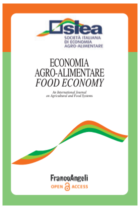
Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 25, Iss. 3, Art. 2, pp. 87-107 - ISSNe 1972-4802
DOI: 10.3280/ecag2023oa15633



The EU agri-food system in the recent crisis scenarios

Carla Zarbà[*,a], Gioacchino Pappalardo[a], Roberta Selvaggi[a], Biagio Pecorino[a]

[a] University of Catania, Italy

Abstract

The European Union agri-food system has faced major challenges in the last years due to the Covid-19 pandemic and the Russian-Ukrainian war. In a scenario where millions of people all over the world suffer from hunger, the uncertainty of food availability and commodity price surge have made it difficult to find and afford food on a large scale even in countries, which apparently are not exposed to those risks. Within the European Union (EU), this has depended upon the vulnerabilities and dependencies inherent in the agri-food system. In order to react and cope with emergency scenarios, the European Institution has adopted some temporary measures. The present paper verifies the level of the EU agri-food Self-Reliance system through the development of Self-sufficiency calculation and the Import Dependency Indices as well as the EU comparative advantage through the Gerard-Lafay Index and the relative comparative advantage proposed by Vollrath. Focusing on wheat and maize, these indices show a good level in the former case, but it may no longer be considered as such in the event of a crisis, and poor levels in the second case already at present time. Based on the achieved results, recommendable actions have been suggested in order to secure the EU food supply and to satisfy the EU demand even in case future adverse events might occur. In addition, further recommended actions to be taken by the European institutions, have been described.

Article info

Type:
Article
Submitted:
17/03/2023
Accepted:
12/09/2023
Available online:
24/11/2023

JEL codes:
Q17, Q56

Keywords:
Agri-food system
Resilience
Crisis
European Union
Self-reliance
War
Covid-19

Managing Editor:
Alessio Cavicchi

* *Corresponding author*: Carla Zarbà - (PhD) Researcher - Department of Agriculture, Food and Environment (Di3A), University of Catania - Via Santa Sofia, 98-100 - 95123 Catania, Italy. Email: carla.zarba@unict.it.

Introduction

The European Union agri-food system and not only (Bin-Nashwan *et al.*, 2022), have faced major challenges over the last years. First, the Covid-19 pandemic, and second, the current war between Russia and Ukraine have resulted in commodity price spikes (European Commission, 2022a) and in concerns about the availability of resources, thus posing the global food security at risk (Zarbà *et al.*, 2021; Howard, 2022; Kemmerling *et al.*, 2022).

While addressing the food security issue, three aspects may be worth considering here: the physical availability (Amin *et al.*, 2022; Polukhin *et al.*, 2022) relating to the physiological needs of the population, the economic availability of food and food adequacy, which entails health and safety implications (Jerzak and Smiglak-Krajewska, 2020).

FAO *et al.* (2021) estimated that 720 to 811 million people across the world faced hunger, next to an increased level of undernourishment, varying from 1.5 percent to 9.9 percent.

Russia and Ukraine have historically played a leading role in global trade. According to FAO (2022), Russia (14%) and Ukraine (4%), used to export a combined total of 18% of the world's cereal production between 2016/17 and 2020/21. However, the Russian-Ukrainian war has changed this scenario, undermining their (Yazbeck *et al.*, 2022) capacity to supply global markets with foodstuffs. Due to the war, Ukraine has stopped its exports, while the labour shortages have made the harvests uncertain. This has affected global food security and impacted the global food market (Ben Hassen and El Bilali, 2022).

The purposes of this paper is to investigate the way the estimated decrease in Ukrainian wheat and maize production during 2022-2023 found out by (Lang *et al.*, 2022; Nasir *et al.*, 2022), and the changes in political relations between Russia and the European Union, as underlined by (Chen *et al.*, 2023), have affected the European Union's agri-food system. Moreover, this paper it explores also as to whether the decreased grain trade volume found out by (Feng *et al.*, 2023; Oteh *et al.*, 2022) and the global wheat average price forecasted by (Lin *et al.*, 2023) could lead to a food insecurity of these products in EU.

According to Jerzak and Smiglak-Krajewska (2020), the European Union production volume of protein raw materials does not seem sufficient to satisfy the internal demand. Therefore, the agri-food system of the internal market has to rely on imported goods (Romanelli and Giovanardi, 2023). That consideration, which regarded the EU agri-food system dependency, preceded even the covid-19 pandemic and so, it could be only reasonable to think that the situation may indeed have worsened. On the contrary, however, other authors (Nasir *et al.*, 2022) affirmed that the European Union covers domestic needs for most agricultural products through its production.

Faced with these different points of view, the present paper aims to verify the agri-food system Self-Reliance index (SRI) in the EU, and the resilience capacity of that system.

Considering the fact that cereals are one of the staple foods of the Mediterranean diet (Serrano *et al.*, 2021; Martinez-Lacoba *et al.*, 2018; Tosti *et al.*, 2018), and that in comparison with other commodities mainly the trade in cereals has been affected by the war (OECD & FAO, 2022), the present investigation focuses on this agri-food category.

Therefore, the Self-Sufficiency and Import Dependency indices (SSI and IDI) were determined first. Second, the Gerard Lafay Index (LFI) was computed to assess the EU's competitiveness. The result allows one to determine whether the EU is relatively specialized in the agri-food sector, as well as its comparative advantage. Third, through the Relative Trade Advantage (RTA) index (Vollrath, 1991) the present analysis verified the influence of the relative export-import competitive performance of the EU versus the Russian Federation and Ukraine, given their marked participation in international markets (OECD & FAO, 2022).

