Multidimensional Food Security Index: A Comprehensive Approach

Abstract

The major challenge in measuring food and nutrition security is to provide policymakers with a single comprehensive measure that is valid, reliable, comparable over time and space, and captures all various elements of food security. Several indicators have been developed for this purpose. However, most of these indicators appear to be limited in capturing all aspects of food and nutrition security, and a comprehensive approach to this measurement requires further investigation. This study introduced a multidimensional food security index for this debate. This index was applied using survey data from 1832 households in Burkina Faso. The study concludes that policymakers should avoid using the easiest and incomplete approaches in measuring food and nutrition security if they expect to know the real situation on the ground.

Key Words: Food security, measurement, multidimensional index, Burkina Faso

1. Introduction

"The major challenge in measuring food and nutrition security (FNS) is to provide policymakers with a single comprehensive measure that is valid, reliable, comparable over time and space, and captures all the various elements of food security" (Maxwell et al., 2013; Wilkinson, 2016). This is crucial for tackling the current complex problems of the FNS that require adapted indicators (Jiren et al., 2020). "Indeed, rapid urbanization and economic and population growth in low- and middle-income countries have increased the pressure on food systems to supply sufficient and healthy food" (Perry et al., 2018). "However, the governance of food security, which refers to how food availability, access, utilization, and stability are managed, often leads to the choice of partial indicators" (Iese et al., 2017; Iese et al., 2018). "Hence, achieving food and nutrition security is currently much more complicated than having sufficient food available" (Meijl et al., 2020).

"The literature organizes FNS indicators around quantity (caloric intake), quality, vulnerability and risks, and fluctuations and trends in consumption over time" (Maxwell et al., 2013). This has revealed four main points in the evolution of the concept of food security and the underlying measurement indicators. First, in the 1970s, most food security indicators focused on food consumption. Caloric intake was the reference point for assessing the level of food (in) security achieved by individuals or households. However, this did not address other aspects of food security, and caloric intake was time consuming, expensive to measure, and only used in basic research (Maxwell et al., 2013). Second, with increasing health issues pertaining to food consumption (obesity, stunting, micronutrient deficiency), the quality of food security comes into play (Maxwell et al., 2013). As food quality includes dietary diversity and micronutrient sufficiency, the focus was on how to guarantee sufficient quantity and quality food to individuals and households. This is a qualitative measure of food consumption, reflecting access to a variety of foods and an adequate intake of micronutrients (Martin-Prével et al., 2015). Third, with worsening environmental issues, capturing FNS entails integrating the increasing climate extremes (droughts, floods, and increasing heat) with their impacts on food access, availability, and utilization over time (Schmidhuber & Tubiello, 2007). Climate extremes create vulnerability and riskier situations among individuals, households, communities, and nations, leading to the concept of resilient food systems (Tendall et al., 2015). Fourth, with the increasing social and political crises, FNS challenges have moved to how to ensure quantitatively and qualitatively sufficient food overtime and when socio-political crises occur.

The literature distinguishes between several food and nutrition security metrics. The first is dietary metrics (Martin-Prével et al., 2015; Kummu et al., 2020; Veger et al., 2020) and food frequency (Maxwell et al., 2013). This type of metric captures the number of different types of food and food groups that people frequently eat. This results in scores that represent the diversity of intake but not necessarily the quantity, although such scores have been shown to be significantly correlated with caloric adequacy measures (Coates et al., 2007). For example, dietary indicators include simple food group indicators (FGIs) (Arimond et al. 2010). Specifically, there is a Household Dietary Diversity Score (HDDS) (Galiè et al., 2019), Minimum Dietary Diversity (MDD) (Chakona & Shackleton, 2017), and women's Dietary Diversity Score (WDDS) (FAO, 2011). HDDS, MDD, WDDS and MDD for women (MDD-W) are good proxy indicators of diet and approximately comparable across different contexts and over time (Verger et al., 2020).

The second is spending on food as a metric of FNS (Maxwell et al., 2013). "Given that a high propensity of people close to poverty spends a greater proportion of their income on food, estimating the proportion of expenditure on food has become an important measure" (Smith et al., 2006).

Third, consumption behavior is a metric of the FNS (Herforth & Ballard, 2016). "These measures indirectly capture FNS through food consumption behavior. An example is the coping strategy index (CSI) (Maxwell & Caldwell, 2008), which counts the frequency and severity of behaviors in which people engage when they do not have enough food or money to buy food". There is also the "reduced-CSI," which is widely used, but it tends to measure only less-severe coping behaviors.

