Original Research Article

Multidimensional Food Security Index: A Comprehensive Approach

Abstract

The major challenge in measuring food and nutrition security is to provide policy makers with a single comprehensive measure that is valid, reliable, comparable over time and space, and which captures all various elements of food security. Many indicators have been developed for this purpose. However, most of these indicators appear to be limited in capturing all the aspects of food and nutrition security, and a comprehensive approach to this measurement needs further investigation. This paper introduces the multidimensional food security index to this debate. This index was applied using survey data of 1832 households in Burkina Faso. The paper concludes that policy-makers 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 policy-makers with a single comprehensive measure that is valid, reliable, comparable over time and space, and which captures all various elements of food security (Wilkinson, 2016; Maxwell et al., 2013). This is crucial as tackling the current complex problems of FNS requires adapted indicators (Jiren et al., 2020). Indeed, the rapid urbanization and economic and population growth in low and middle-income countries increase pressure on food systems to supply sufficient and healthy food for all (Perry et al., 2018). However, the governance of food security, which refers to the way food availability, access, utilization and stability are managed, oftentimes leads to the choice of partial indicators (Iese et al., 2018; Kepple & Segall-Corrêa, 2017). Hence, achieving food and nutrition security in current days is much more complicated than having enough food available (Meijl et al., 2020).

The literature organizes FNS indicators around the quantity (caloric intake), quality, vulnerability and risks, and fluctuations and trends in consumption over time (Maxwell et al., 2013). This has been revealed four main times in the evolution of the concept of food security and the underlying measurement indicators. First, in the 1970s, most food security indicators were focused on the quantity-side of food consumption. Caloric intake was the reference point to assess the level of food (in) security achieved by individuals or households. However, this did not address the other aspects of food security, and caloric intake was meant to be time consuming, expensive to measure, and only used in basic research (Maxwell et al., 2013). Second, with the increasing health issues pertaining to food consumption (obesity, stunting, micronutrient deficiency), the quality-side of food security comes into play (Maxwell et al., 2013). As food quality includes food 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 the access to a variety of food and adequate intake of micronutrients (Martin-Prével et al., 2015). Third, with the worsening environmental issues, capturing FNS entails integrating the increasing climate extremes (droughts, floods, increasing heat) with their impacts on food access, availability and utilization over time (Schmidhuber & Tubiello, 2007). Climate extremes create vulnerability and riskier situations between individuals, households, communities and nations, leading to concepts 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 several food and nutrition security metrics. First are the dietary metrics (Veger et al., 2020; Kummu et al., 2020; Martin-Prével et al., 2015), and food frequency (Maxwell et al., 2013). This type of metric captures the number of different kinds of food/food groups that people frequently eat. This results in scores that represent the diversity of intake, but not necessarily the quantity, though 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); 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).

Second is spending on food as metrics of FNS (Maxwell et al., 2013). Given that a high propensity of people close to poverty spend 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 are consumption behaviors as a metric of FNS (Herforth & Ballard, 2016). These measures capture FNS indirectly through food consumption behaviors. An example is the coping strategies 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 enough money to buy food. There is also the “reduced-CSI”, which is widely used, but it tends to measure only less-severe coping behaviors.

Fourth are the anthropometric indicators (Ghattas, 2014; de Haen et al., 2011). Anthropometric indicators include 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 cover specific nutrients that might be deficient.

Fifth are the experiences-based food security scales (Galiè et al., 2019; Vilar-Compt et al., 2017; Maitra, 2017; Ghattas, 2014) or food security experience scale (Larson et al., 2019), which measure the ‘access’ component of FNS. Household food insecurity access scale (HFIAS) is the best known and most used of these measures in international contexts (it captures 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 disease (Seligman et al., 2010). Moreover, in the context of the 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 self-assessment measures (Maxwell et al., 2013). While subjective in nature and maybe 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 current food security status in a recent recall period and change in livelihood status over a longer period of time.

The literature also identifies unidimensional and multidimensional metrics of FNS. First, unidimensional measures of FNS include dietary diversity measures (Fielden et al., 2014); food safety and food insufficiency measures use a 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 (Pangaribowo et al., 2013; de Haen et al., 2011); 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 (Pangaribowo et al., 2013; Masset, 2011); 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).

