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Full Length Research Paper

Assessing food security in selected Mediterranean countries

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The significant increase in world food prices that occurred in 2007-2008 and 2010-2011 had a serious impact on vulnerable populations. The social revolts that erupted in countries in the south of the Mediterranean led to political instability. Soaring prices were considered to be one of the causes of the so-called "Arab Spring". Food security issues are extremely important in Mediterranean countries (MCs), which are facing complex economic and political changes (CIHEAM, 2012). Assessing food security conditions is a challenging task because of the multidimensional nature and complexity of the issues involved (Maxwell, 1996). The concept of vulnerability, which has been developed in the scientific literature along with food security, is explained in this paper. The research objective is to analyse the different dimensions of food security and highlight the economic issues that determine food security conditions in Mediterranean countries. Subsequently, the aim is to identify appropriate theoretical concepts and methodological tools that can be used to assess food security in a given country (or region), with particular emphasis on the economic dimension.

Keywords: Food Security, Indicators, Vulnerability, Principal Component Analysis, Mediterranean countries.

INTRODUCTION

Food security and vulnerability framework

Recent worldwide trends have triggered the international debate on the issue of food security. This is due to the current changes affecting both food supply and demand. In developing regions, in particular, food demand is boosted by population growth. In addition, per capita GDP and urbanization have led to important structural changes in food consumption patterns. However, the food supply is increasing at a slower rate and key resources (land, water, energy) are under more intense pressure, generating environmental concerns. The resulting imbalance is heightened by globalization, price volatility and regional political instability (Foresight, 2011). The issue of food security was initially raised by the United Nations in 1975. The goal was to provide sufficient food for all people. Over the years, the concept has been adjusted and refined. The latest definition proposed by the FAO in 1996 includes four more important dimensions: physical *availability* (food production, stocks and trade), economic and physical *access* (incomes, expenditure, markets and prices), food *utilization* (sufficient energy and nutrient intake) and *stability* (of the other three dimensions over time).

However, while many papers in the scientific literature focus on the nutritional aspects of food security (FAO, 1999; IFPRI, 2004), its economic implications have only recently been the subject of research.

Saravia-Matus et al. (2012) have developed an approach to the economic issues of food security, highlighting the similarities and the differences in low- and high-income countries. In low-income countries, the main constraints are low agricultural productivity and insufficient local access to food. This is related to production factors

(quality and availability), i.e. natural resources, capital and technology. In high-income countries, food security is related to macroeconomic issues, such as commodity price volatility, international trade and market stability.

Another important concept discussed in the scientific literature along with food security is that of ***vulnerability***. The idea was developed in the 1970s in response to the perception of disaster risk. In the 1980s, vulnerability was used as a concept of reference to assess risk and instability. As a consequence of the recent economic crisis, the issue of vulnerability is increasingly included on the international agenda.

Similarly to food security, vulnerability is multidimensional and includes physical, social, economic and environmental issues. We discuss several definitions and interpretations of vulnerability, which depend on the emphasis given to the dimensions considered.

Sen's (1981) "food entitlement" approach links vulnerability to inadequate access to assets, including intangible assets, such as social capital.

The International Strategy for Disaster Reduction proposes a fairly general definition of vulnerability: the "*conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards*" (UN/ISDR, 2004). The United Nations Development Programme (UNDP) described it as "*a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard*" (UNDP, 2004).

Lovendal et al. (2004) refer to vulnerability as people's and countries' exposure to risk and their resilience to that risk. Risk refers to phenomena, events, shocks and trends that could have a negative impact on the welfare of people and the governments' resilience or the people's ability to implement risk management strategies and policies (prevention, coping and mitigation).

Combes and Guillaumont (2002) and Guillaumont (2009) provide a definition of vulnerability that includes and develops the concepts proposed by previous authors. They suggest that economic vulnerability should be considered as the result of three determinants: shocks, exposure and resilience. A country that is exposed to a shock and has **a poor response** (resilience) is more vulnerable. Size and frequency of shocks determine the conditions of vulnerability. Shocks may be environmental and "natural" (natural disasters, earthquakes, drought, floods, etc.) or external (trade and exchange, world commodity price instability). The latter may result from political instability and change. **Exposure to shocks depends on a country's economic structure and geographic location**. Resilience concerns the capacity of countries to manage shocks and develop coping strategies.