The fourth category includes anthropometric indicators (de Haen et al., 2011; Ghattas, 2014). "Anthropometric indicators included stunting (low height-for-age), underweight (low weight-for-age), and wasting (low weight-for-height) to measure nutritional outcomes at the individual level. They have the advantage of being universal" (Svedberg 2011). However, they do not include specific nutrients that may be deficient.

The fifth is experience-based food security scales (Ghattas, 2014; Vilar-Compt et al., 2017; Maitra, 2017; Galiè et al., 2019) or food security experience scales (Larson et al., 2019), which measure the 'access' component of FNS. "The Household Food Insecurity Access Scale (HFIAS) is the best-known and most used measure in international contexts (it captures the behaviors of households with insufficient food quality and quantity and with anxiety over insecure access). The household hunger score (HHS) is derived from HFIAS as a culturally-invariant subset of three specific questions which are psychological in nature" (Deitchler et al., 2010). "However, experience-based measures of food insecurity do not capture the broader structural determinants of food insecurity (social, economic, and agricultural policies); they are associated with poverty, unemployment, poor access to education, social exclusion, poor mental health, and chronic diseases" (Seligman et al., 2010). "Moreover, in the context of nutrition transition, they no longer cover the full spectrum of possible nutritional outcomes of poverty and food insecurity, which now include overweight and obesity" (Tanumihardjo et al., 2007).

Sixth are the self-assessment measures (Maxwell et al., 2013). "Although subjective in nature and may be too easy to manipulate in programmatic contexts, self-assessment measures have been introduced in recent years" (Maxwell et al., 2013). They include self-assessments of the current food security status in a recent recall period and changes in livelihood status over a longer period of time.

The literature also identifies unidimensional and multidimensional metrics of the FNS. First, unidimensional measures of the FNS include dietary diversity measures (Fielden et al., 2014); food safety and food insufficiency measures use single or combined items from survey scales (Alaimo et al., 1998). Second, multidimensional measures pertain to dietary sufficiency and diversity and have been addressed in the literature. They include:1) 24-hr recall measuring food intake over the last 24 hours (Fielden et al., 2014); Food records (3-day food records) measuring food eaten over the last 3days (Gibson, 2005); Global Food Security Index (Pangaribowo et al., 2013); 2) FAO Indicator of Undernourishment (FAOIU) with dietary energy supply as a proxy for food energy consumption (de Haen et al., 2011; Pangaribowo et al., 2013); 3) Hunger Index (GHI) combining undernourishment, child underweight and child mortality (Pangaribowo et al., 2013); 4) Poverty and Hunger Index (PHI) using the proportion of the population living with less than a dollar per day, the poverty gap, the share of the poorest quintile in national income or consumption, the prevalence of children underweight, and the proportion of undernourished population (Masset, 2011; Pangaribowo et al., 2013); 5) Hunger Reduction Commitment Index (HRCI) which assesses governmental commitment (covering three dimensions of food security: availability, access, and utilization) leading to better nutrition outcomes (Lintelo, 2012); 6) Medical and biomarker indicators (MBI) measuring micronutrient deficiencies with precision (Wasantwisut & Neufeld, 2012).

"There are several limitations to using these multidimensional indicators to measure FNS. 1) FAOIU: There is an increasing need to go beyond calories and analyze the degree of dietary diversity, as calorie availability is a poor predictor of nutritional development, mortality, and productivity" (Qaim et al., 2007), and "aggregating sex- and age-specific minimum dietary requirements might result in a large underestimation of undernutrition" (Svedberg, 2002). "The data on food availability are not fully reliable, and their robustness is questionable because they are sensitive to the three parameters" (de Haen et al., 2011). 2) "GHI: Yet, as these three elements of hunger are correlated, the issue of double counting (of stunted overweight children) has been raised among its critics" (Masset, 2011). 3) "PHI: However, poverty rate and poverty gap indicators are redundant; therefore, PHI suffers from issues similar to those of the FAO indicators, as the data are mostly derived from national data. Thus, quality and current data are major concerns" (Masset 2011). 4) "HRCI: is available for 21 countries, which is a strong limitation compared to the other indexes" (Lintelo, 2012). 5) "MBI may not be better than traditional methods, such as dietary records and recalls, because they can be affected by factors other than diet and are not available for all nutrients" (Daurès et al., 2000). 6) "While GFSI covers three dimensions of FNS (availability, access, and utilization), with stability as a control dimension, its main weaknesses include (i) the fact that a given score in GFSI is meaningless in terms of policy action without a clear understanding of the factors that led to that score; (ii) the lack of a clear theoretical concept justifying the selection of the different variables over others to represent the three dimensions, particularly, there are no indicators of short-term risks to affordability, such as price transmission mechanisms from international to national levels" (Pangaribowo et al., 2013).

