Availability, access and utilization

Identifying the main fragilities for promoting food security in developing countries

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Abstract

Purpose – The purpose of this paper is to identify the association between the levels of food utilization (FU), food availability, economic access (EA) and physical access (PA) to food in developing countries – the main dimensions underlying the concept of food security.

Design/methodology/approach – This study analyzed available data from 57 developing countries. The variables investigated were: food availability (FA), EA to food measured through economic development, PA to food using the Logistics Performance Index as a proxy, and FU. The paper uses factorial, correlation and cluster analyses.

Findings – The results show that the dimensions of food security are strongly and positively correlated. PA has a moderate association with FU ($\rho S = 0.5338$ [$p < 0.001$]; $\rho P = 0.4252$; [$p < 0.01$]). EA has a strong association with FU ($\rho S = 0.6998$ [$p < 0.001$]; $\rho P = 0.6404$; [$p < 0.01$]). Moreover, cluster analysis suggests that some countries present significant urgencies regarding some of the food security dimensions considered.

Research limitations/implications – Cluster analysis has some limitations regarding the interpretations of the key findings. Moreover, many factors affect food security promotion; this paper addresses just a few of them.

Practical implications – Through a better alignment of food security dimensions worldwide, policy makers, as well as private sector actors, might achieve better conditions to reduce food waste or loss, supply a wider diversity of foods, reduce adverse environmental impacts, reduce logistics costs and, finally, reduce food prices.

Originality/value – This study outlines specific fragilities regarding the main dimensions of food security in developing economies. Thus, this study highlights that some countries need to focus urgently on certain, specific dimensions in order to promote the food security for their populaces.

Keywords Cluster analysis, Food insecurity, Food supply, Food access, Undernourishment, Logistics Performance Index

Paper type Research paper

1. Introduction

Food security is an urgent policy goal that still requires attention. Some countries face hunger problems among their populace that should be reduced, just like other countries face challenges among their citizenry with severe obesity and overweight problems. Indeed, a significant portion of the world population is undernourished, especially among children.

Nevertheless, evidence points that per capita world nutrients supply is improving – a very positive sign (Simon, 1996). In 1961, the per capita world macronutrients supply was 2,194 kcal/person/day, 61.5 grams of protein/person/day and 47.5 grams of fat/person/day. Yet, in 2011, these values were 2,868 kcal/person/day, 80.3 grams of protein/person/day, and 82.7 grams of fat/person/day. The Food and Nutrition Board of the USA provides the recommended, healthy intake amount for such nutrients. The minimum intake of protein proposed in The Dietary Reference Intake for an adult male is 56 grams (Food and Nutrition Board, 2005), and the average calculated Minimum Dietary Energy Requirement (kcal/person/day) between years 2006 and 2008 (Food and Agriculture Organization (FAO), 2014) for populations worldwide is 1,852 kcal/person/day. Therefore, the current world per capita supply of food exceeds individual requirements.

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Food security is defined as a situation that exists when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization, 2002, p. 49). Thus, food security can be a chronic or a transitory condition (Food and Agriculture Organization (FAO), 2008). The definition of food security is an ambitious concept, and difficult to be measured (Maxwell *et al.*, 2008). In addition, the concept of food security is related to some complex concepts as nutrition insecurity, hunger, malnutrition, undernourishment and obesity (Radimer *et al.*, 1990; Benson, 2004; Abbade and Dewes, 2016). Therefore, given this complexity, the appropriate measurement of food security is important for delineating actions and initiatives to manage food and economic aid, evaluating nutrition and health conditions and proposing specific actions, programs and policymaking (Jones *et al.*, 2013).

As proposed by FAO (2008), achieving food security requires fulfilling four conditions simultaneously. These conditions are the main dimensions of food security: physical availability of food; economic access (EA) and physical access (PA) to food; food utilization (FU); and stability of the other three dimensions over time (FAO, 2008). Even though there are four dimensions for food security, the fourth dimension listed – stability – is not considered in this study given its complexity and measurement challenges.

Considering the high level of malnutrition observed in some countries, one might hypothesize that nutritional problems are associated with food variety utilization. This study aimed to relate the severity of inferior FU (measured through anthropometric indicators of undernourishment and underweight children) along with other dimensions of food security: FU, food availability, EA to it and PA to it. In addition, this study identified the level of association between each of these dimensions of food security within developing countries. Note that the food access dimension is divided between EA (measured by economic development) and PA (measured by logistical performance). However, in a strictly technical sense, EA and PA are not dimensions of food security, but rather drivers associated with the more general category of food access dimension.

