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# Enlarging the Application of the Food Security Index at European Union Regions

Larisa Mihoreanu[1)], Mariana Laura Cismaş[2)], Laura Maria Dănilă (Jianu)[3)]
[1)] KCL, United Kingdom [2)3)] The West University, Timişoara, România[1]

**Abstract.** *The food security remains a major priority and a typical issue that requires immediate international solutions. Recent studies reveal the increasing complexity of food security issues focusing on the necessity to address formal actions and solve the dramatic situations. New tools are always welcome to facilitate solutions' implementation. In September 2015, the United Nations Assembly adopted the 2030 Agenda of Sustainable Development among the goals of which the followings are fundamental: no poverty, zero hunger, good health and well-being, clean water and climate action. The European Union joined the Program, expressing the full commitment to its implementation. According to the Food and Agriculture Organization (FAO), the number of undernourished people reached in 2017 about 821 million peoples, representing an increase from about 804 million peoples in 2016. The 2018 statistics of FAO state that 22% of children under-five are affected by malnutrition, while over 38 million children in the same age group are overweight.*
*Beyond premises, as a novelty, we contribute to food security knowledge by calculating a regional index at European and Romanian levels to better outline the realities and provide the decision-makers with a new tool to find better solutions.*

**Keywords:** Food security, regional index, measurements and indicators, European Union

**JEL Codes:** I30, I32, F60, D69

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## 1. Introduction

The concept of food security originated at the World Food Summit in 1974, where it was defined as the "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (FAO, 1975). According to Maxwell and Smith (1992), about 200 definitions of the concept of food security circulated during 1970-1990. Some of them focused on: "ensuring that all people at all times have physical and economical access to the basic food that they need" (UN, 1975) while others were watching the "access of all people at all times to enough food for an active, healthy life" (WB, 1986).

What initially started with defining the concept continues nowadays with measuring it to all its dimensions, to adapt it to the present world challenges: rapid political, economic and climatic changes and together with a wilder globalization. The main dimensions of food security concept that we consider at the moment are: a) availability, b) affordability, c) utilization and d) stability (Davood, 2017). There are also

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debates on the vertical levels of this concept, from the global to the individual level, about their relevance and suitability. At the individual level, the indicators are easier to highlight and measure; meanwhile, at a regional, national or global level the best indicators to use allow comparing situations between states or regions.

In order to quantify food security, researchers used/calculated different indexes or, combining indicators, tried to better understand a very complex issue of our world (Asih and Klasen, 2017).

One of those indices is the Global Food Security Index calculated by The Intelligence Unit (EIU) on a sample of 113 countries, including most of EU's member states. The index takes into consideration the following four dimensions of the food security concept: • affordability, • availability, • quality & safety, and • natural resources & resilience. Several indicators are associated to these dimensions; indicators that once normalized give a score allowing comparisons between the countries in a certain sample.

The Food and Agriculture Organization (FAO) of the United Nations measured the intensity of food deprivation, which "indicates how much food-deprived people falls short, on average, of minimum food need in terms of dietary energy. It is measured as the difference between the minimum dietary energy and the average dietary energy intake of the undernourished population (food-deprived)". (FAO, 2009, 2018).

FAO in collaboration with other organizations like UNICEF (the United Nations Children's Fund), IFAD (the International Fund for Agricultural Development), WFC (the World Food Programme) and WHO (the World Health Organization) are publishing an annual report titled "The State of Security and Nutrition in the World" about "monitoring the progress towards achieving a world without hunger and malnutrition. They define the following indicators: "prevalence of undernourishment" and "food insecurity", "stunting, wasting and overweight in children under-five years" (FAO, 2018). In September 2015 the United Nations Assembly adopted the 2030 Agenda of Sustainable Development with 17 goals and 169 targets. The Agenda's goals are: no poverty; zero hunger, achieve food security and promote sustainable agriculture; good health and well-being for all; equitable and inclusive education and promote lifelong learning; gender equality; clean water; affordable, reliable and sustainable energy; sustainable economic growth, full, productive and decent work; resilient infrastructure, sustainable industrialization and foster innovation; reduce countries disparities; make cities and human settlements inclusive, safe and resilience; sustainable consumption; combat climate changes; conserve the oceans, seas and marine resources; protect, restore and promote sustainable use of terrestrial ecosystem; promote peace, provide justice for all and build effective, accountable and inclusive institutions at all levels; and to revitalize the Global Partnership for Sustainable Development. In November 2016, the European Union presented its response to the 2030 Agenda, stating that the EU is committed to implement the Sustainable Development Goals. It seems that food security became a top priority on many Agendas and a topical issue that still requires solutions. Recent studies also reviled its complexity and its multiple dimensions. Based on desk research the present paper is constructed as a review of recent literature on the field and includes the current state of knowledge on the food security subject that will be expended to contain the EU framework on this specific topic. We apply the Global Food Security Index knowledge to calculate a new index at NUTS 2 level (Nomenclature of Territorial Units for Statistics - regional level), for EU's regions, using the data provided by Eurostat.