Several limitations stand in using these multidimensional indicators to measure FNS. 1) FAOIU: There is a rising 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); the cut-off point by aggregating sex and age specific minimum dietary requirements might result in a large underestimation of undernutrition (Svedberg, 2002); and the data on food availability are not fully reliable and the robustness is questionable as it is 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 stuntedoverweight children) has been raised among its critics (Masset, 2011). 3) PHI: However, poverty rate and poverty gap indicators are redundant; therefore, the PHI suffers from similar issues as the FAO indicators, as the data are mostly derived from national data, thus, quality and current-date are major concerns (Masset, 2011). 4) HRCI: is available for 21 countries, which in itself is a strong limitation compared to the other indexes (Lintelo, 2012). 5) MBI: may not be better than traditional methods, for instance 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) whilst 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 which 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, for instance, 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 the four dimensions following FAO et al. (2013), with a strong theoretical foundation (Maxwell et al., 2013). Whilst 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 scale and on an individual scale. Our perspective is also different from the algorithmic approach by Maxwell et al. (2013) since these authors have not used all the FNS indicators proposed in FAO et al. (2013, p.16) as the post-2015 monitoring framework.

Following the introduction, 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's definition appears to be the most used in the literature (Verger et al., 2020; Kummu et al., 2020; Walls et al., 2019; Martin-Prével et al., 2015; FAO et al., 2013; Maxwell et al., 2013). 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). Such a definition encompasses key aspects of food systems which have important implications for a population's food security, food safety, and healthy nutrition (Walls et al., 2019); whilst 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 FNS (FAO et al., 2013). It constitutes the supply-side of food security (Burchi & De Muro, 2016; Pangaribowo et al., 2013). To boost food availability, sectoral focus on agricultural supply (i.e. agriculture, fisheries, silviculture and forestry), productivity and technology are key factors to look into (Burchi & 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 the daily caloric availability (Hoddinott & Yohannes, 2002). It worth noting that providing sufficient food to a given population is a necessary, but not sufficient condition, to enable people to have adequate access to food (FAO et al., 2013; NRC/NAP, 2012). This highlights a linkage between food availability and food access. In practice, food availability comprises indicators on 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 the 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 paper adopts the indicators of food availability dimension proposed by FAO et al. (2013, p.16).

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

Food utilization refers to the ability of individuals to make good use of the food they access (Leroy et al., 2015). This is achieved through adequate diet, clean water, sanitation, and health care, 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) the anthropometric indicators on which undernutrition has an effect; 2) the indicators reflecting on food quality and preparations, health, and hygiene conditions. On the one hand, extensive knowledge exists between the nutritional status (captured by the anthropometric indicators) of an individual or household and their state of food insecurity (Dewi et al., 2020; Ghattas, 2014; de Haen et al., 2011; Osei et al., 2010). The main idea is that there are some nutritional attributes which cannot be found in adults and/or children if they (and their household) 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 (Dewi et al., 2020; Osei, 2010). Consequently, food utilization, through the anthropometric indicators, is a good outcome of 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 illness and hygiene (Memon & Bilali, 2019; Wolfson et al., 2019; Osei et al, 2010). In particular, access to clean water and sanitation are part of the healthful environment, which has multiplier effects on people's heath, which impacts their food utilization (Memom & Bilali, 2019). In addition, food utilization can be explained by the same factors determining food access. For example, Wolfson et al. (2019) have shown that the frequency of cooking meals may inform on the barriers to healthy food access; whilst income status may influence the types of food being prepared and the frequency of skipping meals.

Hence, in the current paper, food utilization includes the 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 and underweight, and underweight adults; 3) prevalence of anemia among pregnant women, children under 5 years of age; 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 of age non-affected by wasting, nonstunted, non-underweight, and adults non-underweight) is applied to fit with the logics of FNS (3.1).