Despite the fact that this study identified two consolidated approaches to evaluate food insecurity (the Global Food Security Index (GFSI), and the Food Security Indicators of FAO (FSI-FAO), some inconsistencies were still found in some specific regions and between some specific indicators (Klasen, 2008; Barrett, 2010; Masset, 2011). Some indicators had unavailable data for certain regions. Thus, the definition of analytical dimensions, with convergent indicators, is an important aspect that still deserves attention.

In addition, the main proposal of this investigation relied on the assumption that logistics have a significant role in promoting food security worldwide; and these two approaches (GFSI and FSI-FAO) incorporate some logistics indicators in a broad way, not considering the logistics issue, or PA, as a main dimension with a significant magnitude (Global Food Security Index, 2014; FAO, 2014; FIVIMS, 2002). The GFSI evaluates food security through three main dimensions (affordability, availability and quality of food). On the other hand, the FSI-FAO uses four dimensions to evaluate food security (availability, access, utilization and stability). However, the access dimension uses indicators that measure logistics infrastructure (e.g. percent of total roads that are paved, roadway density), economic development (e.g. gross domestic product per capita, domestic food price index), and anthropometric indicators for FU (e.g. prevalence of undernourishment). Furthermore, the present investigation, unlike others, also highlighted PA as a main dimension of food security.

2. Method

This study analyzed countries worldwide that have data available that could address the main issues, specifically the severe problem of food insecurity. Data were obtained from

official institutions and quasigovernmental agencies, such as the Food and Agriculture Organization of the United Nations (FAO, 2014), the World Health Organization (WHO) (2014), the United Nations Statistics Division (UNSD) (2014), and the World Bank (2014). Considering that the level of analysis is based on countries that are currently fighting hunger and malnutrition, this investigation was designed as an ecological study. The main variables (dimensions) of this study are the dimensions of food security proposed by FAO (2014). The operational indicators for each one of the four main variables, their respective official sources, and the years for each data were collected as shown in Table I. Despite the fact that there is sometime misalignment between the operational indicators, we believe that the statistical procedures and results remain unbiased.

The first dimension of food security is food availability using carbohydrate, protein and fat supplies as proxies. The total amount of energy (kcal) from carbohydrates, protein (grams) and fat (grams) per person (on average), consumed in a year refers to the number of macronutrients available to each individual over a total population (country) during a reference period. According to FAO's methodology, per person food supplies are derived from the total amount of food available for human consumption by dividing the total calories (or grams of food) by the total population actually partaking of the food supplies during the reference period (FAO, 2014).

The second dimension is the EA to food, using GDP per capita and GNI per capita of populations as proxies. The GDP per capita is gross domestic product divided by midyear population. GDP is the sum of final value added by all resident producers in an economy in a given year, plus any product taxes and minus any subsidies not included in the value of the products. The GNI per capita is the gross national income, converted to US dollars divided by the midyear population. GNI is the sum of value added by all resident producers, plus any goods-specific taxes (fewer subsidies) not included in the valuation of output, plus net receipts of primary income (compensation of employees and property income) from home and abroad (World Bank, 2014). We accept that these two indicators can be used to accurately evaluate the economic conditions, thus the EA to food of the local populace.

The third dimension is PA to food. This dimension is based on the logistical performance at the national level, which is captured by the World Bank's Logistics Performance Index (LPI). This index measures the performance along the logistics chain within a country and

Dimension	Indicators and year of data	Sources
Food availability (FA)	Energy supply (kcal/per capita/year) (average 2008-2012) Protein supply (g/per capita/year) (average 2008-2012) Fat supply (g/per capita/year) (average 2008-2012)	FAO
Economic access to food (EA)	GDP per capita (2010) GNI per capita (2010)	UNSD
Physical access to food (PA)	Logistics Performance Index (six indicators) (2010): efficiency of the clearance process by border control agencies; quality of trade- and transport-related infrastructure; ease of arranging competitively priced shipments; competence and quality of logistics services; ability to track and trace consignments; and timeliness of shipments in reaching destination within the scheduled or expected delivery time	World Bank
(inferior) Food utilization (FU)	Children < 5 years of age who are moderately or severely underweight (available data between 2005 and 2010) Children < 5 years of age who are severely underweight (available data between 2005 and 2010) Undernourished population (available data between 2005 and 2010)	FAO and WHO

Note: Data were obtained at FAO (2014), UNSD (2014), World Bank (2014), and WHO (2014)

Table I.
Dimensions and indicators adopted to evaluate food security

represents an assessment tool designed to assist countries to identify weaknesses or improvement needs with respect to their logistical infrastructure.

