FOOD SECURITY: OVERVIEW OF CURRENT SITUATION IN SELECTED EUROPEAN COUNTRIES

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Abstract

Food security is defined by the World food summit of 1996 as follows: „when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". Such definition includes several aspects; therefore, it is necessary to use multidimensional view to its investigation. This concept is based on three pillars: food availability, food access and food use. This issue is hence complex sustainable development issue closely connected to health, economic, environmental and other issues. Presented paper is focused on the food security analysis in European countries. For this purpose, are used data from Global food security index 2015 database by The Economist Intelligence Unit (EIU) and sponsored by DuPont about food security indicators. In the first part of the paper is analyzed recent development of the food security indicators in the selected European countries, then multivariate analysis is used to reduce dimension of the data. Countries were sorted into classes according their food security performance. Results suggest positive tendency in the European countries from the perspective of increasing welfare, food accessibility and its distribution. On the other side, economic development and sufficient supply of food brings another phenomenon which can significantly reduce quality of life and is connected with prevalence of obesity in most of the European states.

Keywords: Food security, food security indicators, multivariate analysis, sustainable development

JEL Codes: N5, O13, P28, Q01, Q18, Q56

Introduction

In a world of finite resources and rising populations, resource-efficiency is crucial. Over the last few years, food security became important challenge. This issue has an interdisciplinary character considering many factors which influence global food security situation. In accordance to economic, social, environmental and technical development, every country has possibilities which could lead to improvement of food security indicators. Many countries have sufficient food production but worse food allocation (1). Improvement of the food allocation is only one from variety of solutions which could lead to improvement in global food security situation.

Considering these characteristics, the units of analysis generally used in the food availability approach are the country (and its food balance sheet) or the world and the agricultural sector (its production and productivity). (2) However, the most important shift was from food availability at the macro-level to income at the micro-level (GRIFFIN – KHAN, 1977; (3) Haq, 1976; (4) REUTLINGER and SELOWSKY, 1976 (5); REUTLINGER, 1977 (6)). The approach is very similar to the one traditionally used to assess poverty.

While predominantly food demand analyses have been concerned with situations in developing countries, there are also several food demand studies employing household data from developed European countries (6) (e.g., MOLINA, 1994 for Spain; (7) BANKS et al., 1996 (8), 1997 for the UK (9); MORO and SCKOKAI, 2000 (10) for Italy; ABDULAI, 2002

for Switzerland (11)). Similar approach was used also in case of Slovakia by CUPAK, POKRIVCAK and RIZOV (2015) who analyzed food security using households' food demand. (12)

The main shortcomings of both these (country level, resp. world and agricultural production analysis) procedures are the several assumptions made to move from income to food security: (1) from income/expenditure to food through price per unit information; (2) from food to calorie through equivalence tables; (3) from calorie availability to food security/insecurity depending on the threshold. With respect to the unit of analysis, income could potentially be estimated per individual. However, there are problems related to children whose food security also depends on adults' income. Having enough food per capita at the national level is a necessary but not sufficient condition for food security. Therefore, in order to make a food security assessment, we need to extend the informational basis. (2)

A growing number of studies explore the main drivers affecting global food supply and demand in the future, explicitly focusing on agriculture and the food system (DORIN and PAILLARD, 2009; FISCHERETAL., 2009; NELSON et al.,2010), or assessing broader issues (such as climate change) with outcomes that are relevant for food security analysis (e.g. PBL NETHERLANDS ENVIRONMENTAL ASSESSMENT AGENCY, 2012; UNEP, 2012). (13)

In changing conditions of developed world raises also new issues with regard to food security. Recent papers conclude that today's food environments exploit people's biological, psychological, social, and economic vulnerabilities, making it easier for them to eat unhealthy foods. This reinforces preferences and demands for foods of poor nutritional quality, furthering the unhealthy food environments. (1)

ROBERTO C. et. al. (2015) adds that the high profits that come from the successful exploitation of vulnerabilities are often the driving force behind environmental changes that promote overconsumption of food. His paper (14) referred to earlier points out that in high-income countries, energy-dense and nutrient-poor foods tend to be inexpensive, thus saturating low-income neighborhoods with unhealthy options. This means, that especially in developed countries, food security is not only connected with affordability and availability of food but also quality of diet.

Important question connected with food security is the way how to evaluate and measure food security on national level. This problem is connected especially with methods and variables which should be used. The Sustainable Livelihoods (SL) framework is not just an approach to food security, but is a more general approach to development and poverty. (15) Although the concept was certainly used previously, the ‘‘emphasis on livelihood’’ was given in the 1980s by CHAMBERS (1983).

Presented paper follows multivariate approach, which was previously applied on the field of competitiveness, or sustainable development and is a synthesis of previously applied approaches to food security which are mentioned below.

For the purpose of measuring food security was developed many global indexes. One of the most often used is global food security index (GFSI) by the Economist Intelligence Unit (EIU). The index is a dynamic quantitative and qualitative benchmarking model, constructed from 28 unique indicators that measures drivers of food security across 109 developing and

developed countries. Index considers three core pillars of food security – Affordability, Availability and Quality & Safety. This index was published first time in 2012 and since that time has been modified to its present form (16). Global index is too general and includes also indicators, which are not relevant in case of developed countries. Presented paper focus on the set of indicators which influence national food security level in developed countries. Selection of the indicators was carried on the basis of food security pillars as they are defined by leading institutions on this field. The most important are mentioned in following paragraphs.

The Food and AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) uses a different set of indicators to measure various aspects of food security. Indicators allow comparisons across regions over time. They can be divided into four dimensions of food security - availability, access, utilization and stability. An initial set of indicators was developed in 2011 (17).

World Health Organization explains tree pillars of food security as follows. Food availability - sufficient quantities of food available on a consistent basis. Food access - having sufficient resources to obtain appropriate foods for a nutritious diet. Food use - appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation. There also exist some critics, who argues that trade liberalization may reduce a country's food security by reducing agricultural employment (18). These two organizations focus mainly on developing countries, therefore many indicators included especially in first two pillars are not applicable in developed countries.