According to this interpretation, trade dependency affects a country's economic vulnerability when it comes to international commodity price fluctuations and domestic price stability. The magnitude of food price shocks and economic vulnerability can be seen in national trade policies, per capita GDP and the amount of GDP spent on food at household level.

The issues discussed above are extremely important for many countries in the Mediterranean Basin, particularly in the south. In fact, the whole region is facing complex economic and social changes: there is the need to meet the growing population's increasing and changing food demands; simultaneously, economic growth should be promoted and agricultural production should be adapted to satisfy the demand for food (IFPRI, 2012).

Our study focuses on Mediterranean countries where the economic disparities are still considerable (CIHEAM, 2012). Our analysis involves a comparison between several Mediterranean countries, including North African countries (excluding Libya because of lack of data) and some of the most densely populated countries in the north, south and east of the Mediterranean basin.

The objective of the research is to analyse the different dimensions of food security and to show the diverse economic issues that affect the food security conditions in Mediterranean countries. The aim is then to identify appropriate theoretical concepts and methodological tools that can be used to assess food security in a country (or region), with particular emphasis on the economic dimension.

The paper is divided into four sections. The first section provides a general introduction to concepts of food security and vulnerability with a focus on Mediterranean countries. In the second section, we explain the methodology used: the selection of indicators and Principal Component Analysis. The third section presents the measurements used and discusses the PCA results. The fourth section presents the general conclusions.

Focus on Mediterranean countries

In the Mediterranean region, the food and agricultural systems are facing different and complex economic and social changes. One of the main priorities is to satisfy the growing food demand. In addition, there is a drive towards sustainable growth and greater competitiveness in terms of agriculture's environmental performance. Several relatively complex factors should be taken into account, including price volatility and the growing interest in the safety and nutritional aspects of agro-food products. Effective food policies should be developed to achieve this.

Countries in the north and south of the Mediterranean Basin share a number of common features. However, there are also significant disparities in food demand (food consumption patterns, food safety and nutritional conditions), food supply (agricultural production, climate, international market integration) and government policies (Padilla et al., 2005). In addition, other factors may have a major impact on food security conditions in

southern Mediterranean countries (IFPRI, 2012), such as structural dependency on imports to satisfy domestic demand.

Southern Mediterranean countries (SMCs) are undergoing a process of economic and policy transition. They have implemented policies and stabilization plans to control macroeconomic issues, reduce **economic disparities** and boost growth.

The Arab awakening, which began in Tunisia and affected several southern Mediterranean countries, coincided with the 2010 price spike. The uprisings were attributed to lack of democracy, freedom and justice, in addition to the increasing food insecurity due to high international food prices.

Food security has become a serious challenge for various reasons: high food prices, import dependency in southern Mediterranean countries, the rising food demand linked to population growth and problems of access to water resources (IFPRI, 2012).

Belghazi (2013) highlights the fact that in Egypt and Tunisia, the total available food supply has grown considerably over the past 40 years, reaching sufficient food availability (2,700 to 3,500 calories per person per day). The diet is largely vegetarian (no more than 10% of calories are of animal origin in all countries, except Algeria) and cereals remain the basic ingredient, in addition to pulses.

Belghazi (2013) underlines that cereals are the main commodity imported by southern Mediterranean countries, particularly Egypt, Algeria and Morocco. Policies are oriented to protect the national agricultural sector by means of import tariffs and subsidies for domestic producers. In these countries over the last decade, the average productivity per agricultural worker rose significantly (from 2,300 to 3,000 US dollars per year, at constant 2000 prices). Nonetheless, agricultural productivity is still highly sensitive to climate fluctuations (except in Egypt), particularly rainfall, which can vary greatly from year to year. In southern Mediterranean countries, the trends affecting agro-food systems pose a long-term threat to food security, unless specific economic strategies and policy measures are adopted.

METHODOLOGY AND OBJECTIVES

This study develops a critical theoretical and conceptual review in order to propose a set of selected and refined indicators to assess the state of food security in a country (or region).

To achieve this, research was developed in three steps.