The Covid-19 crisis has shown that severe supply challenges, even in the EU, were possible (Pappalardo *et al.*, 2022) and recently the Russian-Ukrainian war has presented new challenges. This uncertainty is in sharp contrast to Article 39.5 of the Treaty on the Functioning of the European Union regarding the importance of ensuring food supplies and food security.

The adverse events that occurred forced drastic and sudden changes that severely put a strain on the resilience of European agri-food systems. It required the need to implement policy and institutional changes in order to enhance its ability to deal with future emergencies (Saboori *et al.*, 2022).

To ensure the future food supply and food security, the European Commission proposed a Contingency Plan (European Commission, 2021) (European Commission, 2022b) to set up and coordinate a food crisis response mechanism to discuss several topics with a transversal approach involving Member States (Matthews, 2021). The goal was to identify the different phases of the crisis management cycle with a view to pointing out which could be the risks in the future landscape for the EU food supply and food security.

The preparedness phase of the contingency planning tends to identify the potential hazards and impacts of the agri-food systems. This results in a prodromal work for the planning of specific emergency measures to mitigate the impact of any actual occurrence of damaging events.

Therefore, the European Commission pointed out some threats through that mechanism. Among the main risks identified were climate change and environmental degradation, which lead to increasing adverse weather events (Indriawati & Prasetyani, 2021; Pengue, 2022).

The European institution's concern is that, apart from the Covid-19 crisis, climate and environmental issues may have a strong impact on the EU food supply. This is probably the case because, recently, severe climate events have appeared to be not sporadic and capable of endangering agricultural productivity, as well as hitting the agri-food system (Brassesco *et al.*, 2022; Khojasteh *et al.*, 2022). In fact, the extreme weather events, which occur due to climate change, together with the increased probability of occurring, have the potential to affect agricultural and seafood production within the EU (Lassa *et al.*, 2019; Ionescu *et al.*, 2022). The failure of fodder crops due to droughts are concrete examples (Muralikrishnan *et al.*, 2022; Mazwi *et al.*, 2022). Climate change in particular, is leading to potential dangerous meteorological disasters and water scarcity (Ercin *et al.*, 2019), thus affecting the food supply chain (Møller *et al.*, 2022; Zupančič *et al.*, 2022). Disasters can destroy healthy crops (Brás *et al.*, 2019), make infrastructural damage to the agricultural production system, and create food products supply difficulties due to transport impossibilities. In case of water scarcity, the production capacity results limited and may lead to inability to produce healthy crops. Among other things, such events may generate price volatility and food stocks insecurity (Götz *et al.*, 2015; Haile *et al.*, 2014; Santeramo *et al.*, 2018; Howard, 2022). These aspects show the vulnerability of the agri-food system, which may be regarded as one of the outputs of the disaster cycle mechanism and therefore, a weakness to be addressed through new EU acts.

Another dependence of the agri-food sector is related to imports. In today's globalized world, food variety availability in a specific country depends on the production capacity of other regions and states (Jerzak and Smiglak-Krajewska, 2020).

Numerous are the imported crop categories, as the EU relies on a limited internal number of sources (No Authors listed, 2022; Brás *et al.*, 2019). EU oilseed meals for feeding are an example of the fact that 76% of the whole amount is imported together with the 14% for the top five species of fish consumed (European Commission, 2021c.).

Considering that cereals are one of the main staple foods of the Mediterranean diet (Roberto *et al.*, 2018; Martinez-Lacoba *et al.*, 2018; Tosti *et al.*, 2018) and that in comparison with other commodities mainly cereals trade has been affected by the war (OECD and FAO 2022), it becomes even more relevant to check as to whether the EU's agri-food system is dependent on this category of products. There mainly two reasons for focusing the attention of this paper on cereals and in particular on wheat and maize.

First, cereals are, in general, one of the main staple foods of the Mediterranean diet (Martinez-Lacoba *et al.*, 2018; Tosti *et al.*, 2018; Serrano *et al.*, 2021).

Second, wheat and maize, specifically, had a pronounced participation in international markets in the current Russian-Ukrainian war context as they constituted the predominant share of cereal production in the agri-food sector in the three-year period 2018-2020, accounting for 46% and 24% respectively of the main cereals produced in the EU (FAOSTAT). Indeed, in comparison with other commodities, mainly cereals trade has been affected by the war (OECD & FAO, 2022) and this is the second reason.

1. Materials and methods (Self-Reliance, Gerard Lafay and Vollrath Indexes calculations)

The present paper aims at identifying the EU Self-Reliance level with respect to wheat and maize, the EU Self-Sufficiency Index (Kaufmann *et al.*, 2022) and the Import Dependency Index (Pavlović, 2018). Furthermore, Gerard Lafay's index (LFI) (Platania *et al.*, 2015) provided the possibility to find out the comparative EU advantage in the agri-food sector.

The analysis is based on FAO statistical data. The imports and exports that EU flows were selected for the whole agri-food system and singularly for wheat and maize for the period 2018-2020. The product codes of the products under investigation within the FAO international nomenclature were wheat [0111] and maize [0112].