CIRAD, the French agricultural research and international cooperation organization defines four basic pillar of food security – Access, Availability, Food quality and Stability. According to research of this institution, is important to apply three main principles. First is increasing agricultural production, second is improving competitiveness of farm production and incomes of farmers and other agro-food sector actors and third is improving food safety as well as food quality, and by adding value to traditional local products (19). This food security definition includes also food safety and local conditions.

Both database obtained from EIU and FAOSTAT use wide range of indicators and includes data from various sources as World Bank, International Labor Organization, and National Statistical Offices´ publications, WHO, FAOSTAT and many others with regards to objects of interest. (20) The set of chosen indicators is extended with background variables including economic development, welfare, lifestyle and social phenomenon strongly linked with measuring and improving food security. Presented paper is based on approaches to food security definition presented above and tries to create synthesis of indicators and methods appropriate for developed countries.

The main objective of the presented paper is the analysis of current food security situation in selected European countries. Since most of current papers on this field are focused on developing countries, there could be questioned relevance of such analysis in case of European countries, where food security does not seem to be crucial problem compared to the rest of the world. Despite of this argument, such analysis is important to detect problems with food allocation and quality which are closely connected with increasing prevalence of obesity. This seems to be important phenomena in case of European countries with increasing incidence. Many papers were also focused to create food security ranking or index (21), on the other hand, this paper is focused to compare countries and detect main differences, especially those which seems to be crucial. Objective of the presented paper is accomplished

by comparing countries with regard to analyzed indicators in the first part. In the second part are investigated countries clustered into different groups according analyzed indicators. Finally, created groups are compared and most different factors are identified. In the conclusion are identified the most and least positioned countries according their performance in food security indicators.

2. Material and methods

Source of the data was Global Food Security Index 2015 database by The Economist Intelligence Unit (EIU) and sponsored by DuPont. Variables were selected according to pillars of food security (affordability or access, availability and food quality and stability which some sources define as a use of food) and include also background variables which can influence food security situation. With regards of analyzing a set of developed European countries from the total number of 36 indicators were selected variables which can be considered as important factors in Europe and represent individual pillars of food security. Following variables presented in the table 1 were selected across 26 European countries (this was influenced by the availability of data) for the period of year 2015. Conducted analysis include following countries: Austria, Belarus, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Spain, Sweden, Switzerland, Turkey, Ukraine and United Kingdom.

Table 1. **Variables selected for the analysis**

Pillar 1: Affordability

Indicators	***Formula***	***Description***
Food consumption	% of household expenditure (% of total share)	household expenditure spent on food at national level
Proportion of population under global poverty line (Poverty)	% of population living under $2/day PPP (%)	prevalence of poverty
GDP per capita	US $ at PPP/capita	individual income and affordability of food

Pillar 2: Availability

Indicators	***Formula***	***Description***
Average food supply	kcal/capita/day	amount of food available for human consumption per capita
Public expenditure on agricultural R&D	rating 1-9 (9=best, 1=worst)	government spending on agricultural research and development[1]
Volatility of agricultural production	standard deviation	standard deviations of the growth in agricultural production over the most recent twenty years period for which data are available
Corruption	rating 0-4 (4=highest risk)	pervasiveness of corruption in country by assessing the risk of corruption[2]
Food loss	total waste/total domestic supply quantity (tonnes)	post-harvest and pre-consumer food loss as a ratio of the total domestic supply of crops, livestock and fish commodities

[1]expenditure on agricultural R&D is a proxy for agricultural innovation and technology that increases market efficiency and access.

[2]corruption can impact availability through distortions and inefficiencies in the use of natural resources, as well as bottleneck inefficiencies in food distribution.

Pillar 3: Quality and Safety

Indicators	*Formula*	*Description*
Diet diversification	% of non-starchy foods (%)	the share of non-starchy foods (all but cereals, roots, and tubers) in total dietary energy consumption

Background variables

Indicators	*Formula*	*Description*
Human Development Index (HDI)	rating 0-1	a composite index that measures development by combining indicators on life expectancy, educational attainment and income
Global Gender Gap Index (GGGI)	rating 0-1	gender equality: the relative gaps between women and men, across a large set of countries and across the four key areas of health, education, economy and politics
EIU Democracy Index	rating 1-10	state of democracy[3]
Prevalence of Obesity	% of obese population	obese population over 20 years of age[4]

[3]index includes indicators in the following 5 categories: Electoral process and pluralism, functioning of government, Political participation, Political culture and Civil liberties in 165 states and 2 territories
[4]obesity is defined as having an age-standardized body mass index (BMI) greater than 30 %
Source: EIU Global Food Security Index, 2012

In the first part of presented research results were applied descriptive statistics to present current situation across investigated countries. Chosen statistics were mean, standard deviation, minimum, maximum, range, median and coefficient of variation. For the purpose of comparison was calculated also world mean of presented indicators which allowed to define each country position at global level. There was also analysed interaction between chosen indicators to show their possible interdependence to each other. Interaction is demonstrated on scatter plots with drawn values of word mean and European mean for the purpose of classifying countries into one of four possible quadrants according to level of indicators. The left lower quadrant represents below average values of both indicators. The right upper quadrant represents above average values of both indicators.

Principal component analysis

To reduce dimension of the data and remove collinearity among indicators was applied multivariate analysis of principal components. This analysis is usually applied in case of too many variables, when it is necessary to preserve same information in less number of variables. Such analysis is usually applied to investigate multidimensional issues, such as human development, sustainable development, food security etc. Principal component analysis seeks to maximize variance of a linear combination of the variables. (22)

Principal component analysis deals with a single sample of n observation vectors y_1, y_2, …y_n that form a swarm of points in a p-dimensional space. Principal component analysis can be applied to any distribution of y, but it will be easier to visualize geometrically if the swarm of points is ellipsoidal.