Ranging from 1 (low performance) to 5 (high performance), the index assesses six major logistical issues: efficiency of the clearance process (i.e. speed, simplicity and predictability of rules and other formalities) by border control agencies, including customs; quality of trade and transport-related infrastructure (e.g. ports, railroads, roads, information technology); ease of arranging competitively priced shipments; competence and quality of logistics services (e.g. transport operators, customs brokers); ability to track and trace consignments; and timeliness of shipments in reaching destination within the scheduled or expected delivery time (World Bank, 2012).

The fourth dimension, the lack of utilization of food (inferior FU), is measured through the prevalence of children (under the age of five) moderately or severely underweight, the prevalence of children (under the age of five) severely underweight, and the prevalence of undernourished population. The prevalence of children moderately or severely underweight is the percentage of children aged 0-59 months whose weights (for their age group) is less than two standard deviations below the median weight for that age group for the international reference population – according to the National Center for Health Statistics (NCHS/WHO). The prevalence of severely underweight children is the percentage of children aged 0-59 months whose weight for age is less than three standard deviations below the median weight for that age group for the international reference population (NCHS/WHO). Moreover, the prevalence of undernourished population (based on the average % calculated using available data from 2006 to 2011) is the percentage of the population that is undernourished or food-deprived (i.e. individuals whose food intake falls below the minimum level of dietary energy requirements suggested by FAO/WHO/UNU).

The assessment of the main dimensions or variables is performed by Factorial Analysis and the Average Variance Extracted (AVE) (Hair *et al.*, 2005). Factorial Analysis examines the correlation matrix of indicators, aiming to put together those highly correlated indicators (factors) that explain significant parts of the variations in the data. The main applications of Factorial Analysis are to reduce the number of variables and to detect structure in the relationships between variables. This study uses Factorial Analysis to reduce the number of indicators.

AVE, which assesses the convergent validity of latent variables, should provide values greater than 0.5 in order to explain more than one-half of the variance of the items that make up a common factor. AVE is calculated through factor loadings and standard errors of the indicators obtained in the factor analysis (Hair *et al.*, 2005; Fornell and Larcker, 1982). This study used the Factorial Analysis because it is plausible that the reduction of some operational indicators to latent variables provides a better statistical fit. The main variables were analyzed through Pearson's correlation analyses and the significance of the associations between the main variables (p-value) was calculated. This study also presented scatterplots for some important associations. This stage of data analysis (Factorial Analysis and correlation) used a sample of 65 countries with available data regarding indicators of the main dimensions of food security.

This study also used the cluster analysis aiming to join countries with similar profile regarding the dimensions of food security. This statistical technique was applied in this study because it is based on procedures and classification algorithms. The same may be said of the joining method (or tree clustering), which aims to join objects together into successively larger clusters, using some measure of similarity or distance, resulting in a dendogram (Figure 2(a)). Regarding a plausible distance measurement, this study used the Pearson's correlation – where distances were computed using one minus the Pearson product-moment correlation coefficient for each pair of objects. It is also necessary to define a linkage or an amalgamation rule to determine when two clusters are sufficiently similar to be linked together. In this study, we used complete linkage as the amalgamation rule.

With this methodology, the distances between clusters are determined by the greatest distance between any two objects in the different clusters (Aldenderfer and Blashfield, 1984; Johnson and Wichern, 1998). Thus, at this stage of data analysis (cluster analysis), a sample of 57 countries was used that was able to address the four dimensions of food security.

3. Results

Initial results demonstrated that the main dimensions or variables, derived from their respective indicators, are well adjusted, confirmed through the analysis of the evidence obtained in the factorial analysis (Table II).

All factor loadings obtained for the operational indicators of their respective main variables were significant ($p < 0.001$). In addition, the values of AVE are all greater than 0.7 (Hair *et al.*, 2005), meaning that the new variables obtained through the factorial reduction explain more than 70 percent of the variance of operational indicators. Indeed, some AVE values are quite high, suggesting that the indicators are suitable to measure the respective main variable. This adequacy level of the main variables obtained through the factorial reduction was reinforced through the observation of the KMO values, which should have values superior to 0.5 (Hair *et al.*, 2005).