1) Our analysis of food security issues involved an extensive literature review, which revealed the complex multidimensional nature of food security. We then applied our methodological approach. First, we chose the FAO definition for food security and three of its dimensions: availability, access and utilization. In a recent publication (2013), the FAO refers to more than four dimensions of food security. Thus, the food security debate is continually evolving. Our research included the additional dimension of vulnerability and its components: shock, exposure and resilience. Figure 1 represents the dimensions of food security that we took into account.

2) The second step involved a qualitative evaluation of the existing food security measurement indicators. This was based on the application of relevant selection criteria (i.e. SMART) in accordance with the research objectives (i.e. to assess economic aspects of food security), with the aim of developing a refined set of indicators. This led to the selection of several economic indicators, which are significant for the assessment of food security, including: price level, income level, import dependency ratio, arable land (per person), dietary share of the major food commodities (cereals, meat, milk, sugar, fruit and vegetables), food commodities (cereals, meat, milk, sugar, fruit and vegetables) per capita production, etc.

3) Lastly, to reduce the number of determinant variables for food security, we conducted a Principal Component Analysis (PCA). It is interesting to note that in 2011, M. Napoli used the same methodology and FAO's four food security dimensions (availability, access, utilization and stability). **However, the indicators were divided among the different dimensions and ran in four different PCA**. In 2012, Ernest Reig described the features of food security across the world with a special focus on the challenges facing Arab and Sub-Saharan African countries. The indicators selected for each of the four dimensions were analysed in a single PCA.

In our research, the PCA was conducted with the aim of comparing 3 years, namely 1990, 2000 and 2009. In the conclusion, we discuss the results of the PCA with a particular focus on the Mediterranean region.

Selected Indicators

Hammond et al. (1995, p. 1) describe an indicator as ''*something that provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. (…) Thus an indicator's significance extends beyond what is actually measured to a larger phenomenon of interest*''.

This study reveals the importance of monitoring the food security phenomenon in order to assess the impact of alternative actions and improve policy guidance. A plethora of definitions and indicators has been proposed in the literature over the years (in 1999 Hoddinott listed up to 200 definitions and 450 indicators).

The selection of the different indicators depends on the context. Indicators can be used in a wide range of contexts, such as sustainable development, food security, policy, economics, etc. Among the various criteria proposed, the so-called SMART criteria are frequently adopted

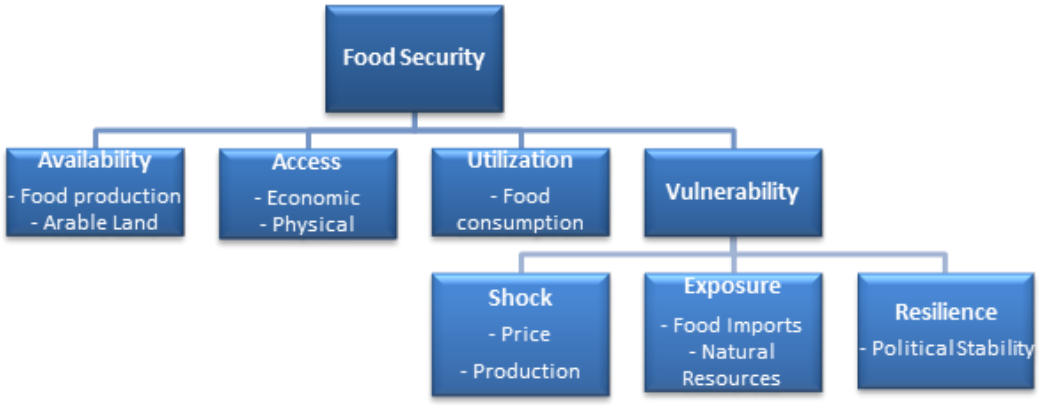


Figure 1. Food Security Dimensions.

by International Organizations (UNDP, UNICEF, Bossell, 1999) with reference to specific subjects, such as sustainable development (UNDP) and project evaluation. The SMART acronym indicates the following requirements:

Specific: also referred to as "validity", an indicator is specific when it is not biased by other factors but measures what it is supposed to measure;

Measurable: it can be both qualitative and quantitative and the indicator must be defined precisely;

Achievable: data required can be collected and measured (feasible);

(but also *Attainable* - results have to be realistic);

Relevant: the information provided by the indicator has to be important to the objectives or the projects; it has to capture the essence of the phenomenon of interest;

(but the indicator should also be *Reliable*, i.e. results should be the same regardless of who is collecting the data or when);

Time-bound: when will the objective be accomplished? A reasonable time frame should be specified and included in the statement of objectives.