Objective of the analysis is to find the natural axes of the swarm of points (the axes of the ellipsoid) with origin at y, the mean vector of y_1, y_2,…, y_n. This is done by translating the origin to y and then rotating the axes. After rotation so that the axes become the natural axes of the ellipsoid, the new variables (principal components) will be uncorrelated. The axes can be rotated by multiplying each y_i by an orthogonal matrix A.

$$z_i = Ay_i \quad (1)$$

where zi – new point (principal component)
A – orthogonal matrix
y_i – vectors of original variables

Thus an orthogonal matrix transforms y_i to a point z_i that is the same distance from the origin, and the axes are effectively rotated. Finding the axes of the ellipsoid is equivalent to finding the orthogonal matrix A that rotates the axes to line up with the natural extensions of the swarm of points so that the new variables (principal components) z1, z2, . . . , z p in z = Ay are uncorrelated.

In presented analysis was obtained four standardized principal components, which were based on the linear combination of the original variables.

$$\begin{aligned}
&\text{Principle 1} = a_{11}*X_1 + a_{12}*X_2 + \ldots..+a_{1p}*X_p \\
&\text{Principle 2} = a_{21}*X_1 + a_{22}*X_2 + \ldots.+a2_p*X_p \\
&\text{Principle 3} = a_{p1}*X_1 + a_{p2}*X_2 + \ldots..+ a_{pp*}X_p \\
&\text{Principle 4} = a_{p1}*X_1 + a_{p2}*X_2 + \ldots.+a_{pp*}X_p
\end{aligned} \quad (2)$$

where: a_{ij} – component score i, j = 1, 2, ….p
X_p – indicators

Cluster analysis

The main objective was achieved by cluster analysis. This was used to find an optimal aggregation where countries within clusters are similar, but clusters are different to each other with regard to the food security indicators.

Cluster analysis (22) is usually used to search for patterns in a data set by grouping the multivariate observations into clusters. This analysis has also been referred to as classification, pattern recognition (specifically, unsupervised learning), and numerical taxonomy. The techniques of cluster analysis have been extensively applied to data in many fields, such as medicine, psychiatry, sociology, criminology, anthropology, archaeology, geology, geography, remote sensing, market research, economics, and engineering.

This kind of analysis is focused on quantitative variables. The data matrix can be written:

$$Y = \begin{pmatrix} y_1' \\ y_2' \\ \ldots \\ y_n' \end{pmatrix} = \left(y_{(1)}, y_{(2)}, \ldots, y_{(p)}\right) \quad (3)$$

Where y'_i is a row (observation vector) and y(j) is a column (corresponding to a variable). We generally wish to group the n y'_i´ s (rows) into g clusters. We may also wish to cluster the columns y(j), j = 1, 2, . . . , p.

To group the observations into clusters, many techniques begin with similarities between all pairs of observations. In many cases the similarities are based on some measure of distance. In this case was used Ward´s method of hierarchical clustering based on the Euclidean distance.

This clustering method is also called the incremental sum of squares method, uses the within cluster (squared) distances and the between-cluster (squared) distances.

$$SSE_A = \sum_{i=1}^{n_A}(y_i - \bar{y}_A)'(y_i - \bar{y}_A), \quad (4)$$

$$SSE_B = \sum_{i=1}^{n_B}(y_i - \bar{y}_B)'(y_i - \bar{y}_B), \quad (5)$$

$$SSE_{AB} = \sum_{i=1}^{n_{AB}}(y_i - \bar{y}_{AB})'(y_i - \bar{y}_{AB}) \quad (6)$$

Where $\bar{y}_{AB} = (n_A\bar{y}_A + n_B\bar{y}_B)/(n_A + n_B)$ and n_A and n_B and $n_{AB}=n_A+n_B$ are the numbers of points in A, B and AB respectively. Since these sums of distances are equivalent to within cluster sums of squares, they are denoted SSE_A, SSE_B and SSE_{AB}. Ward's method joins the two clusters A and B that minimize the increase in SSE, defined as:

$$I_{AB}=SSE_{AB}-((SSE_A+SSE_B) \quad (7)$$

To determine optimal number of clusters was used indicator semi partial R-Square. The result of cluster analysis is presented on the map of Europe where every country is coloured according to corresponding cluster.

Results

Situation in the Europe is characterized by descriptive statistics of indicators which can significantly influence food security situation. Indicators are ordered according to pillars. At the end of this part are described background variables which are not included in the pillars but they are closely connected with the food security. Summary of the descriptive statistics is in the Table 1. Table includes also average value of each indicator in the world (third column) to make situation in Europe comparable with situation in world.

In the food expenditure could be expected higher values in case of less developed countries with lower income level, and low values in developed countries with high income. Average share of food expenditure was 18.13% with the standard deviation 10.02%. Almost half of the analyzed countries exceeded 14.12% share of the food expenditure. Minimum value was in the United Kingdom (9.16%) and Switzerland (9.26%). The highest value of food expenditure was in Romania (49%) where people spend almost half of their expenditure on food. High values were also recorded in Belarus (39.2%), Ukraine (38.9%) and Serbia (27.4%). Average value of this indicator in the world was 33.9%, which means that people in Belarus and Ukraine spend on their food greater proportion of their income than world average. Most of the analyzed countries recorded value of food consumption share under 30%. Food consumption in Slovakia represent 17.36% which is slightly under the European mean and similar to the rest of central European countries (Czech Republic 15.4%, Poland 18.5% and Hungary 17.6%, all countries are below European mean). The difference between highest and lowest food consumption is 40.24p.p. Variability expressed by coefficient of variance was 55%, which means great differences across European countries in food consumption between European countries.