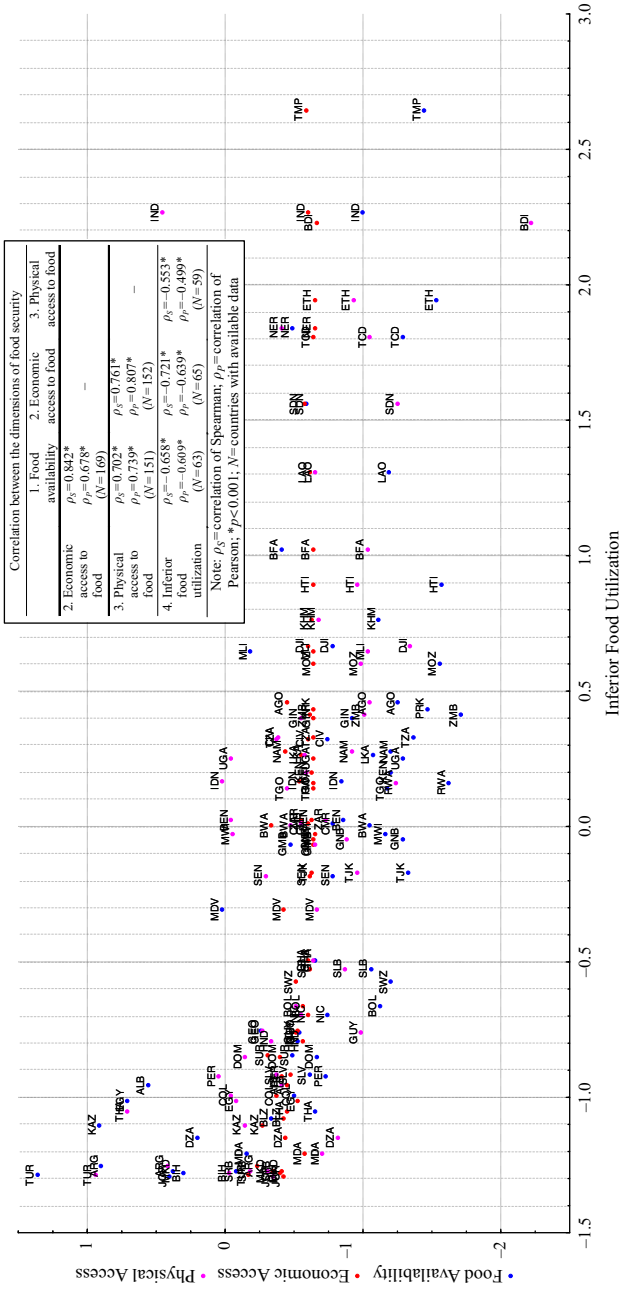
Since the main variables were well adjusted and adequate for further analysis, this study performed a correlation analysis, using Pearson and Spearman coefficients to identify the extent of association of the dimensions of food security worldwide. Thus, a scatterplot presented the relation between the inferior FU and the other three main variables of this study, including the correlation coefficient (Pearson and Spearman) between the dimensions of food security(Figure 1).

The results suggested that the main dimensions of food security evaluated in this study were strongly and positively correlated. Accordingly, on the one hand, PA was the dimension with the weakest association with inferior-quality FU ($\rho_S = 0.553$; $\rho_P = 0.499$; $p < 0.001$). On the other hand, EA was the dimension with the strongest association with inferior-quality FU ($\rho_S = 0.721$; $\rho_P = 0.639$; $p < 0.001$). Thus, the urgency regarding food

Dimension	Indicators	Factor loading	AVE	KMO
Food availability (FA)	Energy supply (kcal/per capita/year)	0.957*	0.895	0.758
	Protein supply (g/per capita/year)	0.953*		
	Fat supply (g/per capita/year)	0.928*		
Economic access to food (EA)	GDP per capita	0.996*	0.991	0.500
	GNI per capita	0.996*		
Physical Access to food (Logistics Performance Index) (PA)	The efficiency of customs and border management clearance	0.971*	0.936	0.935
	The quality of trade and transport infrastructure	0.977*		
	The ease of arranging competitively priced shipments	0.949*		
	The competence and quality of logistics services	0.985*		
	The ability to track and trace consignments	0.978*		
	The frequency with which shipments reach consignees within scheduled or expected delivery times	0.945*		
(inferior) Food Utilization (FU)	Children < 5 years of age who are moderately or severely underweight;	0.933*	0.750	0.550
	Children < 5 years of age who are severely underweight	0.962*		
	Undernourished population	0.673*		