In order to determine the degree of importance when it comes to the production of those cereals, in relation to the internal consumption within the EU, the Food Self-Sufficiency Index (SSI) was determined with reference to the years defined above. Specifically, the food Self-Sufficiency refers to the ability a specific territory to meet its own food requirements from domestic production without taking into account the shares of exports of the same product (Brás *et al.*, 2019; Clapp, 2015).

Given that the domestic availability (total supply) is the total of foodstuff produced together with the related imports in the relative territory excluding the exported shares, SSI equals the total domestic food production as a ratio of total supply. SSI formula consists in dividing the total domestic food output and total supply in a certain country for a certain year (Brankov, 2022) as follows below:

$$\boldsymbol{SSI = \frac{P_j^i}{P_j^i + I_j^i - E_j^i}}$$

Where:

P_j^i = pruduction of region i of a product in economic sector j to the rest of the world;

I_j^i = imports of a product in economic sector *j* from the rest of the world to region *i*;
E_j^i = export of a region i of a product in economic sector *j* to the rest of the world.

When the ratio is less than 100 percent, it expresses low levels of domestic production; the results equal to 100 percent show that the sector's food production capacity is on the edge in supporting the food needs of the population; when the results are greater than 100 percent, it shows that domestic production is efficiently able to support the domestic requirements. The higher the ratio, the greater the Self-Sufficiency (Clapp, 2015).

On the other hand, through food Import Dependency Index (IDI), it is possible to assess the extent to which the EU relies on external resources from its own territory for food needs. It indicates what the weight of imports is on the amounts of Domestic supply and, thus, the degree of linkage from imports, as well as how much comes from the country's own production. IDI is given by the ratio of the amountof imports to total domestic supply. The formula is the following (Smutka *et al.*, 2019):

$$\boldsymbol{IDI = \frac{I_j^i}{P_j^i + I_j^i - E_j^i}}$$

Where:
I_j^i = imports of a product in economic sector *j* from the rest of the world to region *i*;
P_j^i = production of region *i* of a product in economic sector *j* to the rest of the world;
E_j^i = exports of region *i* of a product in economic sector *j* to the rest of the world.

The higher is the resulting value, the higher will be the extent of dependency on imports. As regards the LFI, this is an indicator that determines the specialization of a territory in a given sector both in relative "internal" terms, i.e., with respect to the other sectors that make up the economic system of that territory, and in relative "external" terms with respect to a set of countries taken as reference (Zarbà *et al.*, 2020). In the present paper, the aim is to express the degree of specialization (Brasili and Barone, 2011) of wheat and maize in the EU context, in relative terms i.e., compared to the rest of the EU agri-food system. The EU may consider itself to be relatively specialized in a given sector, compared to all other sectors, if the normalized ratio in that sector is higher than the measured average of the normalized ratios of all other sectors in the EU economy itself.

For the calculation of LFI trade flow analysis is used, i.e. imports and exports data, being LFI highly reliable when considering import and export two-way flows (Allegra *et al.*, 2019). In this way, the resulting normalized ratio is a function of the percentage difference between exports and imports. The sum indicates the totality of imports and exports of agri-food with respect to the degree of specialization of wheat and maize products. Therefore, normalization is achieved by 'weighing' the contribution of the cereal sector in the agri-food trade balance.

The LFI algorithm is expressed, in particular, by the following formula (Boffa *et al.*, 2009) where subscript J indicates the wheat sector or the maize sector, whereas index i identifies the EU; symbol Σ_j indicates the whole of the EU agri-food chains.

Export and import volumes are indicated by the variables x and y respectively.

$$\boldsymbol{LFI_j^i = 100\left[\frac{x_j^i - m_j^i}{x_j^i + m_j^i} - \frac{\sum_{j=1}^{N}(x_j^i - m_j^i)}{\sum_{j=1}^{N}(x_j^i + m_j^i)}\right]\frac{x_j^i + m_j^i}{\sum_{j=1}^{N}(x_j^i + m_j^i)}}$$

Where:
x_j^i = exports of region i of a product in economic sector j to the rest of the world;
m_j^i = imports of a product in economic sector j from the rest of the world to region i;
N = is the number of traded goods.

The Gerard Lafay Index can take negative value, 0 and positive values. 0 value indicates that in the territory of reference exports and imports are equal; positive values denote the specialization of that territory while negative results indicate the contrary. The higher the values of the LFI are the higher is the degrees of specialization. In case the values turn out to be negative, it shows a state of *despecialisation* in the sector, i.e. a situation of reliance on imports.

The Relative comparative advantage guides towards a better identification of the consequences of policy and/or factual changes (Zarbà *et al.*, 2011; Zarbà *et al.*, 2013) and it derived from Balassa index eliminating the criticizes double-counting of Country and product (Crescimano and Galati, 2014; Pappalardo *et al.*, 2013).

The relative comparative advantage (RTA) index introduced by Vollrath (1991) is defined as the difference between the relative advantage index of exports (RXA) and the relative advantage index of imports (RMA). Specifically, RXA refers to the share of exports of a product (a) for the country under consideration (i) at the EU level compared to the share held for other products, while, likewise, RMA refers to the share of imports. The RTA of Vollrath shows a commercial advantage when it assumes positive values and vice versa a comparative disadvantage when they are negative (Bernini Carri & Sassi, 2008). Moreover, compared with Lafay's index, Vollrath eliminates the effect of "double counted" by subtracting the product and the country in question respectively by total exports and by all the countries concerned (Zarbà *et al.*, 2011; Zarbà *et al.*, 2013).