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## 2. Review of scientific literature

Generic and accessible references make the availability and accessibility of food safe. Concerns in this area existed since the ancient times and civilizations – from The Dynasty Qin in China (220-205 BC) and Egypt, for building and managing food stores to be used in times of famine until the Ottoman Empire where clues about the first food transport and distribution policies have been brought to light (Edgerton-Tarpley, 2017). Other important details about the food security concept dates back in 1943; during the Spring Food and Agriculture Conference, references were made to "a safe, adequate and appropriate diet for all" (Napoli, 2011). Another step forward was the establishment of bilateral agencies by donor countries (USA and Canada in the 1950s) that facilitated the transfer of their agricultural surpluses abroad to countries in need. Since the 1960s, the growth of national consciousness influenced also the implementation of the idea that food aid hinders the progress of nations; it was the time when the concept of Food for Development has been born through self-sufficiency. The concept was institutionalized in 1963 through the World Food Program - WFP (Napoli, 2011). According to Fabio Gaetano Santeramo (2014), "the food security debate is growing rapidly and connects to a wide range of disciplines"; thus, it becomes a major issue for academic and international debates, "its global impact on economic fundamentals being already a matter of concern." In 1996, at the World Food Summit, FAO's definition devoted to the field of food security a wider scientific basis reinforcing its multi-dimensional nature by including in the concept the idea of access to food, availability, food use, and stability. In other words, food security exists when "all people have physical and economic access to sufficient safe and nutritious foods that meet their food needs and nutritional preferences for an active and healthy life" (FAO, 2018).

There are four dimensions of the problem: a) availability, b) food security supply, determined by the level of food production, stock level and net trade; c) accessibility - with reference to the sufficiency and access level to food within a household, to ensure the security of food safety; d) use of food, commonly understood as how the body uses in the own benefit, most of the food different nutrients. The appropriate amount of energy and nutrients consumed by the body is the result of the good practice of care and feeding, of the food preparation. In combination with a good biological use of food, the good practices contribute to the determination of the nutritional status of individuals (Leroy, 2015), to the stability over time for the availability, accessibility and use of food (FAO, 2010). A subsidiary dimension of food security is linked to the food insecurity; the analysts have defined two general types of food insecurity - chronic and transient; their characteristics are described below, in table 1.

An important part of the scientific literature in the field refers to the measurement of food security, from simple indicators like: proportion of children who are underweight, percent of undernourished children, children under five stunting, children at risk of morbidity and mortality, to a series of complex indexes computed (Luca, 2013), such as: the Global Hunger Index (GHI), the Action Aid Hunger Index, the Poverty and Hunger Index, the Hunger and Climate Vulnerability Index, the Composite I-distance Indicator (CIDI), the Global Food Security Index (GFSI), etc.

The Global Hunger Index (GHI) is a score computed by International Food Policy Research Institute (IFPRI), using four component indicators: the percentage of the population that is undernourished (PUN), the percentage of children under five years old who suffer from wasting (low weight-for-height) (CWA), the percentage of children under five years old who suffer from stunting (low height-for-age) (CST), and the percentage of children who die before the age of five (child mortality) (CM). After the values for the

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indicators are calculated using available data for each country, the next step is to standardize component indicators by giving them a standardized score based on thresholds set slightly above the highest country level values observed worldwide for that indicator (Luca, 2013). In the end, the standardized scores are aggregated to calculate the GHI score for each country.