The following table (1) summarizes the indicators selected for each of the four dimensions.

Principal Component Analysis (PCA)

Given the number and diversity of variables involved, measuring food security is complex. To simplify the analysis, we applied data reduction methods, namely PCA. This approach is useful when processing data for a number of variables, some of which may be redundant. Redundancy occurs when there is a correlation between variables, which may measure the same **component**. Principal component analysis is appropriate for analysing a small number of artificial variables (or principal components) drawn from a set of measures for a large number of observed variables. In theory, the principal components largely account for the variation in the observed variables.

The PCA is designed to describe the relationship between several quantitative variables. Using statistical analysis, a large number of variables can be examined simultaneously. We work from an array of quantitative data with n rows (one row per individual or "Observation") and p columns (p quantitative variables).

The aim of the PCA is to summarize the information relating to a large number of quantitative variables using a small number of synthetic variables (quantitative) or main factors.

The principle of PCA is to replace the initial p variables with new variables (the main factors). The original dataset is written as a matrix (1):

$$X = \begin{matrix} X1 \\ X2 \\ \vdots \\ X\mathrm{p} \end{matrix} = \begin{matrix} X11 & X1 \ldots & X1\mathrm{p} \\ X21 & X22 \ldots & X2\mathrm{p} \\ \cdots & \cdots & \vdots \\ X\mathrm{p}1 & X\mathrm{p}2 \cdots & X\mathrm{pp} \end{matrix}$$

with *i*= 1,2,…*p* and *j*=1,2,…*p* (1)

Where

- columns represent p observations
- rows represent p variables considered in the analysis

Below is the general form for the formula (2) to compute scores on the first component extracted (created) in a PCA:

$$C = XA' = \begin{Bmatrix} \mathrm{C1}\ \alpha\ 11(\mathrm{X1}) + \alpha\ 12(\mathrm{X2}) + \ldots \alpha 1\mathrm{p}(\mathrm{Xp}) \\ \mathrm{C2}\ \alpha\ 21(\mathrm{X1}) + \alpha\ 22(\mathrm{X2}) + \ \ldots\ \alpha 1\mathrm{p}(\mathrm{Xp}) \\ \ldots \\ \mathrm{Cp}\ \alpha\ \mathrm{p}1(\mathrm{Xp}) + \alpha\ \mathrm{p}2(\mathrm{X2}) + \ldots \alpha\mathrm{pp}(\mathrm{Xp}) \end{Bmatrix}$$

(2)

Table 1. Selected Indicators.

Availability	Access	Utilization	Vulnerability
- Per capita food Production kg/capita/per year - Arable Land (Hectare per person) - Self Sufficiency Ratio - Cereal yields (kg per hectare)	- % Total Rural Population - Road density (per 100 km² of land area) - Food Price Level index GDP, PPP per capita (constant 2005 US$)	- Total Food Supply (kcal/capita/day) - Share of food supply per commodity per person kcal/capita/year	**-** Per capita food production variability (kg/capita/per year) **(shock)** - Per capita food supply variability **(shock)** - Percentage of arable land equipped for irrigation **(exposure)** - Value of food imports over total merchandise exports (%) **(exposure)** - Import Dependency Ratio (IDR) (%)**(exposure)** - Food Import/GDP_PPP (constant 2005 international $) (**exposure**) - Food Export/Food Import **(exposure)** - Index of Political Stability and Absence of Violence **(resilience)**