Table 2. **Descriptive statistics of selected food security indicators**

Indicator	Mean	World Mean	St. Dev	Min	Max	Range	Median	Coeff of variation (%)
Food expenditure	18.13	33.9	10.02	9.16	49.40	40.24	14.12	55.28
Poverty	0.46	25.9	1.01	0.00	3.92	3.92	0.00	218.69
GDP per capita	34131.5	18559	14208.8	8400	68040	59640	34405	41.63
Average food supply	3341.1	2855	267.21	2724	3793	1069	3388.5	8
Public expenditure on agricultural R&D	2.96	2	2.07	1.00	8.00	7.00	2.50	69.76
Volatility of agric. prod.	0.14	0.12	0.08	0.06	0.37	0.31	0.13	55.99
Corruption	1.62	3	1.15	0.00	4.00	4.00	1.50	70.95
Food loss	2.86	5.4	2.01	0.40	9.17	8.77	2.28	70.42
Diet diversification	66.81	52	6.25	53.00	76.00	23.00	68.50	9.35
Human Development Index	0.85	0.687	0.06	0.73	0.94	0.21	0.87	6.68
Global Gender Gap Index	0.74	n/a	0.05	0.62	0.85	0.23	0.73	7.37
EIU Democracy Index	7.74	5.8	1.41	3.69	9.93	6.24	7.94	18.17
Prevalence of Obesity	20.92	16.1	3.88	14.90	29.30	14.40	20.70	18.55

Source: author´s work based on Global Food Security Index 2015 database by The Economist Intelligence Unit

Second indicator expressed proportion of population under global poverty line. In most of the analyzed countries was value of this indicator close to 0. Significantly different values from 0 were recorded in 9 countries: Ukraine (0.03%), Poland (0.11%), Hungary (0.17%), Serbia (0.47%), Slovakia (0.49%), Romania (1.59%), Turkey (2.56%), Spain (2.67%) and Bulgaria (3.92%). Average proportion of poverty in the world is 25.9%, therefore can be concluded good situation in all European countries.

Most frequently used measure of economic development is GDP per capita. Average value of GDP per capita in the analyzed set of countries was 34131$ per capita with standard deviation 14208.83$ per capita. Half of the countries reached less GDP than 34405$ per capita. Difference between country with highest (Norway 68040$ per capita) and lowest GDP (Ukraine 8400$ per capita) is 59640$ per capita. This value suggests big differences in economic development across Europe. This is confirmed also by coefficient of variation, which means that standard deviation is almost 42% of average. Most developed country in the central European region is Czech Republic (29170$ per capita), then Slovak Republic (27640$ per capita), Hungary (24570$ per capita) and Poland (24470 $ per capita). All central European countries performed below mean value. Average value of this indicator in the world is 18559 $ per capita.

Another important food security indicator is the average food supply. The average value of this indicator in the European countries was 3341 kcal/capita/day with standard deviation 267.21 kcal/capita/day. More than 50% of the analyzed countries reached food supply over 3388 kcal/capita/day. Highest value of food supply was in Belgium (3793 kcal/capita/day), Austria (3784 kcal/capita/day) and Turkey (3680 kcal/capita/day). Lowest food supply was in Serbia (2742 kcal/capita/day), Bulgaria (2877 kcal/capita/day) and Slovakia (2902

kcal/capita/day). Food supply in Serbia was even less than world average which is 2855 kcal/capita/day. Variability expressed using coefficient of variation was 8% which mean low difference in food supply among analyzed countries. There can be concluded that all European countries are well supplied. Situation in the central European region is similar. Highest food supply in Central European region was in Poland (3485 kcal/capita/day), which is only central European country above mean value. The rest of central European countries performed under average (Czech Republic 3292 kcal/capita/day), Hungary (2968 kcal/capita/day) and Slovakia (2902 kcal/capita/day).

Relationship between average food supply and GDP is shown on the figure 1. Blue lines on the figure refers to average value of the indicators in Europe and create four quadrants. In the left bottom quadrant are countries with under average value of both indicators. In the upper right quadrant are localized countries with over average value of both indicators. The right bottom and upper left quadrant is for countries with the under average value of one indicator and over average value of the other. Red lines refer to average value of indicators in the world.

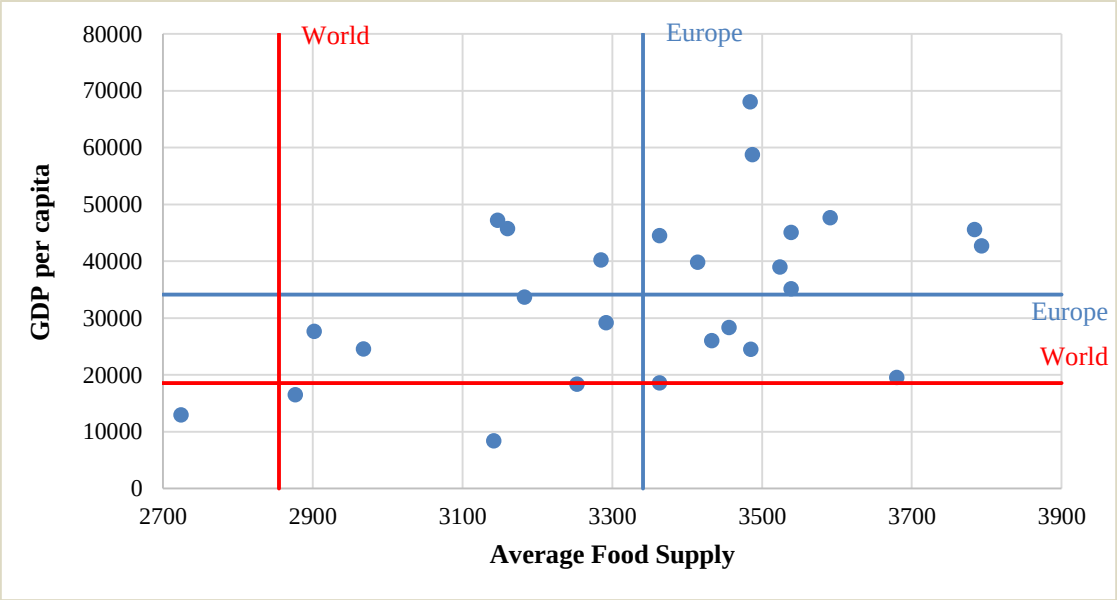

Figure 1. **Average food supply vs. GDP per capita**
Source: author´s work based on Global Food Security Index 2015 database by The Economist Intelligence Unit