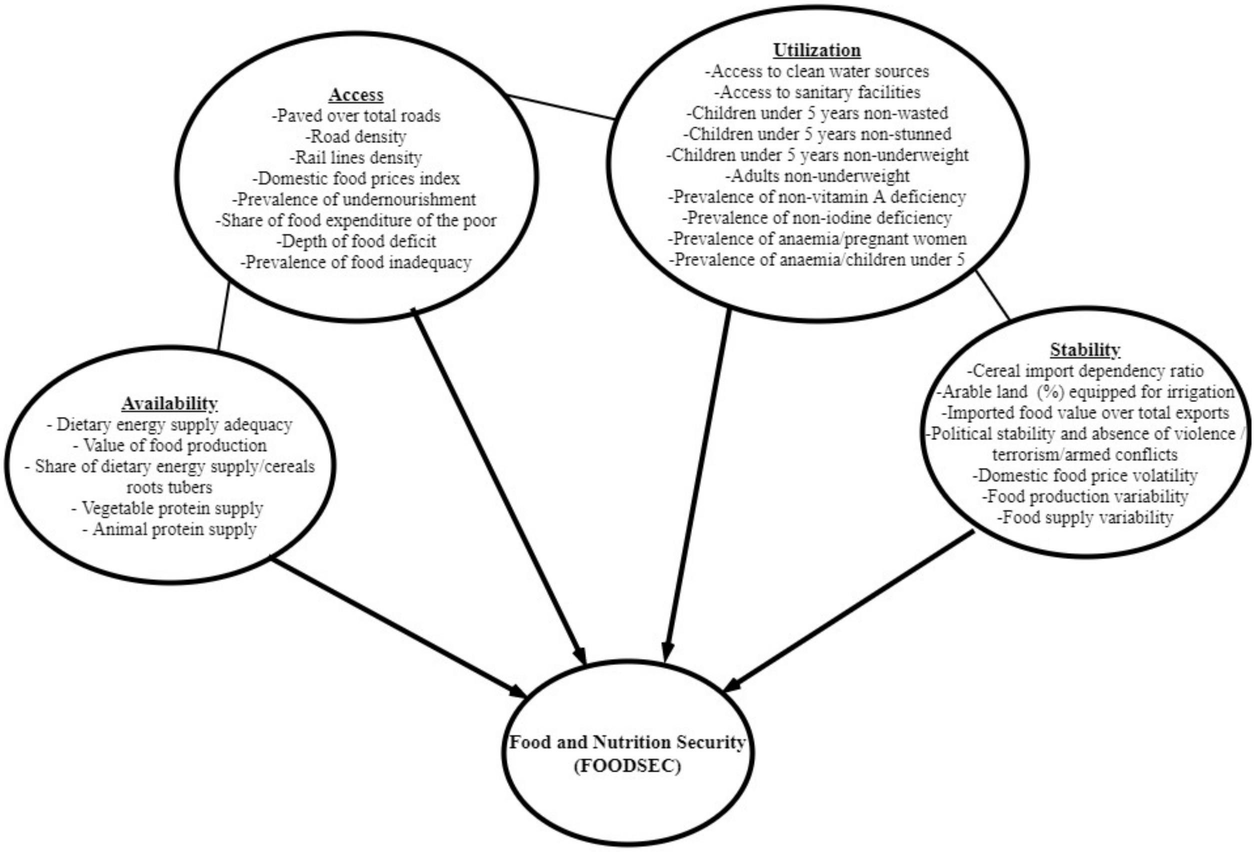
Food stability is a cross-cutting dimension that refers to the available and accessible food and their adequate use at all times, so that people do not have to worry about the risk of being food insecure during certain seasons (Leroy et al., 2015). This involves a particular attention to how to capture the extent and exposure to 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 (Koch, 2020; Hanieh, 2018); climate extremes (due to climate change) risk (drought, flood) (Schmidhuber & Tubiello, 2007); and conflict or socio-political instability risk (Ujunwa et al., 2018; Brück et al., 2019; Bar-Nahum et al., 2020). First, geopolitics of food plays a significant role on food access, availability, utilization, food prices and countries' food imports (Margulis, 2014). Given the intensely global nature of food supply chains today, few places in the world actually 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 with the end of cheap food (Margulis, 2014), states have taken actions to diverge from the world trade organization 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 cuts off most of the country's existing land, sea, and air traffic routes. This mostly affected the country's supply in food as there was not domestic agriculture (Koch, 2020). These examples show how connections between countries can suddenly become sources of serious procurement problems, particularly in the food sector.

Second, climate change affects FNS in complex ways. It affects food production through changes in agro-ecological conditions and indirectly by affecting the growth and distribution of incomes and demand for agricultural produce (Schmidhuber & Tubiello, 2007). For example, changes in temperature and precipitation bring 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 bring greater fluctuation in crop yields and local food supplies and higher risks of landslides and erosion damage (ibid). This adversely affects the stability of food supplies and thus food security (IPCC, 2007; Schmidhuber & Tubiello, 2007). Climate change also affects the ability of individuals to use food effectively by altering the conditions for food safety and changing the disease pressure from vector, water, and food-borne diseases. Lastly, climate change impacts food access through real prices and real incomes (Ahmed et al., 2014; Schmidhuber & Tubiello, 2007). An 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 (George et al., 2019; Ujunwa et al., 2018). 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, we consider these three types of risks in the measurement of FNS as proposed by FAO et al., (2013, p.16). The indicators include 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. 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 the 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 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's 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) and food production patterns (income sources), livestock, anthropometric measurements, land tenure, access to clean water and sanitations facilities/services, spending pattern; 2) access to paved roads (distance from the village), food and other goods prices at 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 in this research. We acknowledge that some shortcomings may reside in this approach in terms of compatibility of data sources (Imbens & Lancaster, 1994); notably 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 and particularly, because aggregate (macro/meso) data are in general useful in giving a 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 level as well as village, municipality and regional levels. Also, we adopted the calculation methods in FAO et al. (2013), whilst showing the sources of macro data used.