Source: the author

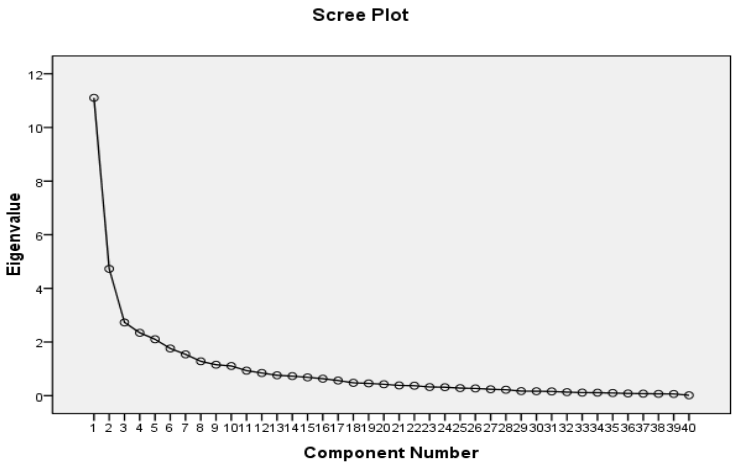


Figure 2. Scree Plot PCA.

Where
p = variables
C = the subject's score on principal component (the component extracted)
α1p= the regression coefficient for observed variable p, as used in creating principal component *p*
Xp= the subject's score on observed variable *p*
In the PCA, the number of components extracted is equal to the number of variables analysed. Usually, the first component explains most of the total variance. However, only the first few components are retained for interpretation (Mazzocchi, 2008).

MEASUREMENT AND RESULTS

Results of Principal Component Analysis

The dataset used is composed of 40 indicators, 93 countries and a timeline that covers 3 years: 1990, 2000 and 2009.
The indicators for each food security dimension analysed in the first phase are combined and run in one PCA. The KMO measures the sampling adequacy, which should be greater than 0.5 for a satisfactory PCA. In this PCA , the KMO measure is 0.777. The Bartlett's test of sphericity is used to show that the significance level is **.0000**, which indicates a strong relationship between variables.
In this PCA, there were 40 initial variables and 40 components are generated. However, when the Eigenvalue is considered (value greater than 1), only 10 PCs are retained for the analysis. The ten PCs explain about 74% of the variance. PC1 and PC2 explain 27.75% and 16% of the variance, respectively.
The scree plot (Fig. 2) is helpful for selecting components. The elbow point is observed at the PC3 level, which suggests that the first two components should be retained. PC1 and PC2 explain around 40% of total variance.
In order to facilitate the interpretation of the results, we decided to rotate the Component Matrix (Table 2). The first factor group shows a positive correlation between income and its variability, cereal yields and milk, meat and sugar consumption. On the contrary, indicators, such as the rural population, price level and cereal consumption, are negatively correlated to the PC1.
The second factor is represented by indicators, which are positively correlated to arable land, self-sufficiency in cereals, cereal production and its variability. Cereal import dependency is negatively correlated to PC1.
On the basis of the results, we can name each of the retained components. For example, PC1 could be “economic development” and PC2 could be “basic food supply”. In a developing economy, when the GDP increases, there is generally an improvement in technology and innovation. Thus, we can observe the positive correlation between PC1 and indicators of infrastructure in terms of access to improved water sources and road density. Political stability is positively correlated to PC1 and is extremely important for economic development. This is coherent with the fact that indicators expressing development problems and reduced well-being are negatively correlated to PC1, for example price level, cereal consumption and rural population percentage. In all societies, cereals are the staple food. However, when incomes increase, there is a decrease in the rural population and in cereal consumption.
The PC2 refers to societies that produce cereals. Therefore, the correlation is positive for variables of cereal self-sufficiency and production and negative for the cereal import indicator. The PC2 level may increase in countries that are self-sufficient in cereals and decrease in countries that are dependent on cereal imports.