Table no. 1: The two general types of food insecurity

| | CHRONIC FOOD INSECURITY | TRANSIENT FOOD INSECURITY |
|---|---|---|
| is… | long-term or persistent. | short-term and temporary. |
| occurs when… | people are unable to meet their minimum food requirements over a sustained period of time | there is a sudden drop in the ability to produce or access enough food to maintain a good nutritional status. |
| results from... | extended periods of poverty, lack of assets and inadequate access to productive or financial resources. | short-term shocks and fluctuations in food availability and food access, including year-to-year variations of the domestic food production, food prices and household incomes. |
| can be overcome with... | typical long term development measures also used to address poverty: education or access to productive resources, such as credit. They may also need more direct access to food to get their productive capacity raised. | transient food insecurity is relatively unpredictable and can emerge suddenly. This makes planning and programming more difficult and requires different capacities and types of intervention, including early warning capacity and safety net programmes. |

Source: FAO, 2009, Food Security Information for Action. Practical Guides.

$$GHIscore = \frac{1}{3} \times PUNs + \frac{1}{6} \times CWA_z + \frac{1}{6} \times CST_z + \frac{1}{3} \times CM_z \quad (1)$$

Both the undernourishment and child mortality contribute one-third of the GHI score each, while the child under nutrition indicators – the loss of a child and child stunting— contribute with one-sixth of the score. The GHI was calculated in 1992 for 95 countries, in 2000 for 115 countries, in 2008 for 118 countries and in 2017 for 119 countries. Between the 119 countries, there are few European Union member states: Bulgaria, Croatia, Estonia, Latvia, Lithuania, and Romania. The score calculated in 2017 for Croatia, Estonia, Latvia and Lithuania is less than 5, as for Bulgaria is 5.4 and for Romania is 5.2 (IFPRI, 2017).

The Hunger and Climate Vulnerability Index computed by Krishnamurthy et all started with the purpose to quantify the vulnerability to the climatic conditions that „increase the food security risks faced by households or communities in case of a shock". They used a set of indicators selected based on a statistical analysis which determines the correlation between some specific indicators and undernourishment (Krishnamurthy et al., 2014).

The indicators selected are organized under six profiles, as follows:

- climate hazard risk including the indicators: mortality (per 100,000 population), reported economic losses per capita (% of GDP), number of droughts (2000–2010) (per unit), number of floods (2000–2010) (per unit), and the number of storms (2000–2010) (per unit);
- agricultural environment: forest cover (% of total area), Rainfed agriculture (% of total agriculture), and cereal crop production (yield/ha);

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- low elevation coastal zones (LECZ): the population in LECZ (% of total) and the rural area in LECZ (% of total);
- infrastructure: water access (rural population, %), water access (urban population, %), and paved roads (% of all roads);
- socio-economic structure: population growth per decade (2000-2010, %), total population below poverty line (2 dollars per day at power purchasing parity, %), live employment (%), and rural population (%);
- governance: government effectiveness.

As the indicators have different units it was necessary to be standardized. The conversion is realized giving values to each indicator indexed and then represented as percentages of the maximum value" (Krishnamurthy et al., 2014).

$$I_s = \frac{I_r}{I_m} \quad (2)$$

where Is means Indicatorstandardized, respectively Indicatorvalue and Indicatormaximum

The indicator values were then summed to obtain the values of the components as arithmetic mean. Component values have been normalized, "such as the maximum value for each is 1.

$$\text{Component value} = \frac{I_1 + I_2 + \cdots + I_n}{n} \quad (3)$$

The normalized result values then multiplied to obtain the index score using the formula:

Vulnerability score = Exposurevalue x Adaptive capacityvalue (4)

The results show that the majority of countries have „above-average vulnerabilities (vulnerability ≤0.525)", the most common category is medium (0.4 ≤ Vulnerability ≤0.6) and just a few have low vulnerabilities (Vulnerability ≤ 0.2). (Krishnamurthy et al, 2014).

The Economist Intelligence Unit (EIU) is a research division of the Economist Group created in 1946. The division publishes free reports, „each year focusing on current issues affecting specific countries, regions and industries" (EIU). In 2018, the EIU calculated a global food security index for 113 countries. It is based on specific criteria and uses 50 indicators grouped in four pillars: a) accessibility, b) availability, c) quality and safety, d) natural resources and resilience related to the four dimensions of the increase of food security defined by the FAO. The analysis also reported data from several EU countries. The indicators were selected by the EIU experts. The fourth pillar was added in 2017. A country score is calculated, from a simple weighted average of the first three category scores (affordability, availability and quality & safety). The natural resources & resilience category is an adjustment factor that serves as a lens through which the overall food security can be noticed to demonstrate the changes of the overall score when „climate-related and natural resource risks are taken into account"(EIU,2018).