Table II.
Main variables (dimensions), their respective indicators, and results for Factorial Analysis

Note: *$p < 0.001$



Note: Correlation analyses were performed using available data from nations

Figure 1.
Comparative evaluation of 65 nations worldwide (with available data) considering the three dimensions of food security

availability was underscored, specifically EA and PA of a populace, judging from its relative severity in quality FU. The evaluation of EA of countries presented in Figure 1 is very similar. Countries with worse FU face severer problems of PA and food availability.

The distance between each transport point for a country suggests a discrepancy between three of the four dimensions of food security. Particularly, BDI (Burundi) had the worst PA to food and had an urgent problem with quality FU. Other countries like TMP (Timor-Leste), IND (India), ETH (Ethiopia), TCD (Chad), and LAO (Laos PDR) had low food availability, indicating greater urgency for food security. Indeed, food availability was the most urgent problem for most countries plotted in Figure 1. Moreover, PA is likewise an urgent problem for many other countries, such as SDN (Sudan), BFA (Burkina Faso) and DJI (Djibouti).

In order to consolidate the findings, a cluster analysis was performed (Figure 2) aiming to join countries with similar profiles regarding the four dimensions.

Results obtained through the cluster analysis indicated that countries with better food access also had better FU (e.g. Turkey, Albania, Argentina and Jordan). Conversely, the cluster of countries with fragile food access also had fragilities regarding PA to food (e.g. Zambia, Mozambique, Haiti and Rwanda). However, while India had satisfactory PA, it also had the worst FU. Indeed, some countries have lower levels of FU and mediocre levels of the other dimensions (e.g. Niger, Sudan and India), suggesting that the lack of FU might stem from other causes. Since the concept of food security is based on a complex construct

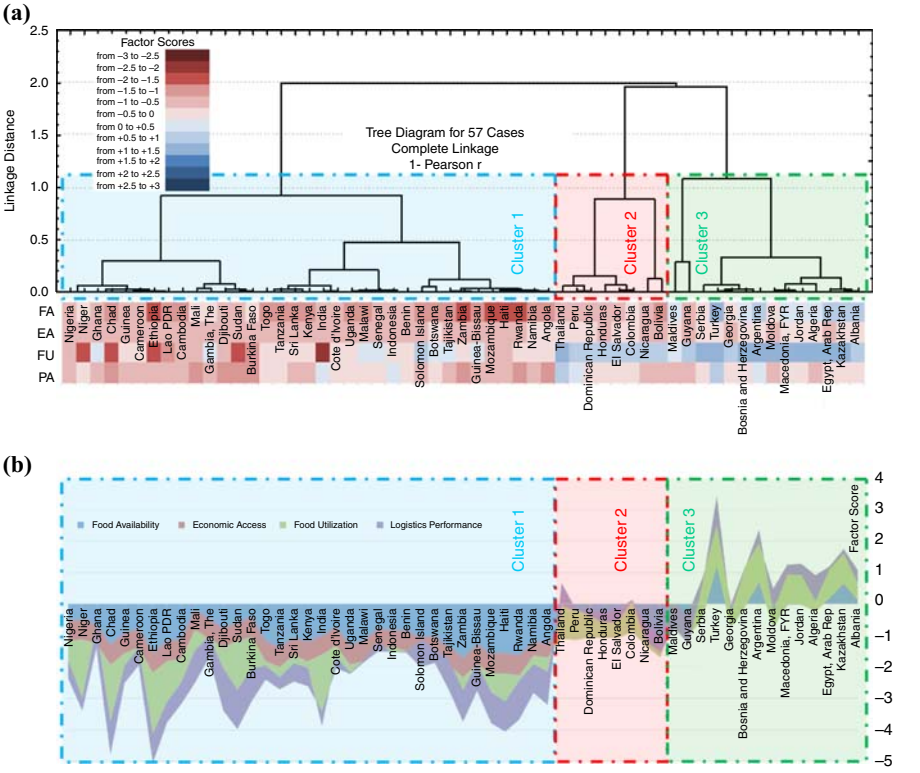


Figure 2.
Clustering 57 nations considering four dimensions of food security and their urgencies

Notes: (a) FA, food availability; EA, economic access; FU, food utilization; e PA, physical access (based on Logistics Performance Index). (b) Factor Score was obtained through the factorial analysis

encompassing a wide range of other concepts, results point to inferior FU of some countries being associated with other physical, environmental, social and economic variables.