The Vollrath index is expressed as follows:

$$\boldsymbol{RTA_a^i = RXA_a^i - RMA_a^i = \left[\frac{\frac{X_a^i}{X_n^i}}{\frac{X_a^r}{A_n^r}} - \frac{\frac{M_a^i}{M_n^i}}{\frac{M_a^r}{M_n^r}}\right]}$$

Where:
X = exports of region;
M = imports;
i = region/country;
a = traded good;
r = European Union;
n = all products exchange except product (a).

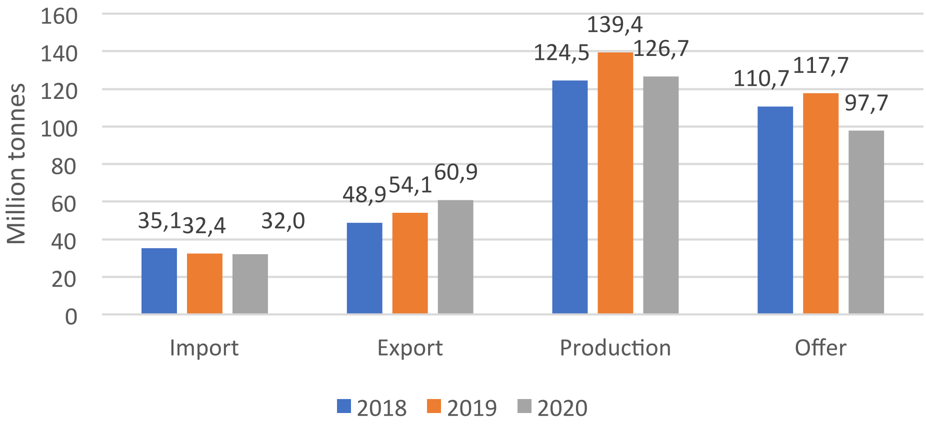
The Vollrath analysis is based on UN COMTRADE statistical data in order to take information relatively to singular Countries, namely the EU, the Russian Federation and Ukraine. The import and export flows were selected for the whole agri-food system and particularly for wheat and maize for the period 2018-2020. The product codes of the items under investigation within the FAO international nomenclature were wheat [1001] and maize [1005].

3. Results and Discussions (Self-Reliance, Gerard Lafay and Vollrath Indexes)

Food Self-Sufficiency related to EU cereal production showed, for the period under examination, different results depending on the types considered: wheat (Figure 1) and maize (Figure 2).

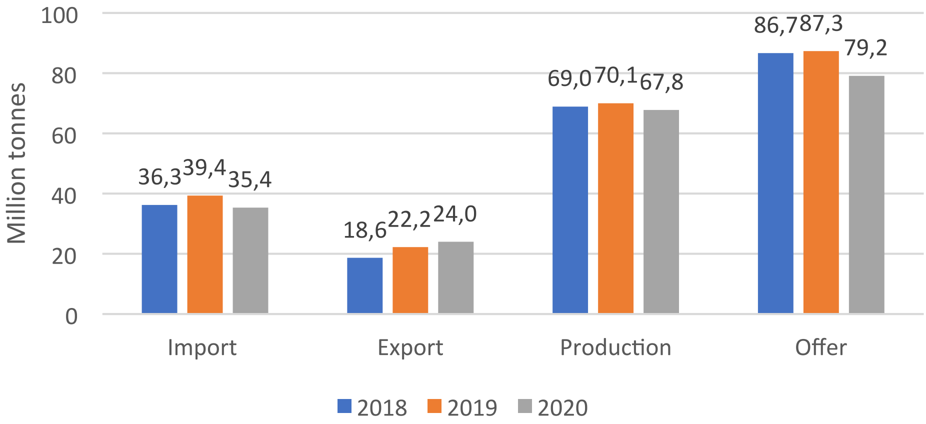
With regards to wheat the calculation of the Self-Sufficiency Index for the three-year period 2018-2020 shows a consistent progressivity moving from one year to the next; in fact, from just over 12% the index rises to just over 18%, and finally to 30% (Table 1). This indicates that the majority of wheat utilization in the EU derived from the internal domestic production. Therefore, SSI's trend displays a consistent progressiveness, which goes from 6% between 2018 and 2019 and doubles between 2018 and 2020 (Table 1).

Figure 1 - Evolution of Wheat supply in the European Union



* Our elaboration.
Source: Faostat.

Figure 2 - Evolution in Maize supply in the European Union



* Our elaboration.
Source: Faostat.

Table 1 - Self Sufficiency Index (SSI) and Import Dependency Index (IDI). % Wheat

Index	2018	2019	2020
SSI	113	118	130
IDI	32	28	33

* Our elaboration.
Source: Faostat (www.fao.org/faostat/en/#home).

This demonstrates that EU wheat production supports the level of food self-sufficiency for this product category as Nasir *et al.*, 2022 stated. However, the wheat self-sufficiency condition could prove to be insufficient and unable to meet the needs of the EU's domestic demand in the event of any crises, which could bring to the surface the vulnerabilities and dependencies already mentioned in paragraph 2.1 above.

In addition, imports from third countries play an important role in wheat availability in the EU. Indeed, the dependency ratio indicates that the external contribution to the overall wheat availability would be 1/3; imports in particular contributed to about 32%, more than 27% and almost 33% in the years 2018, 2019 and 2020 respectively.