In theirs paper Redressing the Global Food Security Index: a Multivariate Composite I-Distance Indicator Approach (2016), Maricic and collaborators tried to „overcome the issue of subjectivity assigned weights to indicators and categories within the GFSI" and proposed a statistical method (I-distance method) to calculate the Composite I-distance Indicator (CIDI). They used the I-distance method to determinate one entity (country) as referent unit. In theirs analysis „the referent entity was the one with the minimal values". Then for a set of variables which they noted, in order to explain the method, XT =(X1, X2, X3, …, Xk)

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chosen for each country, the square I-distance between two countries er =(x1r, x2r, …, xkr) and the second one es =(x1s, x2s, …, xks) is calculated using the formula below:

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} (1 - r_{ji.12\ldots j-1}^2) \quad (5)$$

Where $d_i^2(r,s)$ is the distance between the values of Xi for er and es "e.g. the discriminate effect":

$$d_i^2(r,s) = (x_{ir} - x_{is})^2 \; t \in \{1, \ldots k\} \quad (6)$$

$\sigma_i^2$ is the variance of Xi, and rji.12…j-1 is a partial coefficient of the correlation between Xi and Xj with j<i. (Maricic et al., 2016).

According to the authors the I-distance method stands out because of its lack of bias. They also used Pearson's correlation coefficient in order „to measure the importance of each variable for the ranking process" (Maricic et al., 2016). The Pearson's correlation coefficient was determined for each indicator. The new weights are obtained by dividing the Pearson's correlation coefficient at the sum of all correlation coefficients.

The formula is the following: $W_i = \frac{r_i}{\sum_{j=1}^{k} r_j}$ (7)

where ri with i=1,2,…,k is the Pearson's correlation coefficient the i-th input variable and the I-distance value. The sum of weights obtained using I-distance method is 1. (Maricic et al., 2016). Once the new weights obtained, the authors calculated the CIDI scores and ranks, using the official GFSI data.

Hereinafter we present the top 20 ranked countries with their GFSI score and corresponding ranks already compared with the CIDI scores and ranks. There are differences, but the some countries do not change their positions while others slightly change them. For example, United States keep the top position after GFSI score and remains on the same position according to the CIDI score (GFSI score=89.0, CIDI score=89.09). The second placed is Singapore with a GFSI score by 88.2 and a CIDI score by 88.80, which still remains on the same place. Netherlands id placed after the GFSI score on the fifth position and after the CIDI score becomes the third, with a CIDI score higher with 1.80 points to GFSI score. In fourth place after CIDI score is Australia (GFSI score=88.3, GFI rank 9 and CIDI score=86.28), followed by Ireland (GFSI score=85.4, GFI rank 3 and CIDI score=85.80), France (GFSI score=83.8, GFI rank 10 and CIDI score=85.37), Canada (GFSI score=84.2, GFI rank 7 and CIDI score=85.17), Sweden (GFSI score=82.9, GFI rank 12 and CIDI score=85.11), Austria (GFSI score=85.1, GFI rank 4 and CIDI score=85.03), New Zealand (GFSI score=82.8, GFI rank 13 and CIDI score=84.64), Germany (GFSI score=83.9, GFI rank 8 and CIDI score=84.08), Denmark (GFSI score=82.6, GFI rank 14 and CIDI score=83.97), Switzerland (GFSI score=84.4, GFI rank 6 and CIDI score=83.59), Norway (GFSI score=83.8, GFI rank11 and CIDI score=83.40), Portugal (GFSI score=80.5, GFI rank 16 and CIDI score=83.27), Finland (GFSI score=79.9, GFI rank 17 and CIDI score=82.28), United Kingdom (GFSI score=81.6, GFI rank 15 and CIDI score=81.98), Spain (GFSI score=78.9, GFI rank 20 and CIDI score=81.36), Belgium (GFSI score=79.5, GFI rank 18 and CIDI score=80.83), and Israel (GFSI score=78.9, GFI rank 19 and CIDI score=80.20) (Maricic et al, 2016).

Countries changed grades / positions among themselves, but overall they remained in the top 20. In the other sections, the two methodologies used did not change the first 20 positions, with the overall vision for each country remaining the same.

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## 3. Research methodology

Using the GFSI methodology we have also calculated a regional food security index for all regions of the European Union. To do this, we selected several NUTS2 indicators relevant to food security, using the Eurostat database. The index considers the four dimensions of the concept of food security: • accessibility, • availability, • quality and safety, • natural resources and resilience. For each dimension, there are several associated indicators. The initial index used the weight of the first three dimensions as follows: accessibility (40%); availability (44%), quality and safety (16%). The fourth dimension was added in 2017.

The methodology used by the EIU explains the calculation of the index that followed the steps:

• the indicators have been normalized to become comparable;

• for the aggregation stage, normalized indicators are converted from a value of 0-1 into a score of 0-100. The highest score is 100 for the country with the highest gross data, and the lowest score is 0 assigned to the country with the lowest gross data.