Results in Mediterranean countries

The final step of the analysis involves calculating the scoring of each country in any of the two PCs extracted. The two PCs were calculated for each of the 93 countries. However, the aim is to illustrate and discuss the score of PC1 and PC2 in the Mediterranean area for selected countries.
Figure 3 is a graphic representation of the outcomes of the PCA concerning economic development (PC1) and basic food supply (PC2) in Mediterranean countries.
As can be expected, Figure 3 shows that Northern Mediterranean Countries (NMCs) are higher up the scale of “Economic Development” (PC1) than SMCs. Most countries **have developed** since 1990. However, the food and economic crisis, combined with the price spike of 2008, have had a global impact. Figure 3 shows that all the NMCs have declined in terms of economic development since 2000. This is particularly the case for Spain, which was affected by economic development constraints in 2009. It also applies to some SMCs (Algeria, Lebanon and Syria). Egypt has experienced the lowest rate of economic development, despite improvements over the years. In Tunisia, the level of economic development increased in 2000 and dropped to a negative level in 2009. Tunisia, Turkey and Morocco are the least economically developed countries in the Mediterranean Basin. Although Albania improved its economic development in 2009, it is still the least developed of the NMCs.
As far as “Basic Food Supply” is concerned (PC2), we can see that all SMCs show levels of dependency on cereal imports. In 2000, most SMCs (except Turkey) were extremely vulnerable in terms of cereal imports and low production levels.
Lebanon, Jordan, Israel and Algeria have the lowest PC2 levels. This suggests that they are extremely vulnerable because of cereal imports. Countries, such as Portugal and Albania, which have low productivity and little arable land, are dependent on cereal imports. Compared to NMCs, SMCs have lower levels of economic development, which makes them more vulnerable to shocks and less capable of coping.
NMCs have a higher level of economic development than SMCs. However, Jordan and Lebanon also show a high level of economic development. Israel has reached NMC standards of economic development. Cereals are the staple food in Mediterranean countries. In NMCs, cereal consumption is lower (around 30%) and consumption of meat, milk, fruit and vegetables is greater. In comparison,

Table 2. Rotated Component Matrix.

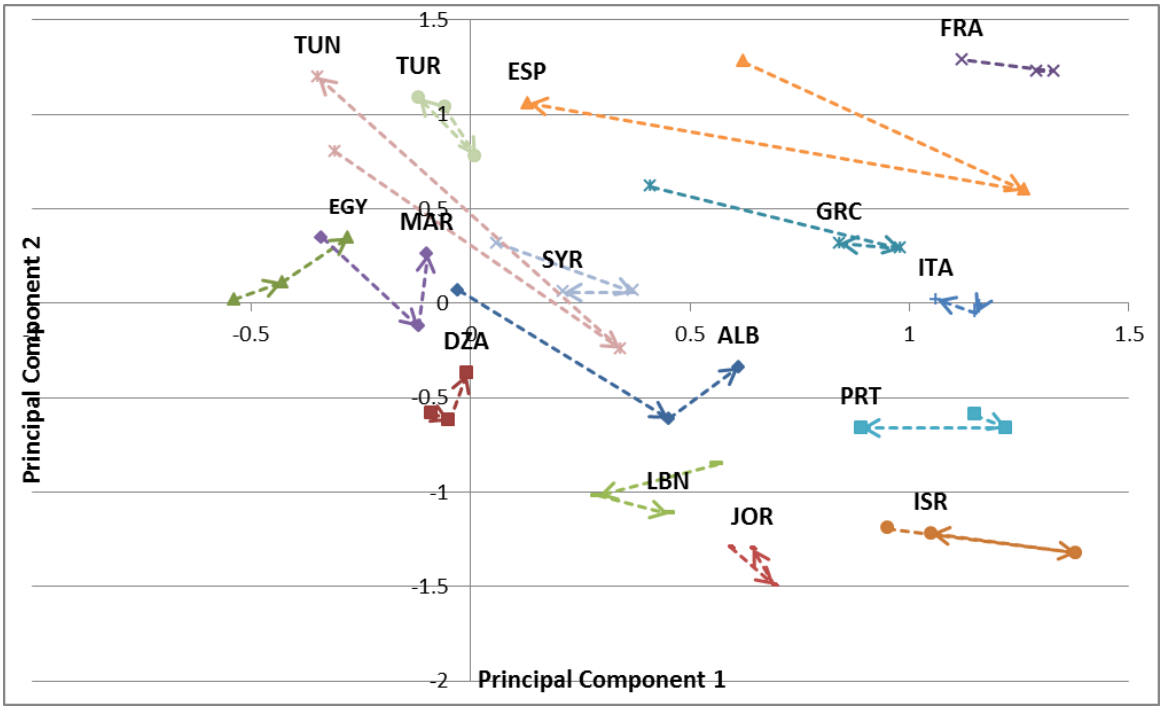
	Component		
	1	2	3
Rural Population (%)	-.846		
IRRIGATED LAND			
Cereal yields	.618		
GDP per capita, PPP	.833		
GDP_PPP Variability	.798		
Domestic price Level	-.729		
Arable Land		.686	
Road Density	.425		
Improved water source	.775		
Food Import/Total Export			
Food Export/Food Import			
Food Import/GDP.PPP			
Total Food Supply	.757		
Food Supply Variability			
Dietary Share_CEREALS	-.595		
Dietary Share_MEAT	.712		
Dietary Share_MILK	.762		
Dietary Share_SUGAR	.721		
Dietary Share_OILS	.437		
%FRUIT+VEGETABLES			
Import Ratio_CEREALS		-.708	
Import Ratio_MEAT	.406		
Import Ratio_MILK			
Import Ratio_SUGAR			
Import Ratio_OILS			
Import FRUIT+VEGETABLES	.551		
Self-Suff._CEREALS		.836	
Self-Suff _MEAT			.835
Self-Suff _MILK			.783
Self_suff F_SUGAR			
Self-Suff _OILS			
Self-Suff _FRUIT+VEG			
Production_CEREALS	.407	.788	
Production_MEAT	.512		.755
Production_MILK			.727
Production_SUGAR	.401		
Production_OILS			
Production_ FRUIT+VEG			
PROD_CEREALS Variability		.740	
POLITICAL_STABILITY	.680		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