The main gap in knowledge pertains to the lack of a comprehensive food and nutrition security index, which includes all four dimensions, following FAO et al. (2013), with a strong theoretical foundation (Maxwell et al., 2013). While the GFSI captures these four dimensions, it does so from a different perspective, as the fourth dimension (stability) is considered a 'control' (i.e., not included in the index calculation). Hence, this paper contributes to the debate on food and nutrition security assessment by introducing a more comprehensible approach and proposing a multidimensional food security index on a household and individual scale. Our perspective is also different from the algorithmic approach of Maxwell et al. (2013), as these authors have not used all the FNS indicators proposed by FAO et al. (2013, p.16) as the post-2015 monitoring framework.

Section 2 addresses the theoretical foundation of the multidimensional food security index, Section 3 addresses the data and methods, and Section 4 presents the results.

2. Theoretical perspective

Several definitions of food and nutrition security exist, but the World Food Summit definition appears to be the most used in the literature (FAO et al., 2013; Maxwell et al., 2013; Martin-Prével et al., 2015; Walls et al., 2019; Verger et al., 2020; Kummu et al., 2020). "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). This definition encompasses key aspects of food systems that have important implications for a population's food security, food safety, and healthy nutrition (Walls et al., 2019), while nutrition security is the last stage of food security (Smith & Haddad, 2000). Four interrelated dimensions emerge from this definition: availability, accessibility, utilization, and stability (FAO et al., 2013).

Food availability plays a predominant role in the FNS (FAO et al., 2013). This constitutes the supply side of food security (Burchi and De al., 2013; Burchi et Muro, 2016). To boost food availability, the sectoral focus on agricultural supply (i.e., agriculture, fisheries, silviculture, and forestry), productivity, and technology are key factors to consider (Burchi and De Muro, 2016). For example, an increase in food diversity and quantity from these sectoral activities has a positive effect on food consumption per capita, caloric intake per capita, and daily caloric availability (Hoddinott and Yohannes 2002). It is worth noting that providing sufficient food to a given population is a necessary but insufficient condition to enable people to have adequate access to food (NRC/NAP, 2012; FAO et al., 2013). This highlights the link between food availability and food access. In practice, food availability comprises indicators of dietary energy supply adequacy; value of food production; dietary energy supply derived from cereals, roots, and tubers; protein supply; and supply of protein of animal origin (FAO et al., 2013). These indicators are assumed to increase total food availability when they increase. Thus, food availability encompasses food supplies and available energetic food in accordance with the energetic needs and quality of energetic diets. Hence, this study adopted the indicators of the food availability dimension proposed by FAO et al. (2013, p.16).

Access to Food refers to the demand of the FNS. Several theoretical and empirical studies link food access to FNS (Regmi & Meade, 2013; Pangaribowo et al., 2013; Wolfson et al., 2019). Two pillars are foundational to the capacity to access food, notably economic access and material access (FAO et al., 2013). On the one hand, economic access is determined by the available income, food prices, the existence of social aid, and possible access to this aid. Theoretically, consumption (food) prices, demographic characteristics, human capital and household characteristics, non-labor income, environment, and non-food and nutrition determinants of wages are factors influencing access to food and the level of FNS achieved (Pangaribowo et al., 2013). Empirically, low-income populations have less access to healthy food than high-income populations, while high food prices (lower affordability) prevent the poor's access to such food (Wolfson et al., 2013; Regmi & Meade, 2019). On the other hand, material access depends on the presence of quality infrastructure such as ports, roads, railways, communication facilities, storages/warehouses, and other facilities that enable market functioning. Theoretically, infrastructure plays a significant role in both food availability and access (Memon & Bilali, 2019). Adequate infrastructure increases agricultural productivity and lowers production costs (Satish 2007). For example, a reduction in food loss through investment in transportation facilities or storage could have an immediate and substantial impact on poor consumers' access to nutritious, safe, and affordable food products (Nyo, 2016). Hence, in this study, food access includes the percentage of paved roads over total roads, road density, rail line density, domestic food price index, prevalence of undernourishment, share of food expenditure of the poor, depth of food deficit, and prevalence of food inadequacy (FAO et al., 2013, p.16).