Starting in 2017, it has been added to the natural resource adjustment factor and resistivity designed so that the user has the option to see the results with or without natural climate-related resistance. Starting 2017 they added to the category "Natural Resource and Resilience adjustment factor designed so that the user can opt to view the results with climate-related and natural resilience" or not. The formula for the overall score with the forth pillar accounting is:

$$Score=X*(1-Z) + [X*(Y/100)*Z] \quad (8)$$

Where X represents the initial score, Y is the fourth pillar score and Z is the adjustment factor weighting (meaning 0=0%; 0.5=50%, 1=100%, and the default setting for the adjustment factor weighting being 0.25=25% - EIU, 2018). The indicators on which the GFSI index is based are presenting in table no.2.

For the affordability indicators the data sources are the Nationals Institutes of Statistics, World Bank (WB) and World Trade Organization (WTO) and (EUI, GFSI 2018) for the calculation of EIU qualitative scores.

Table no. 2: The affordability indicators

| Indicator | Nominal Weight | Weight |
|---|---|---|
| Food consumption as a share of household expenditure | 2.750 | 22.2% |
| Proportion of population under global poverty line | 2.500 | 20.2% |
| Gross domestic product per capita (US$ PPP) | 2.750 | 22.2% |
| Agricultural import tariffs | 1.250 | 10.1% |
| Presence of food safety net programmes | 1.750 | 14.1% |
| Access to financing for farmers | 1.375 | 11.1% |

Source: EIU GFSI, 2018

For the availability indicators, the data sources are: World Bank, FAO, OECD and again the calculus of qualitative scores of the EIU.

Table no. 3: The availability indicators

| Indicator | Nominal Weight | Weight |
|---|---|---|
| Sufficiency of supply | 3.250 | 23.4% |
| Public expenditure on agricultural | 1.125 | 8.1% |

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| | | |
|---|---|---|
| R&D | | |
| Agricultural infrastructure | 1.75 | 12.6% |
| Volatility of agricultural production | 1.875 | 13.5% |
| Political stability risk | 1.375 | 9.9% |
| Corruption | 1.375 | 9.9% |
| Urban absorption capacity | 1.375 | 9.9% |
| Food loss | 1.750 | 12.6% |

Source: The Economist Intelligence Unit, GFSI 2018

In the case of sufficiency of supply there were two sub-indicators used–average food supply (kcal/capita/day) and dependency of chronic food aid. For the agricultural infrastructure there were three sub-indicators used - existence of adequate crop storage facilities, road infrastructure, sea-port infrastructure –qualitative assessments. (EUI GFSI 2018).

Table no. 4: The quality and safety indicators

| Indicator | Nominal Weight | Weight |
|---|---|---|
| Food diet diversification | 1.500 | 20.3% |
| Nutritional standards | 1.000 | 13.6% |
| Micronutrient availability | 1.875 | 25.4% |
| Quality of proteins | 1.750 | 23.7% |
| Food safety | 1.250 | 16.9% |

Source: EIU GFSI, 2018

The data sources for the indicators are as mentioned above. For the nutritional standards (Leroy, 2015) there have been used three sub-indicators - national dietary guidelines, national nutrition plans or strategy and nutrition monitoring and surveillance –qualitative assessments. For the micronutrient availability there were used three indicators – dietary availability of vitamin A (qualitative assessment), dietary availability of animal iron (mg/person/day) and dietary availability of vegetal iron (mg/person/day).

The food safety has three other sub-indicators: a) the possibility of ensuring food safety and health, b) the presence of the formal food sector as qualitative assessments, and c) the percentage of the population with access to drinking water as a percentage of the population using at least water Drinking Basic Services. EIU GFSI, 2018).

Table no. 5: The Natural resources and resilience indicators

| Indicator | Nominal Weight | Weight |
|---|---|---|
| Exposure | 3.00 | 21.8% |
| Water | 2.00 | 14.5% |
| Land | 2.00 | 14.5% |
| Oceans | 1.75 | 12.7% |
| Sensitivity | 1.50 | 10.9% |
| Adaptive capacity | 2.50 | 18.2% |
| Demographic stresses | 1.00 | 7.3% |

Source: EIUGFSI, 2018

Each indicator belonging to this category has sub-indicators most of them being qualitative assessments or indexes. The exposure score is based on six sub-indicators: temperature rise (an index