As for maize, the food contribution to the EU appears rather unsatisfactory, although it tends to improve slightly when taking into account the fact that the self-sufficiency index indicates deficient values, which from -20% in both 2018 and 2019, rises to -14% in 2020 (Table 2). Thus, this trend reveals the inadequacy of the EU's food production level to meet domestic cereal demand, especially in the consideration of the abovementioned vulnerabilities to which cereals production and the agri-food system in general, might be subjected.

Table 2 - Self Sufficiency Index (SSI) and Import Dependency Index (IDI). % Maize

Index	**2018**	**2019**	**2020**
SSI	80	80	86
IDI	42	45	45

* Our elaboration.
Source: Faostat (www.fao.org/faostat/en/#home).

With regard to the role of maize imports in the EU's food needs, Import Dependency Index notes the relative importance of the corresponding traffic flows over the three years under consideration. Specifically, the IDI confirms SSI results; in fact, in 2018 it was over 41%, in 2019 about 45% and in 2020 almost 45% (Table 2).

Therefore, in the light of these findings, it appears advisable to boost the production of these two products, thus, raising the extent of domestic grain supply by increasing its production capacity.

With regard to the Gerard Lafay Index, over the period 2018-2020, the trend of the specialisation level for wheat showed increasingly satisfactory trends, as Table 3 shows. Specifically, it was 2.06 %, in the year 2018, 2.73%, in the year 2019 and 3.35% in the year 2020 (Table 3).

Table 3 - Gerard-Lafay Index (GLI)

Cereals	**2018**	**2019**	**2020**
Wheat	2,06	2,74	3,35
Maize	–1,91	–1,93	–1,36

* Our elaboration.
Source: Faostat (www.fao.org/faostat/en/#home).

In addition, when it comes to maize, no specialization conditions prove to be as evident as the results of the Gerard Lafay Index. In fact, they are negative. The figures in Table 3 (–1.91, –1.93 and –1.36 referring to the years 2018, 2019 and 2020) show the weight of the EU's dependence on third countries.

Therefore, the affirmation of Nasir *et al.*, 2022 stating that the European Union covers domestic needs for most agricultural products through its production does not seem to apply to maize.

Given that, the level of specialization of both types of the cereals in question is not sufficient to establish satisfactory conditions for the needs of the EU internal market. Thus, it seems grounded the statement of Romanelli and Giovanardi, 2023 about the dependency of EU market on imported goods. These results are not reassuring in a context where the recent crisis events that have led to the decrease and, in some cases, to the halting of trade flows of the products under consideration from the Russian Federation and Ukraine (Yazbeck *et al.*, 2022). Therefore, it is recommendable to adopt strategies to raise the EU's level of productivity for both agricultural products. This should be done in order to increase both the level of EU Self-Reliance and comparative advantage, since the higher the degree of specialization of wheat and maize is, the higher their contribution to the cereal trade balance becomes.

The results about maize are in line with Jerzak and Smiglak-Krajewska (2020) who found out a EU dependence in respect to protein raw materials.

Vollrath's index (RTA) allowed for a step forward; in fact, it was calculated in order to propose a more circumstantial analysis on the two products, wheat and corn, considered in the present survey and addressed specifically to the trade relations between the European Union and Russian Federation, and separately between the European Union and Ukraine.

The results, for both products, show a relative comparative advantage for both Eastern European countries (Table 4).

Table 4 - Vollrath Index (RTD)

Indications	**Maize**			**Wheat**		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
Russian Federation						
RXA	1,45	0,98	0,59	11,20	7,68	7,32
RMA	0,02	0,02	0,03	0,18	0,11	0,12
RTA	1,42	0,96	0,56	11,02	7,57	7,21
Ukraine						
RXA	10,63	11,82	10,36	2,53	2,2	1,97
RMA	0,14	0,10	0,07	0,02	0,01	0,04
RTA	10,49	11,72	10,29	2,51	2,19	1,93

* Our elaboration.
Source: Faostat (www.fao.org/faostat/en/#home).

Specifically, with regard to maize, the Russian Federation's RTA is 1.42 percent in 2018, 0.96 in 2019, and 0.55 in 2020. Therefore, although there is a relative comparative advantage, the values have been decreasing in the period under review.

In relation to Ukraine, the relative comparative advantage is very high, in fact it stands at 10.49 % % in 2018, 11.71 in 2019 and 10.29 in 2020, and unlike the situation in Russian Federation shows constant levels.

With reference to wheat, Russian Federation shows high levels of relative comparative advantage.

In fact, those are 11.02% in 2018, 7.56 in 2019 and 7.20 in 2020 characterized by a slight inflection between the year 2018 and subsequent years remain constant with each other.

In contrast, the levels of relative comparative advantage of Ukraine are 2.51% in 2018, 2.18 in 2019 and 1.93 in 2020 and show a slight inflection regarding the latter year.

A look at the volumes (Table 5) of the European Union's wheat and maize imports from Russian Federation and Ukraine arise some considerations.

It allow to quantify in detail the extent to which the EU relies on the flows from these two countries (the extent to which the EU relies on these two countries' exports) and thus how much the halt in trade of those two products, due to the Russia-Ukrainian war, may impact the European Union's Agribusiness System.