Food utilization refers to individuals' ability to make good use of the food they access (Leroy et al., 2015). This is achieved through adequate diet, clean water, sanitation, and healthcare, thus ensuring that individuals' nutritional and physiological needs are met. Two types of indicators are used to assess the contribution of food utilization to food and nutrition security (FAO et al., 2013):1) anthropometric indicators on which undernutrition has an effect; and 2) indicators reflecting food quality and preparations, health, and hygiene conditions. On the one hand, extensive knowledge exists between the nutritional status (captured by anthropometric indicators) of an individual or household and their state of food insecurity (Osei et al., 2010; de Haen et al., 2011; Dewi et al., 2020; Ghattas, 2014). The main idea is that there are some nutritional attributes that cannot be found in adults and/or children if they (and their households) have access to adequate food, both in quantity and quality (food availability and access). These attributes include, among others, the maternal height, child stunting or underweight and wasting (Osei, 2010; Dewi et al., 2020). Consequently, food utilization through anthropometric indicators is a good outcome for people's access to quantity and quality food (thus food security). On the other hand, the literature also shows that food utilization is influenced most immediately by nutrition knowledge and beliefs, but also by access to healthcare, water and sanitation services, and practices related to the management of childhood illnesses and hygiene (Osei et al., 2010; Memon & Bilali, 2019; Wolfson et al., 2019). In particular, access to clean water and sanitation are part of a healthy environment, which has multiplier effects on people's health and impacts their food utilization (Memom & Bilali, 2019). In addition, food utilization can be explained by factors that determine food access. For example, Wolfson et al. (2019) showed that the frequency of cooking meals may be related to barriers to healthy food access, while income status may influence the types of food being prepared and the frequency of skipping meals.

Hence, in the current study, food utilization includes indicators related to access to 1) improved water sources and sanitary services; 2) percentage of children under 5 years of age affected by wasting, stunting, underweight, and underweight adults; 3) prevalence of anemia among pregnant women, children under 5 years of age, and 4) prevalence of vitamin A deficiency and iodine deficiency (FAO et al., 2013, p.16). In their current state, these indicators (except those in 1) negatively affect the state of food security as they directly capture information on food insecurity. Thus, a mathematical change (e.g., prevalence of non-vitamin A deficiency and non-iodine deficiency, percentage of children under 5 years of age not affected by wasting, non-stunted, non-underweight, and adults non-underweight) is applied to fit the logic of FNS (3.1).