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computed by The Notre Dame Global Adaptation Initiative (ND-GAIN), drought (qualitative assessment 0-5 scale, 5 meaning most risk, from World Resources Institute Aqueduct (WRI)), flooding (an index computed by ND-GAIN), Storm severity from Global Assessment Report on Disaster Risk Reduction 2015), sea level rise (an index computed by ND-GAIN), and commitment to managing exposure (from a research program on Climate Change, Agriculture and Food Security of The Consultative Group on International Agricultural Research (CGIAR)). The water score is based on two: agricultural water risk-quantity and agricultural water risk-quality of WRI- Aqueduct. The land score is based on 1-4 scale for soil erosion/organic matter, where 1 means best soil quality (from Harmonized World Soil Database), on grassland as net emission/removals (CO2) from FAO database, and forest change regarding change in forest area as a percentage of total land area from World Bank database.

The oceans score is based on the eutrophication and hypoxia 0-2 scale, with 2 being associated to healthiest oceans (WRI source). It is to be mentioned here that for Romania it is considered 2, but we only have openness to sea. The second sub-indicator is marine biodiversity as a percentage (Yale Environmental Performance Index), and the third is marine protected areas from World Database on Protected Areas,

The sensitivity score is based on ratio of food import dependency from FAO database, dependence on natural capital (%) from World Bank database and disaster risk management from an EIU risk briefing based on World Bank's indicators on Climate Smart Agriculture, a scale 0-7 where 7 means the best.

The adaptive capacity score is based on two scales: early warning measures/climate smart, a 0-2 scale where 2 is best, and national agricultural risk management system, a 0-6 scale where 6 is best.

Finally, the demographic stresses score is about the population growth and the urbanization percentage, using the research program on Climate Change, Agriculture and Food Security of The CGIAR and World Bank's indicators on Climate Smart Agriculture. The index was calculated at a national level for 113 countries among which there are 20 member states of European Union, and the most of them have a "very good" score (15 out of 20), the rest of them having a "good" score. To compute the regional food security index the first step was to identify regional indicators related to the interest issue. Considering the lack of data on regional level regarding the category of natural resources and resilience we computed the index only for the first three dimensions of food security: affordability, availability and quality and safety. Using EUROSTAT database we selected some indicators on regional level associating them to a certain dimension. We also imputed two qualitative scores computed by the Economist Intelligence Unit, for the quality and safety dimension. This scores are offices to ensure the safety and health of food (qualitative assessment, 0 meaning no and 1 meaning yes), and presence of formal grocery sector a qualitative assessment on a 0-2 scale, where 0 for „minimal presence", 1 for „moderate presence" and 2 for „widespread presence" (EIU 2018). The next step was to normalize the indicators, a different method was used as for some indicators a high level represent a favorable environment, meanwhile for some indicators the lowest value represent the favorable environment. For indicators with a high level as a favorable environment the formula applied is:

$$X=(X-Min(x))/Max(x)-Min(x) \quad (9)$$

where X is the value of the indicator for a European Union region, Min(x) is the lowest value for an indicator among the EU regions and Max(x) is the highest value for an indicator among the EU regions. When the lowest value of the indicator is considered as a favorable environment the normalizing formula is: $X=(X-Max(x))/Max(x)-Min(x)$ (10)

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All the normalized values are 0 to 1 values. From values within the range 0-1 we transformed them into scores from 0 to 100, for each indicator.

Table no. 6: The indicators of regional food security index

| Affordability | Availability | Quality and Safety |
|---|---|---|
| Disposable income of private households (PPS per inhabitant) | Gross Value Added at basic prices for agriculture | Severe material deprivation rate (% of total population) |
| Regional gross domestic product (PPS per inhabitant) | Agriculture land used (percentage) | Offices to ensure the safety and health of food*(qualitative assessment, 0=no, 1=yes) |
| People at risk of poverty or social exclusion (% of total population) | Share of irrigable and irrigated areas in utilized agricultural area | Presence of formal grocery sector* (qualitative assessment, 0-2 scale) |
| People (0 to 59 years) living in households with very low work intensity (% of total population) | Animal populations (thousand head ) | |
| | Production of cow's milk on farms (1000 tone) | |

Source: EUROSTAT database, *EIU qualitative score, own processing

The weighting stage follows the normalization one in order to compute the affordability, availability and quality and safety scores. Inside each domain we applied equal weighting. Then for the overall score we used the first three dimensions weight used for GFSI index: affordability (40%); availability (44%), and quality& safety (16%).