Table 5 - Maize and Wheat Imports Evolution in the EU from Russian Federation, Ukraine, and World

Indications	**2018**		**2019**		**2020**	
	Thousand Tonnes	**%**	**Thousand Tonnes**	**%**	**Thousand Tonnes**	**%**
Maize						
EU - Russian Federation	497.859,1	2,3	202.744,0	0,9	213.113,6	1,0
EU - Ukraine	11.367.457,7	52,4	15.244.997,0	64,1	8.763.052,7	55,8
EU - World	21.678.304,5	100,0	23.771.621,4	100,0	15.716.498,3	100,0
Wheat						
EU - Russian Federation	1.296.672,0	22,0	411.315,2	9,2	318.737,6	6,7
EU - Ukraine	1.342.906,6	22,7	1.068.032,0	23,9	734.259,3	15,4
EU - World	5.906.355,1	100,0	4.460.637,5	100,0	4.757.465,6	100,0

* Our elaboration.
Source: Un comtrade (https://comtradeplus.un.org).

As a matter of fact, the EU's wheat imports from Russian federation and Ukraine together stand at about 45% in 2018 and specifically 22.0 % and 22.7 % respectively, in 2019 at 33% i.e. 9.2% and 23.9% and finally in 2020 at 22% i.e. 6.7% and 15.4%.

The European Union's maize imports from the Russian Federation and Ukraine together stand at about 58% in 2018 and specifically 2.3% and 52.4% respectively, in 2019 at 65% i.e. 0.9% and 64.1% and finally in 2020 at just over 57% i.e. 1.4% and 55.8%.

From the above, it appears that a large part of EU imports come from the aforementioned Eastern European Countries and so a situation of scarcity in the availability of raw materials for the agri-food system for the years 2021, 2022 and onwards is foreseeable. These results support the suggestion to strengthen the agri-food sector, not only in terms of increasing productivity levels, but also as a system. In fact, increasing productivity alone may not be enough, but also not feasible, as it requires a greater exploitation of resources in a context of them scarcity in nature. To address this issue the attempting to develop environmentally and economically sustainable production systems could represent a feasible solution. However, after the crises derived from the war in Ukraine and the covid 19 pandemic that challenged the idea of a globalised world open to continuous exchange, the agri-food system must set itself resilience objectives to strengthen its capacity to be self-sufficient in the event other potential adverse events trigger new crises.

Conclusions

The Covid-19 pandemic and the war in Ukraine have presented the EU agri-food system with challenges.

The decrease and, in some cases, the halting of trade flows of agri-food commodity across the world allows one to foresee a situation of scarcity in the availability of raw materials for the EU agri-food system, which was expected for the years 2021, 2022, and as of now, onwards.

The present analysis showed that even if wheat EU production seems to maintain the level of food self-sufficiency, imports from third countries play an important role in wheat and maize availability in the EU.

As for maize, the self-sufficiency index indicates deficient values. This trend reveals the inadequacy of the EU's food production level in meeting domestic demands for this product category.

Similarly, the level of EU agri-food system' specialisation and the relative comparative advantage of both cereal types in question did not appear sufficient enough to establish satisfactory conditions for the needs of the EU internal market.

In view of the above-mentioned, next to the consideration of the discussed vulnerabilities to which cereals production and the EU agri-food system in general might be subjected, the agri-food sector does not seem prepared to additional potential adverse events. In fact, the one already occurred have forcefully revealed the cracks that have long existed in the EU agri-food system. However, the next challenge could be turning weaknesses into opportunities, which could activate a transformative change that would lead to the implementation of resilience strategies that would include a higher level of productivity in the EU's regrading both agricultural products.

Providing a resilient response means organising a system that would combine at its core the achievement of food security and sustainability objectives (set by European policy and legislation) with the ability to cope with any known (such as resource scarcity, vulnerabilities and dependencies in the agri-food sector) and unknown (such as the various emergencies that may occur) criticalities.

This entails the re-design of the current systems in order to make agricultural production and processing processes sustainable and circular, for instance, by extending the life cycle of products, developing renewable energy sources, which can replace the current fossil-fuel based ones; the purpose of all this is to overcome system dependence and transform vulnerabilities into strength. A potential strategy may be implementing the ecological transition in accordance with the objectives designed by Horizon Europe, while ensuring, at the same time, the flexibility and adaptability of systems towards potential new crises.

Accelerating the global transition of the agri-food system towards sustainability and resilience is the European institutions' preferred way to mitigate climate change and contain the threat of resource scarcity (European Commission, 2021). The reorganisation of systems should include the adoption of key approaches to achieve an ecological transition, such as sustainability and circularity (Zarbà *et al.*, 2023). This implies less pollution footprint, the reuse of resources and waste reduction next to the reduction of food loss, which could feed around 1.26 billion people per year (FAO, 2022).

In light of the above considerations, in order to prepare a better response to future crises and make the EU agri-food system more stable, the EU institutions should orientate the general and overall re-design of the agri-food systems by dealing in the long-term with its dependence issue, because especially in case of potential crises, triggered by climate disasters or other adverse events, the agri-food vulnerabilities may disrupt the entire system itself.

References

Allegra, V., Zarbà, C., La Via G., & Zarbà, A.S. (2019). Why the new orange juice consumption model favors global trade and growth in orange production. *British Food Journal*. Doi: 10.1108/BFJ-05-2019-0316.

Ben Hassen, T., & El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: Towards more sustainable and resilient food systems?. *Foods*, *11*: 15. Doi: 10.3390/foods11152301.

Bernini Carri, C., & Sassi, M. (2008). *Scambi commerciali agricoli e accordi di partenariato tra Unione Europea e Africa*. Paper prepared for presentation at the XVI Meeting SIEA Trieste, Italy, June 5-6, 2008.