The three clusters have different profiles. Countries comprising cluster 1 have urgent problems regarding food availability and economic conditions to access food. Thus, logistical performance is a serious problem in some countries of this cluster. The results suggest, accordingly, that these countries must deal with all four food security dimensions. Cluster 2 presents a significant association between access dimensions (physical and economic) and FU, suggesting that those eight countries might perceive an improving food security, along with ameliorated EA and PA to food. However, countries comprising cluster 3 present a much better situation regarding all four dimensions. FA and utilization have positive values in these countries. Since the three clusters manifest significant differences, Table III summarizes the correlation analysis in order to highlight them.

When considering all 57 countries addressed at this stage of the study, correlation coefficients suggested that the four dimensions were strongly associated. However, the clusters individually did not show a similar strong level. Some specific countries and regions worldwide, with problems of undernourishment and underweight children, also had differing problems regarding the other dimensions of food security. EA is similarly low for each of those countries evaluated. Consequently, the evidence suggests that some countries have lack of EA as their major problem. Still, food availability might be seen as the major problem for some countries in Eastern Africa, Southern Asia and perhaps a few in South America. In addition, PA might affect certain countries more severely than others, such as countries in Western and Middle Africa. Plausibly, therefore, regions of Africa that are strongly affected by undernourishment and underweight children must trace the root of food insecurity to PA harming food availability. However, Southern Asia seems to be more affected by food availability, even though this region has relative moderate PA.

4. Discussion

Unavailability of food, people's insufficient purchasing power, inappropriate distribution, and inadequate use of food at the household level aggravate food insecurity worldwide. Moreover, food insecurity may be chronic, seasonal or transitory (FAO, 2014). Considering the definition of food insecurity, underweight children and malnourishment are included within its scope. In addition, the world population continues to grow and raises a significant

	FA	EA	PA		FA	EA	PA
Cluster 1 (35 countries)				*Cluster 2 (8 countries)*			
EA	$\rho_P = 0.0013$	–	–	EA	$\rho_P = 0.4374$	–	–
	$\rho_S = 0.2655$				$\rho_S = 0.5238$		
PA	$\rho_P = 0.1395$	$\rho_P = -0.0200$	–	PA	$\rho_P = 0.3057$	$\rho_P = 0.5898$	–
	$\rho_S = 0.1989$	$\rho_S = 0.0056$			$\rho_S = 0.4048$	$\rho_S = 0.7619$	
FU	$\rho_P = -0.0134$	$\rho_P = 0.1683$	$\rho_P = 0.0539$	FU	$\rho_P = 0.6210$	$\rho_P = 0.7937^{***}$	$\rho_P = 0.8358^{*}$
	$\rho_S = 0.0134$	$\rho_S = 0.1524$	$\rho_S = 0.3039$		$\rho_S = 0.5714$	$\rho_S = 0.7381^{***}$	$\rho_S = 0.8809^{*}$
Cluster 3 (14 countries)				*All clusters (57 countries)*			
EA	$\rho_P = 0.7459^{*}$	–	–	EA	$\rho_P = 0.7013^{**}$	–	–
	$\rho_S = 0.5912$				$\rho_S = 0.6202^{**}$		
PA	$\rho_P = 0.8056^{**}$	$\rho_P = 0.7722^{*}$	–	PA	$\rho_P = 0.4809^{**}$	$\rho_P = 0.5275^{**}$	–
	$\rho_S = 0.6747^{*}$	$\rho_S = 0.6396$			$\rho_S = 0.4088^{*}$	$\rho_S = 0.4305^{**}$	
FU	$\rho_P = 0.4336$	$\rho_P = 0.3817$	$\rho_P = 0.4639$	FU	$\rho_P = 0.6075^{**}$	$\rho_P = 0.6404^{**}$	$\rho_P = 0.4252^{*}$
	$\rho_S = 0.3938$	$\rho_S = 0.5743$	$\rho_S = 0.4554$		$\rho_S = 0.6370^{**}$	$\rho_S = 0.6998^{**}$	$\rho_S = 0.5338^{**}$