## 4. Results and discussion

We firstly present below the results of the EIU's Global Food Security Index for the European Union member states, calculated for 20/28 EU countries. Nineteen of them are in the top 40; only Bulgaria occupies the 47th position of the 113 countries. Eleven of the twenty EU's member states are among the first top 20 and only five of them are among first ten ranked (Ireland rank 2, United Kingdom rank 3, Netherlands rank 5, Finland rank 8 and France rank 10).

Ireland has the higher overall score by 85.5 between the twenty member states, but has a low natural resources and resilience score by 69.2, the same as United Kingdom which has the next overall score by 85.0 and the lowest natural resources and resilience score by 64.8 among them. Even looking at the Global Food Security Index it is obvious that there are discrepancies between European Union's member states, and again Romania and Bulgaria are situated at the end of the ranking. Romania has an overall score by 68.9 and Bulgaria's overall score reaches only 64.5.

The Regional Food Security Index has been calculated for 276 NUTSII regions of EU's member states, based on the Eurostat database. All the regional indicators were analyzed. Given the lack of regional data on natural resources and resistance, we have calculated the index for the first three dimensions of food security only: accessibility, availability and quality and safety. The research faced numerous limitations, including: the lack of data at regional level, the lack of data for certain regions and for identified indicators; we have been obliged to let aside some indicators for which too much data was missing. That is why we have attributed some national data at regional level, because the ones for the regions missed. Here are the results of our processing below, in table no.8.

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Table no.7. Global Food Security Index 2018 for European Union's member states

| | Rank | Overall score | Affordability | Availability | Quality/Safety | Resilience /Resources |
|---|---|---|---|---|---|---|
| Austria | 14 | 82.1 | 83.5 | 81.3 | 81.0 | 80.2 |
| Belgium | 17 | 80.2 | 81.1 | 79.0 | 81.2 | 68.5 |
| Bulgaria | 47 | 64.5 | 70.1 | 60.0 | 63.2 | 74.7 |
| Czech R. | 24 | 76.1 | 77.9 | 75.4 | 73.7 | 80.9 |
| Denmark | 16 | 80.9 | 82.5 | 79.0 | 82.3 | 81.5 |
| Finland | 8 | 83.3 | 81.3 | 84.2 | 86.0 | 71.8 |
| France | 10 | 82.9 | 80.5 | 83.8 | 86.5 | 76.0 |
| Germany | 11 | 82.7 | 82.9 | 83.6 | 79.7 | 75.7 |
| Greece | 33 | 71.6 | 69.4 | 69.2 | 83.7 | 74.6 |
| Hungary | 30 | 72.8 | 75.6 | 70.5 | 72.0 | 79.2 |
| Ireland | 2 | 85.5 | 87.8 | 83.6 | 84.8 | 69.2 |
| Italy | 23 | 76.3 | 79.2 | 71.6 | 81.9 | 74.3 |
| Netherlands | 5 | 84.7 | 82.8 | 86.1 | 85.1 | 67.9 |
| Poland | 26 | 75.4 | 76.4 | 75.0 | 74.1 | 77.7 |
| Portugal | 19 | 79.3 | 76.7 | 78.7 | 87.3 | 75.7 |
| Romania | 38 | 68.9 | 67.5 | 68.8 | 72.6 | 74.7 |
| Slovakia | 35 | 70.3 | 73.6 | 69.4 | 64.6 | 81.7 |
| Spain | 21 | 78.0 | 79.2 | 74.9 | 83.6 | 71.9 |
| Sweden | 12 | 82.2 | 82.0 | 81.7 | 83.9 | 77.3 |
| U. Kingdom | 3 | 85.0 | 82.6 | 88.8 | 804 | 64.8 |

Source: The Economist Intelligence Unit, the Global Food Security Index 2018

Concerning the quality and safety dimension, we identified only one regional indicator that attributed two EIU qualitative scores, official offices to ensure food safety and quality and the presence of the official food sector. Finally, while the global food security index is calculated for 2018, our available data to calculate the regional food security index is only by 2016. In the following, we present the top 10 and the last ten NUTS 2 regions after the overall score on which I have calculated. Then we will present Romania and its regions.