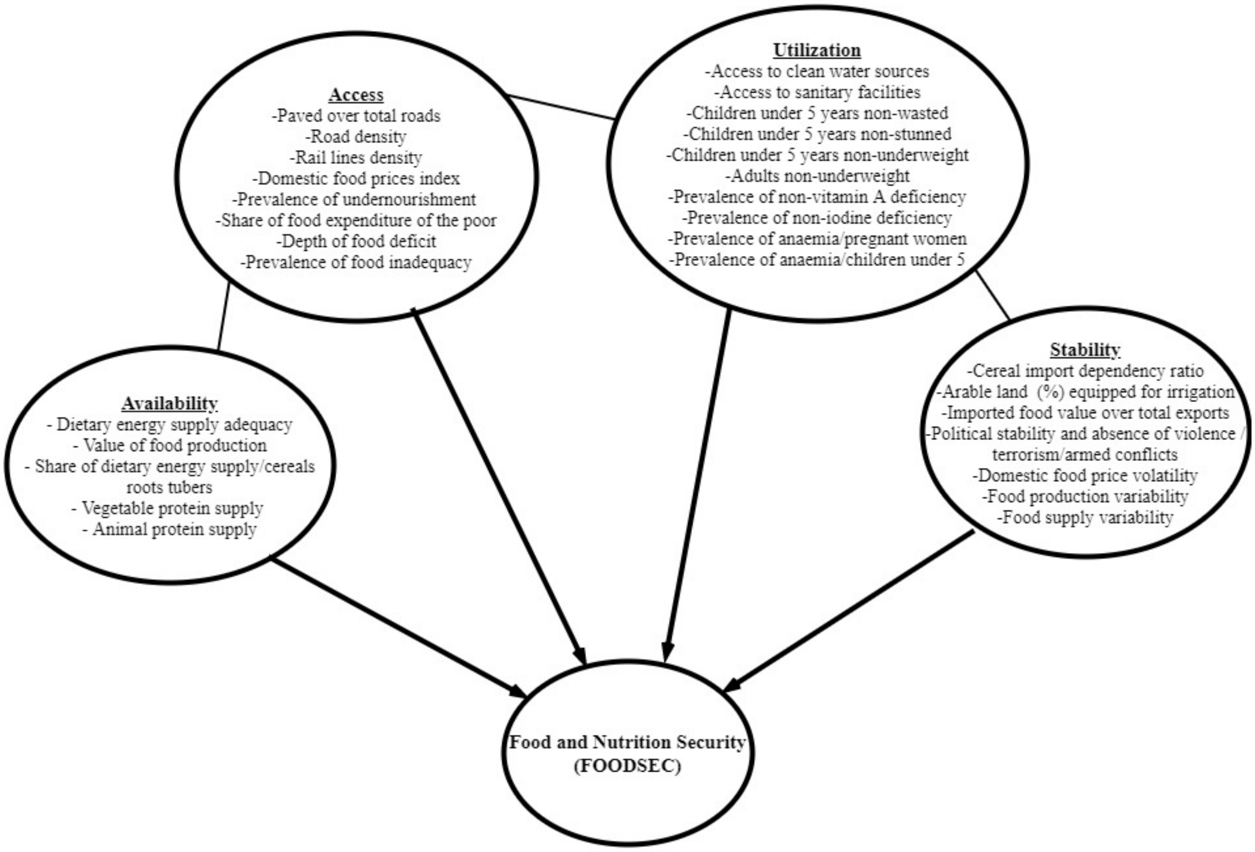
Food stability is a cross-cutting dimension that refers to the availability and accessibility of food and their adequate use at all times, so that people do not have to worry about the risk of food insecurity during certain seasons (Leroy et al., 2015). This involves particular attention to how to capture the extent and exposure to the risk of instability in these three dimensions of food security (FAO et al., 2013). We discuss the main sets of instability, including the impact of geopolitics of food security as a national risk (Hanieh, 2018; Koch, 2020), climate extremes (due to climate change) risk (drought and flood) (Schmidhuber & Tubiello, 2007), and conflict or sociopolitical instability risk (Ujunwa et al., 2018; Brück et al., 2019; Bar-Nahum et al., 2020). First, food geopolitics plays a significant role in food access, availability, utilization, prices, and imports (Margulis, 2014). Given the global nature of food supply chains, few places in the world have a monopoly on certain food items or supply chains (Koch 2020). Since geopolitics involves a game of power relations between countries and regions (Koch, 2020; Margulis, 2014), it has a significant influence on food trade, and thus, import quantities and food prices (Margulis, 2014). For example, since the food crisis in 2008, accompanied by the end of cheap food (Margulis, 2014), states have taken action to diverge from the World Trade Organization's mission of freer trade in food, including food export restrictions, national food self-sufficiency policies, efforts to regulate agricultural derivatives, and the acquisition of farmland abroad (FAO, 2009). Another example is the gulf rift between Qatar and its neighbors in June 2017, which cut off most of the country's existing land, sea, and air traffic routes. This mostly affected the country's food supply, as there was no domestic agriculture (Koch, 2020). These examples demonstrate how connections between countries can suddenly become sources of serious procurement problems, particularly in the food sector.

"Second, climate change affects the FNS in complex ways. It affects food production through changes in agro-ecological conditions, and indirectly by affecting the growth and distribution of income and demand for agricultural produce" (Schmidhuber & Tubiello, 2007). For example, "changes in temperature and precipitation cause changes in land suitability and crop yields" (IPCC, 2007). "Increases in the frequency and severity of extreme events such as cyclones, floods, hailstorms, and droughts cause greater fluctuations in crop yields, local food supplies, and higher risks of landslides and erosion (ibid). This adversely affects the stability of food supplies and food security" (IPCC, 2007; Schmidhuber and Tubiello, 2007). "Climate change also affects the ability of individuals to use food effectively by altering the conditions for food safety and changing the pressure from vectors, water, and food-borne diseases. Finally, climate change impacts food access through real prices and real income" (Ahmed et al., 2007; Ahmed et al., 2014). "Increased purchasing power allows a number of people to purchase not only more food but also more nutritious food with more protein, micronutrients, and vitamins" (Schmidhuber & Shetty, 2005).