Expenditure on agricultural research and development is another indicator belonging to second pillar of food security. Average mark among evaluated countries was 2.68. Highest spending on agricultural research and development was recorded in Ireland and Netherland (both 8) which clearly over performed the rest of the Europe. Second place belong to France, Germany and Spain (5). The worst result (evaluated 1) was recorded in Norway, Greece, Denmark, Romania, Czech Republic, Belarus, Sweden, Ukraine, Hungary and Serbia. Best result in the expenditure on agricultural research and development in central European region was in Slovakia (4) and Poland (2). This refers to good situation in agricultural research and development, compared to world mean has score 2.
Volatility of Agricultural production is another indicator in accordance with second pillar. Many countries recorded relatively low level of production volatility, which means sufficient amount of available production. Average value of volatility was 0.14, and 50% of countries performed over value 0.13. Highest volatility of production was recorded in Belgium (0.37)

and Bulgaria (0.31). Lowest volatility of agricultural production was in Greece (0.059), Denmark (0.062) and Turkey (0.066). Value of this indicator is strongly influenced by climate and environmental conditions in analyzed countries. Highest volatility in central European region was in Hungary (0.25) and Slovakia (0.18) then followed Poland (0.13) and Czech Republic (0.12). This result means stable agricultural production in central European region. Average volatility of agricultural production in the world is 0.12.

Another factor which influence availability of food, especially in less developed countries, is corruption. This factor is also important for overall development of the country. Average value of this rating in European countries was 1.62, with standard deviation 1.15. 50% of countries performed over value 1.5. Highest risk of corruption was found in Ukraine (rating 4). Then followed Bulgaria, Romania, Serbia, Italy, Turkey and Greece (rating 4). Lowest risk of corruption (rating 0) was found in Switzerland, Netherland, Sweden, Norway and Denmark. Risk of corruption in all central European countries was evaluated by rating 2. This means stable situation in the set of analyzed countries, whereas average score in the world is 3.

Last indicator in the pillar 2 is food loss. Average value of this ratio in the analyzed set of countries was 2.86 with standard deviation 2.01. 50% of countries recorded food loss above 2.28. Highest food loss was in Romania (9.17) and Turkey (8.98) which clearly exceeded the rest. Then followed Greece (4.57) and Serbia (4.28). This result suggests low efficiency of food industry in these countries. On the other side, lowest food loss was in Finland (0.19) and Switzerland (0.39). The only central European country with food loss value over average is Poland (3.75). Then follows Hungary (2.74) and Slovakia (2.36). Least value of food loss in region was found in Czech Republic (1.36). All Central European countries are below world average which is 5.4.
The only indicator from the pillar 3 included in presented analysis is diet diversification. Average value of this indicator was 66.81% with the standard deviation 6.25%. 50% of analyzed countries exceeded 68.5%. Highest share of non-starchy foods in total dietary consumption was in Switzerland (76%), Spain (75%), Austria (74%), Netherlands (73%) and Germany (72%). All of these are developed countries where population prefer healthy lifestyle. On the other side, the least share of non-starchy food in total dietary energy consumption was recorded in Turkey (53%), Romania (55%), Bulgaria (57%) and Ukraine (58%). Central European countries with the result over average were Hungary (70%) and Czech Republic (69%). Slovakia (65%) and Poland (59%) performed under the mean. Diet diversification is connected not only with food supply, economic development but also with eating habits in analyzed countries. All countries in the Europe recorded greater diet diversification than world average (52).

All variables described above were included in the basic three pillars of food security. In our research work were also analyzed background variables closely linked with food security – Human Development Index, Global Gender Gap Index, EIU Democracy Index and Prevalence of obesity. Average value of HDI in the set of analyzed European countries was 0.85 with standard deviation 0.06 which means well developed countries with low variability. 50% of the countries reached level above 0.87. Most developed countries are Norway (0.94), Switzerland (0.92), Netherlands (0.92) and Germany (0.91). On the other side, least developed in the analyzed set of countries were Ukraine (0.73), Serbia (0.74) and Turkey (0.76). The only central European country which performed over average value was Czech Republic (0.86). Then followed Poland and Slovakia (both 0.83) and Hungary 0.82. According to this indicator are all the analyzed countries developed better than world average (0.687)

Another background variable is Global Gender Gap Index. This indicator is also connected to almost all sectors including agriculture. There can be expected better gender equality in more developed countries. Average value was 0.74 with standard deviation 0.05. 50% of countries performed under 0.73. Highest value of this index were recorded in northern European countries Finland (0.85), Norway (0.84) and Sweden (0.82). Least gender equality was found in Turkey (0.62), Czech Republic (0.67), Hungary (0.68), Greece (0.68) and Slovakia (0.68). All central European countries performed under average, best result was in Poland (0.7). The rest of the central European countries was among the worst in the Europe.

Variable which can indirectly affect food security (especially access to food) is the state of democracy, in this case quantified using EIU Democracy Index. Average value of this index in the set of analyzed countries was 7.74 with the standard deviation 1.41. 50% of the countries reached even higher value than 7.94. This means good status of democracy in most of the analyzed countries. Best situation is in Norway (9.9), Sweden (9.7), Denmark (9.1), Switzerland (9.1) and Finland (9.0). Most of the countries with the highest democratic score is situated in the Northern Europe. Worst state of democracy was recorded in Belarus (3.6), Turkey (5.1) and Ukraine (5.4). These countries were also below world average which is 5.8. Best result in central Europe was recorded in Czech Republic (7.94), which is actually value of median. The rest of central European countries performed under the average were Poland, Slovakia and Hungary (7.5, 7.4 and 6.9 respectively).