Notes: ρP, Pearson correlation; ρS, spearman correlation; FA, food availability; EA, economic access; FU, food utilization; PA, physical access. $^{*}p < 0.01$; $^{**}p < 0.001$; $^{***}p < 0.05$

Table III. Correlation analyses for clusters

challenge for humanity to produce and supply enough food to meet the nutritional needs of the entire world (Godfray *et al.*, 2010). Obviously, global food distribution is not aligned to global food needs (De Schutter, 2011). Considering malnutrition traits associated with food insecurity, it might be possible to promote food security worldwide through changing the focus of agricultural production to a food system focused on substantive equality, local production, biodiversity and dietary diversity (Frison *et al.*, 2006; Friel *et al.*, 2007).

Regarding the diagnoses of food insecurity worldwide, and considering the main dimensions of the concept of food security, African countries are still the most affected by undernourishment and are beleaguered by a prevalence of underweight children. Evidence suggests that the lack of adequate food access is aggravated by a poor EA, high levels of unemployment and lack of economic opportunities for people (Crush *et al.*, 2012). Thus, India is a country where alarming proportions of its population suffer from food anomalies, both in terms of overweight/obesity and hunger/undernourishment (Doak *et al.*, 2005; Stein *et al.*, 2005).

Evidence suggests that many African and Asian countries are included among those with the worst situations of food insecurity worldwide (Food and Agriculture Organization, 2010, 2013). Indeed, some regions of Africa and Asia have food supply patterns highly dependent upon just a few food groups (e.g. starchy roots or cereals), and the unbalanced food supply is associated with food insecurity (Abbade and Dewes, 2015). Regarding this imbalance, the evidence suggests that food diversity is highly important in promoting human health and food security (Bernstein *et al.*, 2002; Ruel, 2003; Lee *et al.*, 2011; Hoddinott and Yohannes, 2002; Marshall *et al.*, 2001). In addition, evidence suggests that a regular consumption of important nutrients and food groups, as vegetables and fruits, can promote a better health and food security (Eppolito and Papareschi, 2009; Klein and Moller, 2010; Wolfenden *et al.*, 2012; Keatinge *et al.*, 2011; Miewald *et al.*, 2012).

However, the supply and affordability of some specific and highly perishable food groups, like vegetables, fruit, milk, meat and fish, rather than less perishable staples, like cereals and legumes (Miller and Welch, 2013) are strongly affected by poor logistical infrastructure. So, in some developing countries, despite the globalization and international trade in food, the food supply strongly depends upon local farming (Funk and Brown, 2009; Lamb, 2000; Devereux and Maxwell, 2001). Indeed, local farming in poorer regions, which is strongly affected by lack of food access, has the potential to alleviate this problem and, consequently, much food insecurity (Schmidhuber and Tubiello, 2007).

The access to food dimension of this study is extremely important in promoting food security. Thus, this study split the access dimension into EA and PA. EA depends upon purchasing power and economic emancipation of individuals and households (Nord *et al.*, 2008; Weathers, 2005; Bania and Leete, 2007; Iceland and Bauman, 2007). In addition, EA depends upon the food prices and other economic conditions for food access (Swinnen and Squicciarini, 2012; Martin-Prevel *et al.*, 2012).

PA depends upon logistical infrastructure, access to retailers and grocers, storage conditions for food (especially quickly perishable food) and other infrastructural issues, guaranteeing an adequate food supply (Pereira *et al.*, 2014; Lagerkvist *et al.*, 2013). Indeed, the adequate food supply of perishable foods requires the articulation of the supply chain and the understanding the specificity of this kind of products (Lagerkvist *et al.*, 2013). Thus, the EA and PA to food have mutual implications for success in nourishment, given that wealthier people tend to diversify their diets (Parfitt *et al.*, 2010), and logistics play a crucial role in supplying a balanced and diversified diet.

Several economic and social implications can be highlighted through the improvement of logistics worldwide. Regarding this motif, improving logistics might attenuate the urgent problem of food waste. Important evidence suggests that the losses of fruits and vegetables (highly perishable food groups), from production to distribution, in developing countries are close to 50 percent (Gustavsson *et al.*, 2011). Even in the USA, 41 percent of perishable food

(meat, poultry and fish) is wasted at the retail/consumer levels (Buzby and Hyman, 2012; Gunders, 2012). Therefore, reducing the food waste/loss that occurs during the supply chain level, through innovation, as well as scientific and technological advancements, the overall food supply could be more effective, helping to promote food security (Floros *et al.*, 2010).