Third, conflict (armed) or political instability (or conflict) have comprehensive adverse effects on economic activity, and thus, substantially harm social welfare (Bar-Nahum et al., 2020). Depending on the nature and trend, armed conflicts are serious threats to food security (Ujunwa et al., 2018; George et al., 2019). Armed conflicts negatively affect households' food security via the decline of their resilience capacity (income stability and diversification), which is necessary to resist food insecurity (Brück et al., 2018). Particularly, in countries heavily affected by violent political conflicts, large parts of the population are poor and food purchases account for significant shares of household expenditures (Aitchison & Brown, 1954). Thus, violent conflict often substantially impairs the availability, access and stability dimensions of the right to food (World Bank, 2011). Social conflict can lead to disruptions in food production, physical access to food, and food safety efforts (Ayala & Meier, 2017). Moreover, armed conflicts exacerbate women and children vulnerability and their FNS because they are mostly targeted by such conflicts (Ayala & Meier, 2017). Furthermore, armed conflicts negatively impact FNS through illegal appropriation and use of natural resources/banditry, food shortage through the interrupted production of food and even destruction of physical and natural infrastructure (Afolabi, 2009).

Hence, in this research, these three types of risks are considered in the measurement of FNS, as proposed by FAO et al. (2013, p.16). The indicators include the cereal import dependency ratio, percentage of arable land equipped for irrigation, value of food imports over total merchandise exports, political stability and absence of violence/terrorism, domestic food price volatility, per capita food production variability, and per capita food supply variability. Consequently, this study proposes a multidimensional food security index (MFSI) as a metric that combines the four dimensions of food security: availability, access, utilization, and stability. Figure 1 below shows the conceptual framework of FNS.

Figure 1: Conceptual Framework of Food and Nutrition Security



Source: The Author

3. Methods

3.1 Data

We used survey data collected under the Second National Land Management Program (PNGT2) impact evaluation by the Group of Quantitative Analysis Applied to Sahel Development (LAQAD-S) at the University of Thomas Sankara, in Burkina Faso. The survey consisted of two rounds:2010 and 2011, covering 45 provinces, 270 villages and 2160 households; we used the dataset of 2011. The questionnaire included 1) households' living conditions: census of household members and their socio-demographic information (age, height, weight for children and women particularly), education (formal and non-formal), health state, literacy, food consumption (FNS-related information), food production patterns (income sources), livestock, anthropometric measurements, land tenure, access to clean water and sanitation facilities/services, spending pattern; 2) access to paved roads (distance from the village), food, and other goods prices in the village market.

Since some variables are macro, we considered regional-, province-, municipality-, or village-scale data to characterize each household (see 3.2). Thus, we used both household/individual data combined with macro/meso-level data to measure FNS at the household level. We acknowledge that some shortcomings may reside in this approach in terms of compatibility of data sources (Imbens & Lancaster, 1994) and potential estimation and measurement problems in micro data, including sampling and reporting bias, while macro data may need to allow some bias in the household sector to satisfy the balancing constraints (Kavonius & Honkkila, 2016). However, doing so appears to be the only way to consider FNS indicators, particularly because aggregate (macro/meso) data are generally useful in giving meaning to the relationship involving micro and macro information sources (Imbens & Lancaster, 1994).

3.2. Mathematical form of the multidimensional food security index

The multidimensional food security index (MFSI) proposed in the paper included all the indicators of the four dimensions presented above. This food security index can be computed at the household, village, municipality, and regional levels. In addition, we adopted the calculation methods in FAO et al. (2013) while showing the sources of macro data used.