The mathematical form of MFSI follows the composite index consisting of multiple indicators. The literature addresses the choice of the adequate form of a composite index (Kini, 2017; Giné & Pérez-Foguet, 2010) in various fields including food security and water poverty. Some authors argue for the additive form of the index (Nardo et al., 2005; Sullivan et al., 2003), whereas others prefer the multiplicative or geometric form (Kini, 2017; Giné & Pérez-Foguet, 2010). In this research, we adopted the multiplicative form as the index's mathematical formulation, because it prevents the possibilities of a 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 $X_i \in X = \left(D\ (Availability), A\ (Access),\ U(Utilization), S\ (Stability)\right)$ 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 a mean of the average dietary energy supply adequacy, average value of food production, share of dietary energy supply/cereals roots tubers, average vegetable protein supply and average animal protein supply. Access is a mean of the percentage of paved roads over total roads, road density, rail lines density, domestic food prices 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, access to sanitary facilities, children under 5 years non-wasted, children under 5 years non-stunned, children under 5 years non-underweight, adults non-underweight, prevalence of non-vitamin A deficiency, prevalence of non-iodine deficiency, prevalence of anemia/pregnant women, prevalence of anemia/children under 5. Stability is the average of 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,

food supply variability. For macro data, we resorted to the national institute for statistics and demography (INSD) estimates 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 ways: principal components analysis (PCA) when data are available, experts' opinion (subjective) or a default solution attributing an equal power to all dimensions (Giné & Pérez-Foguet, 2010). We argue that all four dimensions of FNS are collectively important so that they should be considered on an equal basis (none can exist alone without others). This led us to attribute an equal power[1] to each component. Thus, the power value is estimated at (1/4=0.25). However, we also applied the PCA to derive the contribution of each dimension to 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, arithmetic mean of the indicators composing a component is considered (see Kini, 2017; Giné & Pérez-Foguet, 2010). 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

[1] The weakness of equal power is that it supposes that all components of an index have the same extent of contribution to its index value. This hides the specific weaknesses of some components of the index.

observed value of indicator i, X_{min} is the minimum value of the indicator, and X_{max} its maximum value.

As 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. Application results and conclusion

Table 2 shows the descriptive statistics of the unweighted dimensions of the FNS index (MFSI). They are low in general for all dimensions. Food availability (D) is the lowest: 0.125 on average, SD: 0.104; whilst food access is the highest: 0.391 on average, SD: 0.203. Food utilization is 0.195 on average, SD 0.042; whilst food stability is 0.329 on average, SD 0.049. It is worth noting that the variability of food availability and access are greater than food utilization and stability. Table 3 presents the descriptive statistics respectively of the equal-weighting dimensions of MFSI. It stands that food availability is the lowest (0.562 on average, SD 0.111); whilst access is the highest (0.760 on average, SD: 0.135), follows by stability (0.756 on average, SD: 0.027) and utilization (0.661 on average, SD: 0.035). In addition, based on MFSI data in Table 2, we computed the proportion of households in regards 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); whilst stability is the highest (0.884 on average, SD: 0.014); follows 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).

Overall, these statistics first inform that the quantity-side (availability) of FNS is more critical as the surveyed households do not product enough food to meet the adequate food quantity (proteins) intake to guarantee their sufficient and healthy diet overtime. Second, statistics inform that access to food is better for rural households even though the food might 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, notably weak access to clean water, sanitation and hygiene services. They also show signs of weak food quality in regards to the micro-nutriments deficiency that informs the statistics. Fourth, statistics inform that food stability over time is weak, meaning that rural households are exposed to great vulnerability to climate extremes, global food crisis as the study country is highly dependent on imports. Consequently, MFSI estimates show for both (un)equal-weighting approaches that only 0.49% of the surveyed households are food and nutrition secure; that is 99.51% are not food and nutrition secure. This shows that the weighting approach does not influence the proportion of households in food and nutrition (in) security.

Hence, this paper has come up with the conclusion that a comprehensive approach to food and nutrition security is feasible, meaningful and may provide a trusty assessment of the real state of FNS compared to the existing indicators. Therefore, we disagree with the argument that a multidimensional index is difficult to explain (Babu & Sanyal, 2009). We recommend policy-makers to 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 policy-makers and practitioners expect to achieve the SDG2. Future research should focus on a better integration of macro data on stability (e.g. conflicts, climate extremes) in the measurement of FNS. The main limitation of this work pertains to use of old surveyed data from 2011. For instance, this surveyed occurred at a moment there was no terrorism in Burkina Faso. Thus, we lacked data on this issue.

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

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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