Bin-Nashwan, S.A., Hassan, M.K., & Muneeza, A. (2022). Russia-Ukraine conflict: 2030 agenda for SDGs hangs in the balance. *International Journal of Ethics and Systems*. Doi: 10.1108/IJOES-06-2022-0136.

Boffa, F., Bolatto S., & Zanetti, G. (2009). *Specializzazione produttiva e crescita: un'analisi mediante indicatori*. CERIS Working Paper 200901, Institute for Economic Research on Firms and Growth - Moncalieri (TO) ITALY -NOW- Research Institute on Sustainable Economic Growth - Moncalieri (TO) ITALY.

Brankov, T., & Matkovski, B. (2022). Is a Food Shortage Coming to the Western Balkans?. *Foods*, 11, 3672. Doi: 10.3390/foods11223672.

Brás, T.A., Jägermeyr, J., & Seixas, J. (2019). Exposure of the EU-28 food imports to extreme weather disasters in exporting countries. *Food Security*, *11*(6), 1373-1393. Doi: 10.1007/s12571-019-00975-2.

Brasili, C., & Barone, B. (2011). Rapporto 2010-2011. L'Italia nell'economia internazionale - Contributi e approfondimenti aggiuntivi - Capitolo 7 Il territorio. 2 - Contributo in volume – 2.01 Capitolo Saggio in libro. Ministero dello Sviluppo Economico. https://hdl.handle.net/11585/117387. -- (Available on: www.ice.it/

it/sites/default/files/inline-files/Rapporto%20Ice%202011%20-%20Brasili%20%E2%80%93%20Baroni.pdf).

Brassesco, M.E., Pintado, M., & Coscueta, E.R. (2022). Food system resilience thinking: From digital to integral. *Journal of the Science of Food and Agriculture*, *102*(3), 887-891. Doi: 10.1002/jsfa.11533.

Chen, Y., Jiang, J., Wang, L., & Wang, R. (2023). Impact assessment of energy sanctions in geo-conflict: Russian-Ukrainian war. *Energy Reports*, *9*, 3082-3095. Doi: 10.1016/j.egyr.2023.01.124.

Clapp, J. (2015). Food Self Sufficiency and International Trade: A False Dichotomy? In the State of Agricultural Commodity Markets 2015-16. Rome, Italy. I5222E/1/12.15. Doi: 10.13140/RG.2.1.2447.2080.

Crescimano, M., & Galati, A. (2014). Competitiveness of Italian wines in the international market. *Bulgarian Journal of Agricultural Science*, *20*: 12-22.

Ercin, E., Chico, D., & Chapagain, A.K. (2019). Vulnerabilities of the European Union's economy to hydrological extremes outside its borders. *Atmosphere*, *10*(10), 593.

European Commission (2021). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Contingency plan for ensuring food supply and food security in times of crisis. COM/2021/689 final.

European Commission (2022a). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and social committee and the committee of the Regions - Safeguarding food security and reinforcing the resilience of food systems. COM/2022/133 final.

European Commission (2022b). State aid: Commission prolongs and amends Temporary Crisis Framework. European Commission - Press release. Brussels, 28 October 2022. (Available on: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_6468).

European Parliament (2021) European Union Solidarity Fund – SUMMARY. -- (Available on: www.europarl.europa.eu/RegData/etudes/BRIE/2021/696193/EPRS_BRI(2021)696193_EN.pdf).

FAO, IFAD, UNICEF, WFP, WHO (2021). The State of Food Security and Nutrition in the World 2021. Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All. FAO, Rome. -- (Available on: www.fao.org/3/cb4474en/cb4474en.pdf).

FAO (2022). The importance of Ukraine and the Russian federation for global agricultural markets and the risks associated with the war in Ukraine. Food and Agriculture Organization of the United Nations (FAO). -- (Available on: www.fao.org/3/cb9013en/cb9013en.pdf).

FAOSTAT: -- www.fao.org/faostat/en.

Feng, F., Jia, N., & Lin, F. (2023). Quantifying the impact of Russia-Ukraine crisis on food security and trade pattern: Evidence from a structural general equilibrium trade model. *China Agricultural Economic Review*. Doi: 10.1108/CAER-07-2022-0156.

Götz, L., Djuric, I., & Glauben, T. (2015). Wheat export restrictions in Kazakhstan, Russia and Ukraine: Impact on prices along the wheat-to-bread supply chain.