The mathematical form of the MFSI is a composite index consisting of multiple indicators. The literature addresses the choice of an adequate form of composite index (Giné & Pérez-Foguet, 2010; Kini, 2017) in various fields, including food security and water poverty. Some authors argue for the additive form of the index (Sullivan et al., 2003; Nardo et al., 2005), whereas others prefer multiplicative or geometric forms (Giné and Pérez-Foguet, 2010; Kini, 2017). In this research, we adopted the multiplicative form as the index's mathematical formulation because it prevents the possibility of compensation among the five components of the index (Giné & Pérez-Foguet, 2010). Thus, MFSI is computed as follows:

$$MFSI = \prod_{i=1}^{n} X_i^{w_i} \quad i = 1,2,3,4; and \ MFSI \in [0,1] \qquad (Eq. 1)$$

Where $X_i \in X = \big(D\ (Availability), A\ (Access), \ U(Utilization), S\ (Stability)\big)$ are the different dimensions of MFSI; and $w_i = w_1, w_2, w_3, and\ w_4 \ with \sum w_i = 1$ is the sum total (sigma) of the respective powers of the dimensions' availability, access, utilization and stability. In particular, availability is the mean of the average dietary energy supply adequacy, average value of food production, share of dietary energy supply/cereal root tubers, average vegetable protein supply, and average animal protein supply. Access is the mean of the percentage of paved roads over the total roads, road density, rail line density, domestic food price index, prevalence of undernourishment, share of food expenditure of the poor, depth of food deficit, and prevalence of food inadequacy. Utilization is the average of access to clean water, sanitary facilities, children under five years non-wasted, children under five years non-stunned, children under five years non-underweight, adults non-underweight, prevalence of non-vitamin A deficiency, prevalence of non-iodine deficiency, prevalence of anemia/pregnancy, prevalence of anemia/children under 5. Stability is the average cereal import dependency ratio, percentage of arable land equipped for irrigation, imported food value over total exports, political stability and absence of violence/terrorism/armed conflicts, domestic food price volatility, food production variability,

and food supply variability. For macro data, we resorted to the National Institute for Statistics and Demography (INSD) estimates that are still up-to-date in 2011 in Burkina Faso.
Thus, based on equation .1 :

$$MFSI = D^{w_1} * A^{w_2} * U^{w_3} * S^{w_4} \qquad (Eq.2)$$

The values of w_i can be obtained through several methods: principal component analysis (PCA) when data are available, experts' opinions (subjective), or a default solution attributing equal power to all dimensions (Giné & Pérez-Foguet, 2010). We argue that all four dimensions of the FNS are collectively important and should be considered on an equal basis (none can exist alone without others). This led us to attribute equal powers to each component. Thus, the power value was estimated to (1/4=0.25). We also applied PCA to derive the contribution of each dimension to the MFSI (see Table 1). Doing so was meant to draw a conclusion of both approaches.

Table 1: Power of MFSI dimension drawn from PCA

Dimension	Proportion
D	0.39
A	0.26
U	0.24
S	0.11

Source: Survey PNGT2, 2011

As a consequence, equation $Eq.3$ becomes:

$$MFSI1 = D_1^{0.25} * A_1^{0.25} * U_1^{0.25} * S_1^{0.25} \qquad (Eq.3)$$

and

$$MFSI2 = D_2^{0.39} * A_2^{0.26} * U_2^{0.24} * S_2^{0.11} \qquad (Eq.4)$$

MFSI is additive in its indicators and multiplicative in its dimensions. That is, the arithmetic mean of the indicators composing a component is considered (Giné and Pérez-Foguet, 2010; Kini, 2017). Consequently, MFSI is operational and can be computed using empirical data. However, as the data may be of different types (nominal or scale), we normalized/standardized them using the formula proposed by Wilk and Jonsson (2013) as follows: $\frac{X_i - X_{min}}{X_{max} - X_{min}}$, where X_i is an observed value of indicator i, X_{min} is the minimum value of the indicator, and X_{max} its maximum value.

Because a composite index is difficult to explain (Babu & Sanyal, 2009), we introduced a food security threshold from the index. In accordance to the fact that a person or a household is in food insecurity when its consumption provides less than 80% of the daily energy necessary for a healthy, active and full life, estimated at 2200 kilocalories per person per day (Babu & Sanyal, 2009), we referred to this condition by analogy and stated that there is FNS when all the indicators of all the four dimensions of MFSI record at least 0.4 as value (the ideal value is 1.0).