The concept of food security is complex and still needs attention, mainly considering measurement procedures and indicators. Most users and researchers use only a few indicators that are capable of capturing only a small portion of the full concept of food security (Coates, 2013). Indeed, the literature proposes a wide range of different FSIs that capture different aspects of the multi-faceted concept of food security (Barrett, 2010; Becquey *et al.*, 2010; Maxwell *et al.*, 2011).

This study presented some implications regarding theoretical and practical issues. Initially, considering that the concept of food security has several levels and interpretations, a sharper focus on an ecological and macro level approach is needed. The focus on food security at a societal and national level needs to be better defined in order to help the policymaking. Thus, the identification of specific fragilities and bottlenecks regarding dimensions of food security in developing countries has potential to help and orientate managers and policy makers to promote better conditions of food security. Countries with problems associated with food availability perhaps have to design efforts to produce and/or import food, focusing in initiatives as rural and farm development, agricultural qualification, technological investments in agriculture, and partnerships with food supplier countries and sociopolitical development (Beddington, 2010; Khan and Zaks, 2009; Godfray *et al.*, 2010; Gebbers and Adamchuk, 2010). On the other hand, problems associated with EA to food security might justify some specific actions regarding the market regulation, use of food stamps and promotion of lower prices for staple foods (Beddington, 2010; Khan and Zaks, 2009). Problems regarding PA might be attenuated through investments in logistics infrastructure and investments in the retail sector (Pereira *et al.*, 2014; Sadler *et al.*, 2013). Thus, problems related to FU might be resolved through nutritional programs and force tasks in order to fight malnutrition through better nutritional habits and diets, as well as through economic development in long terms (Miller and Welch, 2013; Soriano and Garrido, 2016).

5. Conclusions

This study initially argued that the concept of food security is ambiguous and complex, and can be studied from several analytical perspectives. This study used a conceptual framework for food security using the main dimensions suggested by FAO (2014) – availability, access and utilization. Indeed, the access dimension is divided into physical and EA. Then, this study relates the severity of inferior FU with these other dimensions of food security, highlighting PA as a strong strangle point for the promotion of food security worldwide.

Considering that the EA to food has a stronger association with the inferior FU than the PA to food, it is possible to argue that the EA is a closer condition to promote the FU for a population. On the other hand, PA to food is a more distant condition of FU, but this condition is a major urgent priority to promote food security since the guarantee of EA, without guaranteeing PA to food, possibly will not significantly affect FU. The availability of food is an intermediate dimension, being positioned between PA and EA to food. This fact seems to be logical since the food availability can be promoted through the food supply imported from other countries (and in this case logistics has a significant role) or food produced locally (and logistical performance has a less significant role).

PA, associated strongly with the logistics performance and infrastructure, is a strategic condition to enhance the food security worldwide. Indeed, this dimension has implications for all agribusiness sectors, mostly for food supply chains, and it needs urgent attention. Urgent issues like food waste/loss, associated with the supply of diversity of food groups (promoting a diversify dietary pattern), promoting a reduction of environmental impacts, and reducing

logistics costs that directly affect food prices, need urgent attention from policy makers, researchers and the private sector. Thus, future studies regarding innovations in agribusiness and short food supply chains, along with a focus on the development of communities, enhancing social and economic emancipation, become key goals.

Food security is a complex concept that still deserves attention regarding methodological approaches and evaluation procedures. Despite the fact that FAO and GFSI have consistent sets of indicators, there are some inconsistencies, and this study aimed to advance this issue, analyzing four dimensions considered as the core of the food security concept. Food inequality and the other qualitative dimensions of food not mentioned in this study harms the level of food security. Alternatively, this study encouraged additional research in order to relate the four dimensions of food security with the concept of nutritional insecurity and its dimensions.

It is important to highlight that this study's topic still needs attention, with the aim being to consolidate the methodology and evaluation procedures regarding food security worldwide. Nevertheless, the results presented here might serve as a guide to policy makers in intervening on behalf of food insecurity, since more complete knowledge of lacking dimensions of food security is useful and, indeed, needed prior to intervention.

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