Last indicator used in the presented analysis was the prevalence of the obesity. This indicator can influence consumption and therefore sufficiency of the food. Indicator can be also used as the measure of the quality of diet. Average value of the indicator was 20.92% with the standard deviation 3.88%. 50% of countries recorded more than 20.7% of obese population over 20 year of age. Highest share of obese population was found in Turkey (29.3%) and Czech Republic (28.7%). On the other hand, the least share of obese population was found in Switzerland (14.9%) and France (15.6%). All central European countries scored among most obese nations. There are Slovakia, Hungary and Poland (24.6%, 24.5% and 23.2% respectively). Prevalence of obesity in most countries is above world average which is 16.1%.

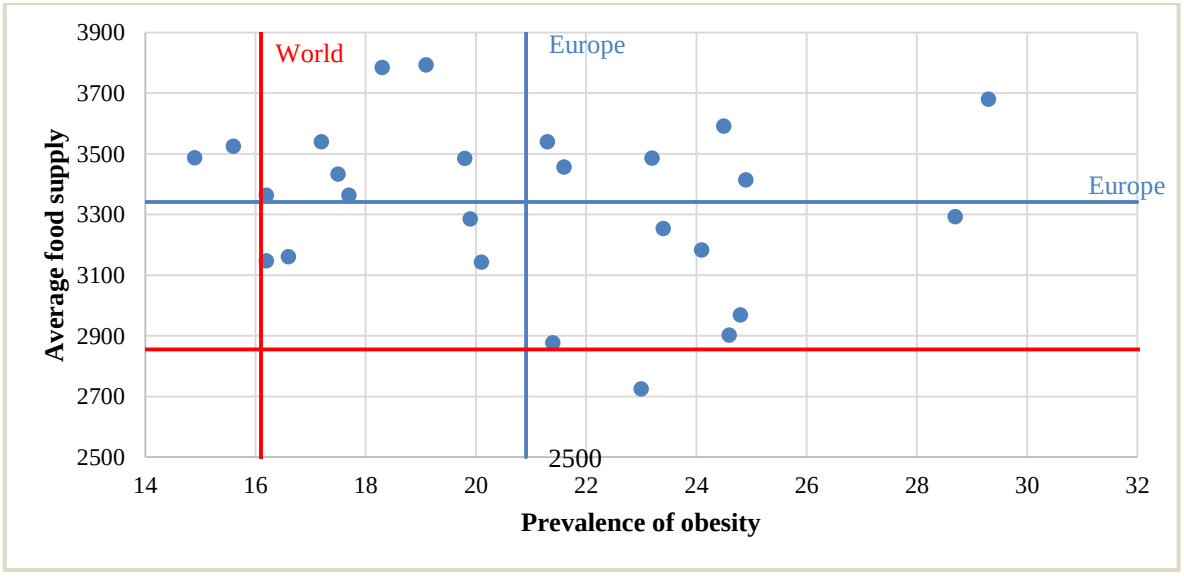

Figure 2. **Prevalence of obesity vs. Average food supply**
Source: author´s work based Global Food Security Index 2015 database by The Economist Intelligence Unit

Relationship between prevalence of obesity and average food supply is on the figure 2. The logic of the figure is the same as was in the previous case (figure 2). There cannot be found clear relationship, but on the other side it is obvious which countries are above or under average. There can be also identified countries with low prevalence of obesity despite of high food supply and on the other side, countries with high prevalence of obesity despite of high food supply.

Obesity seems to be problem in most of the developed countries. Factors which can influence this fact can be various. One of them could be possibly also diet diversification. Relationship between diet diversification and prevalence of obesity is shown on the figure 3. Between countries with higher prevalence of obesity is also Spain despite of great diet diversification.

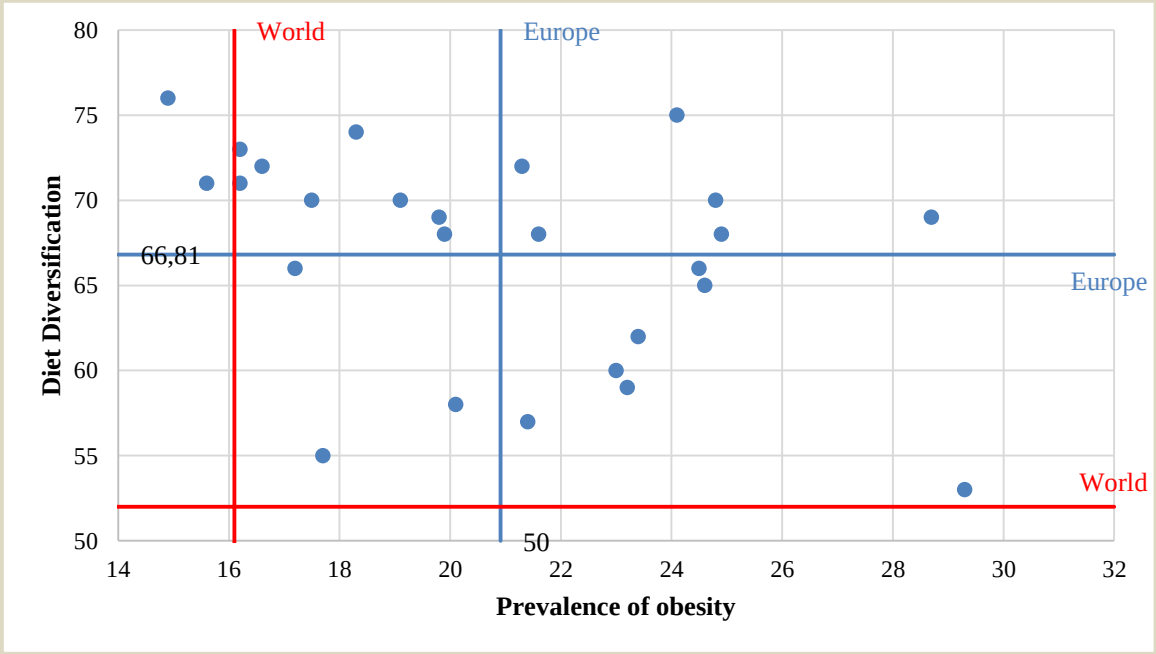

Figure 3. **Prevalence of obesity vs. Diet diversification**
Source: author´s work based Global Food Security Index 2015 database by The Economist Intelligence Unit