Table no. 8. Regional Food Security Index for EU NUTSII regions, the first and the last 20

| Region | State | Overall score | Rank | Region | State | Overall score | Rank |
|---|---|---|---|---|---|---|---|
| Lombardia | IT | 60.2 | 1 | Sardegna | IT | 31.1 | 257 |
| Weser-Ems | DE | 58.4 | 2 | Attiki | EL | 31.1 | 258 |
| Oberbayern | DE | 57.3 | 3 | Ciudad Autónoma de Melilla | ES | 31.0 | 259 |
| Lüneburg | DE | 56.6 | 4 | Dytiki Ellada | EL | 30.8 | 260 |
| Inner London - West | UK | 55.7 | 5 | Anatoliki Makedonia, Thraki | EL | 30.6 | 261 |
| Schwaben | DE | 55.6 | 6 | West | RO | 29.8 | 262 |
| Emilia-Romagna | IT | 54.8 | 7 | Notio Aigaio | EL | 29.3 | 263 |
| Bretagne | FR | 54.6 | 8 | Jadranska Hrvatska | HR | 29.2 | 264 |
| Tübingen | DE | 54.3 | 9 | South-West | RO | 29.1 | 265 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Oltenia | | | |
| Veneto | IT | 53.8 | 10 | Voreio Aigaio | EL | 28.9 | 266 |
| Pays de la Loire | FR | 53.7 | 11 | Ipeiros | EL | 28.6 | 267 |
| Münster | DE | 53.6 | 12 | Campania | IT | 27.8 | 268 |
| Stuttgart | DE | 53.2 | 13 | Calabria | IT | 27.7 | 269 |
| Detmold | DE | 53.0 | 14 | Sicilia | IT | 27.7 | 270 |
| Hannover | DE | 52.7 | 15 | Yugoiztochen | BG | 27.0 | 271 |
| Niederbayern | DE | 52.5 | 16 | Severoiztochen | BG | 26.4 | 272 |
| Southern and Eastern | IE | 52.3 | 17 | Severen tsentralen | BG | 26.0 | 273 |
| Darmstadt | DE | 51.9 | 18 | Canarias | ES | 24.9 | 274 |
| Köln | DE | 51.8 | 19 | Yuzhen tsentralen | BG | 23.5 | 275 |
| Kassel | DE | 51.7 | 20 | Severozapaden | BG | 23.4 | 276 |

Source: own processing

The data shows that Germany dominates the top twenty of NUTS II regions. But the first ranked is Lombardia (Italy) with an overall score by 60.2 followed by Wese-Ems (58.4). The lowest score is 23.4 for Severozapaden, Bulgaria. Between the last twenty regions there are two Romanian ones - West with an overall score by 29.8 and South-West Oltenia (28.9). As GFSI highlights, along with another indicator, the discrepancies that still exist among the European Union's member states. The Regional Food Security Index highlights also the discrepancies that still exist even at the regional level. For Romania's regions, the situation is as presented in the following table no.9. Among the 113 countries for which the global food security index is calculated is the majority of EU Member States. For most Member States, the situation is very good, and for the rest, the overall score is relatively good. It is noteworthy that, in some ways, the GFSI has its subjectivity. But the statistical method used to reduce subjectivity has shown a similar number of countries.

Table no. 9: The Regional Food Security Index for the regions of Romania

| Region | Rank | Overall score | Affordability | Availability | Quality / Safety |
|---|---|---|---|---|---|
| North-West | 195 | 37.7 | 16.0 | 8.2 | 13.5 |
| Center | 231 | 34.7 | 14.2 | 7.2 | 13.4 |
| North-East | 54 | 47.8 | 16.6 | 16.1 | 15.2 |
| South-East | 250 | 31.8 | 10.1 | 10.0 | 11.7 |
| South - Muntenia | 246 | 32.7 | 10.9 | 9.8 | 12.0 |
| Bucharest - Ilfov | 178 | 38.7 | 19.6 | 6.8 | 12.3 |
| South-West Oltenia | 265 | 29.1 | 8.9 | 7.8 | 12.5 |
| West | 262 | 29.8 | 10.4 | 6.6 | 12.8 |

Source: own processing

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Numbers have changed between them, but overall they remain in the top 20. In the other sections, the two methodologies used did not change the top 20 ranking, and the overall vision for each country remains similar.

## 5. Conclusions

The Regional Food Security Index was calculated for 276 NUTS 2 regions of the EU member states. One of the limits of our study is the lack of regional data. Another limit is the lack of data for certain regions, for specific identified indicators and the fact that we had to let aside some indicators for which too much data was missing. We also had to impute some national data at regional level, as some data are missing in the region of some countries.

On the other hand, for already vulnerable areas, measuring any indicators, given that data is available, is important, but for the rest of the regions, the vulnerability to some changes is more important than their current state. It is also clear that some indicators are more relevant at national level than at regional or global level more than at national level.

As Pinstrup-Andersen has pointed out (2009), individual behavior is the one that, above all, needs to be reconciled as the household.

The idea that deserves to remain is that, before politics, the individual / household represents and defines unity.

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