline a research agenda for the field of food self-sufficiency, organized by priority area:

- *Data quality of food consumption and food composition databases:* Most nutritional self-sufficiency assessments rely on food balance sheets, which estimate availability, but they do not capture what populations actually eat. Household surveys provide direct consumption data and can capture heterogeneity in food-consumption behaviour masked by aggregate statistics, but they are often restricted in geographic scope and frequency and are subject to recall bias and under-reporting. Integrating these two data streams, for example by using household surveys to validate or disaggregate food balance sheet estimates, may combine the strengths of each while mitigating their respective weaknesses. Whether the main data source is food balance sheets or household surveys, researchers need to consider FLW, which are typically either ignored or based on regional estimates rather than country-specific data. In the near term, incorporating the best available FLW estimates while assessing uncertainty through sensitivity analyses can improve reliability; in the longer term, investment in primary data collection on food loss and waste at the food-commodity and nutrient level is needed. Moreover, applying consistent rules for aggregating and matching production categories to composition data and expanding food composition databases to include local and/or traditional food items would also reduce uncertainty that currently affects most nutritional self-sufficiency assessments.

- *Geographic contexts to be prioritized:* Future nutritional self-sufficiency assessments should prioritize underrepresented regions, such as Sub-Saharan Africa, Central Asia, and the Middle East. Within these regions, large and diverse countries warrant particular attention, as national-level assessments mask critical sub-national heterogeneities in domestic production capacity and import dependence.
- *Methodological improvements for nutritional self-sufficiency:* Future studies should expand the number of nutrients evaluated and select nutrients of public health importance for the target population. In addition, besides assessing the single nutrients' adequacy, researchers can compute composite nutritional indicators, in line with nutrient profiling frameworks (Celorio-Sardà et al. 2026), to capture the overall level of nutritional self-sufficiency. Also, a more consistent application of nutrient bioavailability and/or digestibility factors is needed.
- *New research frontiers:* The reviewed studies have advanced from volume and energy-based metrics toward nutrient adequacy assessment. A further step would be to evaluate whether domestic production supports overall dietary quality rather than individual nutrient sufficiency alone. Integrating dietary quality indices such as the AHEI with production diversity metrics such as the Shannon index and H-index could provide a more holistic picture of food system resilience. Integrating price-based self-sufficiency indicators with nutritional ones would reveal misalignments between the economic and nutritional dimensions of domestic food production, identifying cases where high economic self-sufficiency masks nutritional gaps or where nutritional adequacy is achieved despite low monetary value of domestic output. Finally, while some studies have begun incorporating future projections, most nutritional self-sufficiency assessments remain static. Future research should integrate demographic projections, dietary shifts, and trade dynamics to assess how nutritional self-sufficiency evolve under changing conditions.

5 | Conclusions

The present review has achieved its principal objective of critically evaluating the current literature on food self-sufficiency. It examined the multiple dimensions of FSS, the methods by which it is assessed, and its relationship to food security and nutrition. We found that when FSS integrates the perspectives of nutrition and diet, it offers much more comprehensive, in-depth and useful insights.

Domestic production and food trade both play a key role in ensuring food security and nutrition, and in most cases a combination of both may lead to the most beneficial results, whilst always keeping in mind sustainability constraints. Among other factors, population growth, rising food demand, dietary changes, and environmental constraints represent the most significant threats to nutritional self-sufficiency. This situation calls for the rapid implementation of appropriate adaptation and mitigation measures. In this regard, the articles under review proposed a range of actions to be implemented at all levels, from agricultural production to consumption habits and food waste management, with the objective of achieving higher levels of food security and nutritional self-sufficiency. The FSS field still offers many opportunities for the expansion and deepening of existing research to provide governments, policymakers, and other food systems stakeholders with a more reliable and comprehensive set of data as well as indicators on which to base their decisions.

Author Contributions

Silvia Zingale: conceptualization, methodology, data curation, data analysis, visualization, and writing – original draft. **Barbara Walther:** conceptualization, methodology, writing – review and editing. **Albert von Ow:** conceptualization, methodology, writing – review and editing. **Thomas Nemecek:** conceptualization, methodology, writing – review and editing, supervision.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated in this review are included in this published article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Classification of the reviewed articles, with corresponding references.