cereal and sugar consumption in SMCs is high (40-50% and 12-15%, respectively). In NMCs, Infrastructure is generally more developed and GDP is higher. Israel is the only SMC to attain the same levels (**infrastructure and GDP**) as NMCs. Jordan, Lebanon and Israel have an extremely low level of basic food supply. All three countries have very little available arable land (about 0.03ha/cap). Thus, they are dependent on cereal imports (90-100%). The level of cereal imports in all SMCs is high, for example, Algeria (69% in 2009), Syria (65%), Tunisia (47%) and Morocco (44%). Of all the SMCs, Turkey has the lowest level for import dependency ratio.

Tunisia and Spain experienced the most severe constraints in terms of economic development from 2000 to 2009. In Spain, the cereal yields dropped from 3609 kg/ha in 2000 to 2938 kg/ha in 2009. In addition, GDP per capita increased at a lower growth rate compared to 1990 levels. Tunisia improved the basic food supply level,

Figure 3. Principal component Score in Mediterranean countries.



Source: the author

despite the negative level of economic development in 2009. In Morocco, the tendency for PC2 is similar. SMCs are vulnerable to food imports. Food security is affected by cereal production. Climatic conditions play a key role in terms of productivity.

Limits and Recommendations

Before conducting the analysis, we were aware that the available data was out of date. Our objective was to update data and highlight the limitations of the poor data provided by the large international organizations. The FAO has data available up until 2014 and 2015. However, we encountered some obstacles when we targeted our analysis on Mediterranean countries. There was a lack of data for a number of selected indicators. For a few of the selected indicators, several Mediterranean countries only had data for 2009. However, the main objective was to build a guide to assess food security and to develop a research methodology that can be applied to the years for which data is available and for the different indicators selected. We focused on the economic dimension of food security. However, the issue is complex and multidimensional. Other aspects of food security could be analysed to fit different research objectives. This article sets out to show the limitations of available data when it comes to conducting an analysis and developing food policies. Useful indicators, such as income distribution or the percentage of food expenses over total income, are essential for assessing food security. However, they are not available for all the years considered. One of the main reasons for the poor data availability on indicators is lack of resources, particularly time and money.

PCA methodology also has its limitations because of its static nature. Therefore, using PCA to monitor dynamic processes, such as food security, yields unsatisfactory results. Nonetheless, PCA results could help improve the analysis and development of an econometric model in order to assess the vulnerability of food security over time.

CONCLUSIONS

The aim of the research project was to analyse the different dimensions of food security and highlight the main economic issues affecting food security in Mediterranean countries in order to identify an appropriate theoretical concept and methodological tools for assessing food security in a country (or region), with particular emphasis on the economic dimension. Our analysis provides a useful **contribution to the research on** assessing food security in the Mediterranean region.

PCA results show the food security situation in the 93 countries selected. As expected, developed countries

(DCs) have the greatest food security, high levels of economic development and positive levels of basic food supply compared to less developed countries.