4. Classification of the countries according to selected food security indicators

Multivariate analysis of principal components was applied to reduce dimension of the data and remove collinearity among variables. Result of this analysis were four standardized principal components. First component can be characterized as the Economic and development factor. Highest weights in the first component have variables: HDI, GDP, Democracy index and Diet diversification. Highest negative weight has corruption and food expenditure. Second component is connected with agriculture, because highest weights have variables expenditure on agricultural research and development, food loss and food supply. Significant role in this component plays also poverty and prevalence of obesity. Third component is closely connected with negative factors with highest weight on poverty and volatility of agricultural production. Significant role in this component play also Global Gender Gap Index. Last component is connected especially with food usage. Highest weight has Average food supply and Food expenditure. Highest negative weight in this component has Prevalence of obesity. All principal components with weights for each variable are in table 2.

Table 2. **Principal components**

Variable	Principal 1	Principal 2	Principal 3	Principal 4
Food expenditure	-.303025	-.312451	-.121643	0.284753
Poverty	-.214778	0.351857	0.535971	0.081937
GDP per capita	0.362882	0.077126	0.085546	0.111197
Average food supply	0.158529	0.299565	-.358728	0.688100
Expenditure on ag. R&D	0.146512	0.536935	0.028553	0.049987
Volatility of ag. Prod.	-.141657	-.208994	0.541757	0.131087
Corruption	-.345626	0.005508	-.108371	0.033430
Food loss	-.255586	0.388452	0.265563	0.187280
Diet diversification	0.327935	-.010887	-.006097	-.249595
HDI	0.371785	0.087755	0.029780	0.000807
GGGI	0.285921	-.231709	0.342087	0.132949
Democracy Index	0.340685	0.015870	0.209255	-.091548
Prevalence of Obesity	-.187974	0.371779	-.153674	-.531156

Source: author´s work based Global Food Security Index 2015 database by The Economist Intelligence Unit

Estimated four components were used as the inputs into cluster analysis. This analysis was used in order to classify countries into different clusters according their performance. Countries in the same cluster should be similar in terms of analyzed indicators, on the other hand clusters should be as different as it is possible. Countries were classified into six clusters presented on the figure 4.

First cluster includes 5 countries: Austria, France, Germany, Ireland and Netherlands. All these countries can be characterized as developed countries with great quality of democracy and human development, and also low gender, no poverty, very low rate of corruption and obesity. From the point of food security view, all these countries have high food supply and high investment into agricultural research and development with great diet diversification.

Second cluster includes four countries: Greece, Poland, Portugal and Italy. All of these countries have great food supply and low rate of volatility in agricultural production. Despite of well evaluated state of democracy in these countries it is there present significant rate of corruption.

Third cluster includes countries: Sweden, Finland, Switzerland, Norway, Denmark and Belgium. All of these countries are developed countries with high value of GDP per capita and low rate of obesity and corruption. The only difference with the first cluster is in lower food supply and very low rate of food loss.

Fourth cluster includes Belarus, Ukraine and Romania. These countries recorded highest share of the food expenditure, low GDP, very low investment into agricultural research and development, low level of human development and democracy. All these countries are characterized also by the presence of poverty and very high rate of corruption and high rate of volatility of agricultural production.

Cluster number five includes only two countries: Turkey and Bulgaria. These two countries report highest rate of poverty among analyzed set of countries. There is also very high rate of corruption, great volatility of agricultural production and very high food loss. These countries

can be also characterized as less developed with bad diet diversification, poor state of democracy according index and great gender gap. In spite of less development, there is evident high prevalence of obesity.

Sixth cluster includes Serbia, Slovakia, Hungary, Spain, United Kingdom and Czech Republic. In most of these countries is still present poverty. Other common characteristics of these countries includes low food supply, good diet diversification and high prevalence of obesity. Last two facts are probably reason why Great Britain was surprisingly classified into this cluster.