4. Results and Discussion

Table 2 shows the descriptive statistics of the unweighted FNS index (MFSI). They are generally low for all dimensions. Food availability (D) was the lowest (0.125 on average, SD:0.104), whereas food access was the highest (0.391 on average, SD:0.203). Food utilization was 0.195 on average (SD = 0.042), while food stability was 0.329 on average (SD = 0.049). It is worth noting that the variability in food availability and access is greater than that in food utilization and stability. Table 3 presents descriptive statistics of the equal-weighting dimensions of the MFSI. Food availability was the lowest (0.562 on average, SD: 0.111), while access was the highest (0.760 on average, SD:0.135), followed by stability (0.756 on average, SD:0.027) and utilization (0.661 on average, SD:0.035). Additionally, based on the MFSI data in Table 2, we computed the proportion of households with regard to their state of food and nutrition security (see Table 4). In Table 4, availability is the lowest (0.753 on average, SD: 0.138), while stability is the highest (0.884 on average, SD:0.014), followed by access (0.756 on average, SD:0.027), and utilization (0.672 on average, SD:0.034). Therefore, MFSI1 is 0.214 on average (SD: 0.060); whilst MFSI2 is 0.185 on average (SD: 0.068), meaning that the equal-power index (MFSI1) is higher than the unequal-power index-MFSI2 (on average).

Table 2: MSFI non-weighted dimensions

Dimension	Obs	Mean	Std. Dev. (SD)	Min	Max
D	1,835	0.125	0.104	0.004	0.756
A	1,835	0.391	0.203	0.010	0.866
S	1,835	0.329	0.049	0.221	0.701
U	1,832	0.195	0.042	0.139	0.277

Source: Survey PNGT2, 2011

Table 3: Weighted dimensions and MFSI1 values

	Obs	Mean	Std. Dev.	Min	Max
D1	1,835	0.562	0.111	0.247	0.932
A1	1,835	0.760	0.135	0.319	0.965
U1	1,832	0.661	0.035	0.610	0.726
S1	1,835	0.756	0.027	0.686	0.915
MFSI1	1,832	0.214	0.060	0.075	0.497

Source: Survey PNGT2, 2011

Table 4: Weighted dimensions and MFSI2 values

	Obs	Mean	Std. Dev.	Min	Max

D2	1,835	0.414	0.128	0.113	0.896
A2	1,835	0.753	0.138	0.305	0.963
U2	1,832	0.672	0.034	0.622	0.735
S2	1,835	0.884	0.014	0.847	0.962
MFSI2	1,832	0.185	0.068	0.041	0.506

Source: Survey PNGT2, 2011

Overall, these statistics indicate that the quantity-side (availability) of FNS is more critical, as the surveyed households do not produce enough food to meet the adequate food quantity (proteins) intake to guarantee a sufficient and healthy diet over time. Second, statistics indicate that access to food is better for rural households, even though food may not be of good quality. This is probably due to the fact that rural areas in the study country constitute the areas where most of food is produced, and then food may be more physically and economically accessible notably during the first term after harvests. Third, food utilization is low, meaning that surveyed households experience poor living conditions and notably weak access to clean water, sanitation, and hygiene services. They also show signs of weak food quality with regard to micronutrient deficiency, which informs the statistics. Fourth, statistics indicate that food stability over time is weak, meaning that rural households are exposed to great vulnerability to climate extremes, such as the global food crisis, as the study country is highly dependent on imports. Consequently, MFSI estimates show that for both (un)equal-weighting approaches, only 0.49% of the surveyed households were food and nutrition secure, that is, 99.51% were not food and nutrition secure. This shows that the weighting approach does not influence the proportion of households in food and nutrition (in) security.

Conclusion

Hence, this study concludes that a comprehensive approach to food and nutrition security is feasible, meaningful, and may provide a reliable assessment of the real state of FNS compared to existing indicators. Therefore, we disagree with the argument that a multidimensional index is difficult to explain (Babu and Sanyal, 2009). We recommend that policymakers avoid choosing the easiest way to assess food and nutrition security through simple and cheap (but also limited) indicators, if they expect to know the real state of FNS on the ground. Instead, the so called 'complex and costly indices', like MFSI, can provide a better footprint of the food and nutrition state. Thus, investing in this comprehensive approach to FNS assessment is required if policymakers and practitioners expect to achieve SDG2. Future research should focus on better integration of macro data on stability (e.g., conflicts and climate extremes) in the measurement of FNS. The main limitation of this study pertains to the use of old survey data from 2011. For instance, this survey was conducted when there was no terrorism in Burkina Faso. Therefore, we lacked data on this issue.

Availability of data and materials

The datasets used and/or analyzed in this paper are available from the author on reasonable request

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