Our results show that DCs are not exposed to the risk of food insecurity. High-income countries have access to more financial resources, technology and strategies in order to guarantee food security. The main concerns in high-income countries are food sustainability, long-term availability and affordability. The challenge for food security in these countries is to meet the rising demand for food **through the implementation of environmentally, socially and economically sustainable practices**. In comparison, low-income countries, such as those in Sub-Saharan Africa and many parts of Asia, face problems of undernourishment and chronic hunger. The lack of infrastructure and improved technology are a threat to food security. In low-income countries, productivity could be improved without expanding the area of arable land. However, the lack of infrastructure and the marginal arid environments are a major obstacle.

Overall, the results obtained show moderate and gradual improvements, both in vulnerability and food security conditions in the target countries. On closer examination, it is clear that country-specific issues are crucial when it comes to identifying the various characteristics of food security and vulnerability.

The evolution of food security in Mediterranean countries is not homogeneous. The disparities can partly be explained by the diversity of countries (developed, North African and East-Asian). Compared to NMCs, SMCs show a higher level of vulnerability to food insecurity. SMCs are generally dependent on cereal imports, experience greater political instability and are exposed to more severe climatic conditions. However, some SMCs, such as Lebanon and Israel (high level of cereal imports) seem to be less exposed to problems of food security and more resilient because of their financial resources. Some MCs (Morocco, Tunisia and Spain) have experienced major fluctuations in their basic food supply. This reveals their vulnerability to food imports. Food security is affected by constraints, which are often climatic and directly impact cereal production.

In addition, in the wake of the 2008 financial and food crisis, the increasing political instability led to the uprisings of the so-called “Arab Spring” in 2011.

MCs are vulnerable to food insecurity. Therefore, a common agricultural policy for Mediterranean countries is important so that the following issues can be addressed:

1) Food availability – our research shows that MCs have an adequate food supply. However, production is threatened by climatic conditions and the amount of arable land is diminishing. The development of compensation and mitigation policies for natural resource management is important to guarantee farmers’ incomes and **to provide support to accompany the trade liberalization process**.

2) Access remains an important challenge for SMCs, especially improved infrastructure and technology. To achieve general food security objectives, technology enhancement (access and availability) is one of the key factors that could help stabilize productivity and boost efficiency. To achieve nutritional security, access to infrastructure must go hand in hand with access to health services, education, healthy environments and safe water resources.

3) **MCs still facing problems of food quality and use should implement strategies to promote access to quality-assured and balanced food**. Public intervention could strengthen control systems. Pricing and taxation policies could be implemented to rationalize the consumption of certain strategic products.

4) Furthermore, MCs remain vulnerable to food insecurity. They are exposed to food imports and shocks that affect food production and prices. Agricultural policies include impact correction and containment mechanisms to prevent market failure due to a **low price equilibrium** and asymmetric information, generated by poor resource allocation and unequal income distribution along the food chain. South Mediterranean countries should try to improve their policies to reduce their economic and political vulnerability.

This study revealed that food security remains a challenging issue not only for least developed countries. Other elements emerged from our research: the vulnerability dimension plays a determining role in food security; economies in transition, which is the case for SMCs, are exposed to food (in)security vulnerability; economic development, as well as government policies and strategies play a key role; including specific country characteristics is fundamental to the design of strategies to guarantee food security; access to data is essential.

Implementing strategies and policies is important for guaranteeing food security. Strategies should focus on: improving data access so that the evolution of phenomena over time can be understood; studying the shocks (production, climate, economic crisis), the reforms, the policy system and the social background; increasing economic growth (the more vulnerable a country is economically, the more it will be exposed to shocks); and improving the distribution of public expenditure.

Other constraints limit this type of research: macroeconomic data may not be precise or accessible. Some important indicators were excluded from the analysis due to lack of data (i.e. income distribution, the share of food expenditure over total expenditure). The methodology used helped reduce the number of variables included in the food security assessment. However, as PCA is a static process, the results obtained from monitoring dynamic processes, such as food security, may be unsatisfactory. However, **our results make an important contribution to research by providing a**

methodological approach to assess food security. The PCA methodology provides the basis for improving the analysis. The next step is to develop an econometric model to analyse the vulnerability of food security over time.

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