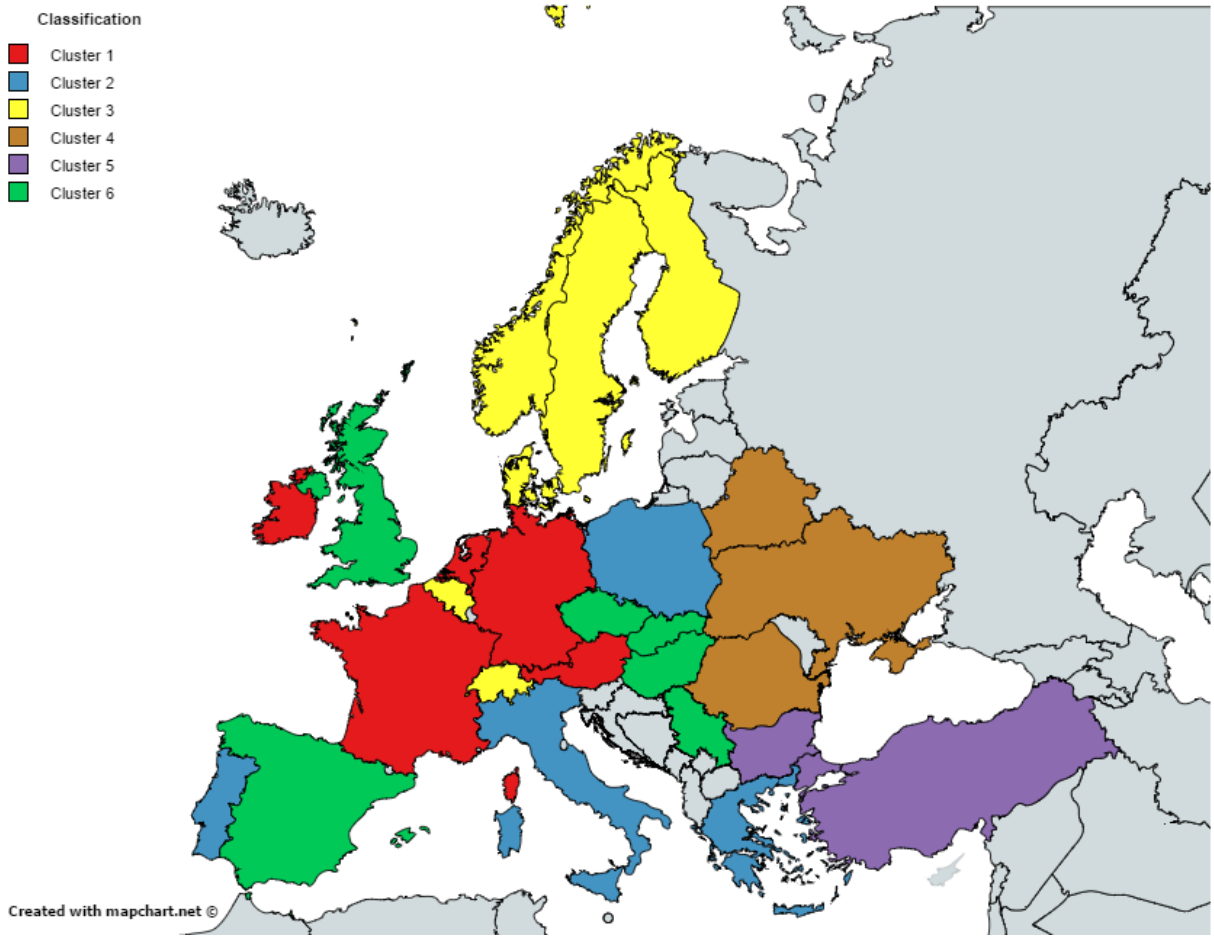

Figure 4. **Classification of European countries according their food security indicators**
Source: author´s work based Global Food Security Index 2015 database by The Economist Intelligence Unit

5. Discussion

On the field of food security was already published many papers which investigated food security at the national level. Some of them were selected to offer discussion with presented result.

Michiel van Dijk et al. (2016) (23) used scenario analysis to investigate food security. They present four scenarios to explore global food security up to 2050. They described process, storylines and drivers designed for food security modelling. The six key long-run drivers are: population growth, GDP per capita, cereal yield, nominal rate of assistance, meat

consumption and land use. Key drivers used in scenarios analysis are also used in a set of indicators in the Global Food Security Index. These authors used different approach to food security analysis, and also analyzed global food security status, however presented paper investigated national food security. Various ways of analyzing and measuring food security lead to different views of global food security and different attitudes to solve global food security problems. Global level is significantly influenced by national food security level. In conclusion we can confirm significant role of economic and lifestyle indicators in food security status.

Different types of public policies which can influence food security situation at country's level were analyzed by another team of authors (QURESHI – DIXON – WOOD 2015) (24). They conclude that the effectiveness of food security policies is determined by selecting the best bundle of policy instruments for the specific context and country and that tradeoffs between policy instruments should be well-understood, in order to achieve the right goals and avoid perverse outcomes. However, policy analysis was not the objective of this paper, it is obvious that policy instruments has significant influence especially in effective food production and allocation. This is measured by many indicators in presented analysis which also show weak spots in some of the analyzed countries. It can be concluded, that some countries are still looking for their best bundle of policy instruments.

On the other hand, FIREL – FORD (2015) argue, that food security is not just a food policy issue. (25) These influences operate both directly through the food system and indirectly through political, economic, social, and cultural pathways - peoples' dietary behaviors are a response to the broader daily living conditions in which they are born, live, learn, work and age. They propose that to address food insecurity and diet-related death and disease, policy must tackle the systemic problems that generate poor nutrition in all its forms, and reflect how our food systems are making people sick. This has implications for economic, agriculture, food, social and health policy at the global, regional, national and local levels. Presented paper offer another proves for this argument. Especially in case of developed European countries, there raised new problems connected with proper diet diversification and prevalence of obesity which will be challenge in following years. This is also responsibility of developed world in view of still developing countries with hunger issues.

GODFRAY – BEDDINGTON – CRUDE et. al. (2010) claim, that growing competition for land, water, and energy, in addition to the overexploitation of fisheries, will affect ability to produce food, as will the urgent requirement to reduce the impact of the food system on the environment. (26) The effects of climate change are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably. They emphasize, that multifaceted and linked global strategy is needed to ensure sustainable and equitable food security, different components of which are explored here. On the other hand, this paper offered strong evidence that even in case of developed European countries, responsible sustainable food security policy is still needed.

Conclusions

The main objective of the presented paper was to offer general overview of the food security situation in selected European countries and indicators which can influence it. After detailed analysis of indicators relevant for the situation in Europe can be concluded that food security situation in Europe is stable in relation to all pillars of food security, but there are still some weak spots especially in less developed countries.

Main problem which can influence especially affordability and availability of food in sufficient amount is poverty which is still present in some countries despite of relatively good situation in Europe. This is actual problem especially in Bulgaria, Spain, Turkey and Romania. This problem can be even deeper in the future when will be connected with current immigration crisis. In contrast with obesity can be concluded serious problem with allocation of food supply.

Another important problem is low efficiency of food use and huge food loss especially in Turkey and Bulgaria. High food loss problem concerns also European commission and is also mentioned in the European action plan for the Circular Economy (European Commission 2015), which suggest certain actions on this field. However, this problem is still actual in the entire Europe. Overall European mean (2,86) is according Global Food Security Index records (2012) much higher than average food loss in the United States (0,9).

Development is connected with efficient use of available food in adequate quality, quality of food influence wellbeing and quality of life of the population. Last few years, especially in developed countries raised new problem, which is not connected with insufficient food supply, but with prevalence of obesity which decrease quality of life in many developed countries. Average prevalence of obesity in analyzed countries was 20,92%, which is accounted only for population in the age over 20. Solving of this problem is challenge and is also connected with promotion of healthy lifestyle and adequate food allocation.

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