Transition to agricultural market economies: The future of Kazakhstan, Russia and Ukraine (pp. 191-203).
Haile, M.G., Kalkuhl, M., & Braun J. (2014). Inter- and intraseasonal crop acreage response to international food prices and implications of volatility. *Agricultural Economics*, *45*: 693-710.
Howard, J.A. (2022). Facing up to our converging climate and food system catastrophes. *Advances in Food Security and Sustainability*, *7*, 1-34. Doi: 10.1016/bs.af2s.2022.07.003.
Indriawati, R.M., & Prasetyani, D. (2021). The effect of climate change damages on agriculture, forestry and fisheries in ASEAN countries. IOP Conference Series: Earth and Environmental Science, 905(1), 012120.
Ionescu, R.V., Zlati, M.L., & Antohi, V.M. (2022). A New Approach on Making European Agriculture More Efficient under Uncertainty Conditions. *Agronomy*, *12*(10), 2559. Doi: 10.3390/agronomy12102559.
Kaufmann, L., Mayer, A., Matej, S., Kalt, G., Lauk, C., Theurl, M.C., & Erb, K. (2022). Regional self-sufficiency: A multi-dimensional analysis relating agricultural production and consumption in the European Union. *Sustainable Production and Consumption*, *34*, 12-25. Doi: 10.1016/j.spc.2022.08.014.
Kemmerling, B., Schetter, C., & Wirkus, L. (2022). The logics of war and food (in) security. *Global Food Security*, *33*. Doi:10.1016/j.gfs.2022.100634.
Khojasteh, D., Davani, E., Shamsipour, A., Haghani, M., & Glamore, W. (2022). Climate change and Covid-19: Interdisciplinary perspectives from two global crises. *Science of the Total Environment*, 844. Doi: 10.1016/j.scitotenv.2022.157142.
Lang, T., & McKee, M. The Reinvasion of Ukraine Threatens Global Food Supplies. *BMJ*, 376, 10-11.
Lassa, J.A., Teng, P., Caballero-Anthony, M., & Shrestha, M. (2019). Revisiting emergency food reserve policy and practice under disaster and extreme climate events. *International Journal of Disaster Risk Science*, *10*(1), 1-13. Doi: 10.1007/s13753-018-0200-y.
Lin, F., Li, X., Jia, N., Feng, F., Huang, H., Huang, J., … Song, X. (2023). The impact of russia-ukraine conflict on global food security. *Global Food Security*, *36*. Doi: 10.1016/j.gfs.2022.100661.
Jerzak, M.A., & Smiglak-Krajewska M. (2020). Globalization of the Market for Vegetable Protein Feed and Its Impact on Sustainable Agricultural Development and Food Security in EU Countries Illustrated by the Example of Poland. *Sustainability*, *12*, 888. Doi: 10.3390/su12030888.
Matthews, A. (2021). *European Commission Workshop report: Contingency plan for ensuring food supply and food security*. Publications Office of the European Union, Luxembourg, 2021. Doi: 10.2760/569694.
Mazwi, Q., Coetzer, G.M., Fouche, H.J., & Ceronio, G.M. (2022). *The role of nitrogen fertilizer on 'Morado' cactus pear as a potential fodder crop*. Doi: 10.17660/ActaHortic.2022.1343.12.
Møller, H.B., Sørensen, P., Olesen, J.E., Petersen, S.O., Nyord, T., & Sommer, S.G. (2022). Agricultural Biogas Production – Climate and Environmental Impacts. *Sustainability*, *14*, 1849. Doi: 10.3390/su14031849.

Muralikrishnan, L., Padaria, R.N., Choudhary, A.K., Dass, A., Shokralla, S., Zin El-Abedin, T.K. *et al.* (2022). Climate change-induced drought impacts, adaptation and mitigation measures in semi-arid pastoral and agricultural watersheds. *Sustainability* (Switzerland), *14*(1). Doi: 10.3390/su14010006.

Nasir, M.A., Nugroho, A.D., & Lakner, Z. (2022). Impact of the Russian-Ukrainian conflict on global food crops. *Foods*, *11*(19). Doi: 10.3390/foods11192979.

No Authors listed (2022). The war in Ukraine is exposing gaps in the world's food-systems research. *Nature*, *604*(7905), 217-218. Doi: 10.1038/d41586-022-00994-8.

OECD and FAO (2022). 3 Cereals. OECD-FAO AGRICULTURAL OUTLOOK 2022-2031©. -- (Available on: www.fao.org/3/CC0308EN/Cereals.pdf).

Oteh, O.U., Agwu, N.M., Mbanasor, J.A., Ibem, N.C., Okpokiri, C., Oloveze, A.O., & Onwusiribe, C. (2022). Wheat or cassava flour? Marketing and willingness to pay for cassava flour confectionery in Nigeria. *Economia agro-alimentare / Food Economy*, *24*(3). Doi: 10.3280/ecag2022oa14625.

Pappalardo, G., Allegra, V., Bucca, M., & Zarbà A. S. (2013). Gli scambi commerciali agroalimentari euromediterranei. Contributo allo sviluppo del "Processo di Barcellona: Unione per il Mediterraneo". *Economia agro-alimentare*, 37-72. Doi: 10.3280/ECAG2013-001003.

Pappalardo, G., Selvaggi, R., Pittalà, M., & Bellia, C. (2022). Purchasing behavior in rural areas for food products during the Covid-19 pandemic. *Frontiers in Sustainable Food Systems*, *6*. Doi: 10.3389/fsufs.2022.1042289.

Pavlović, D., Banovac, E., & Vištica, N. (2018). Defining a composite index for measuring natural gas supply security - the croatian gas market case. *Energy Policy*, *114*, 30-38. Doi: 10.1016/j.enpol.2017.11.029.

Pengue, W.A. (2022). Local food systems: Making visible the invisible through urban agroecology. *Frontiers in Sustainable Cities*, *4*. Doi: 10.3389/frsc.2022.867691.

Platania, M., Rapisarda, P., & Rizzo, M. (2015). Italian trade specialization: Persistence and change in regional agri-food production. *Agris on-Line Papers in Economics and Informatics*, *7*(4), 101-109. Doi: 10.7160/aol.2015.070410.

Roberto, M.L., Pardo-Garcia, I., Amo-Saus, E., & Escribano-Sotos, F. (2018). Mediterranean diet and health outcomes: a systematic meta-review. *European Journal of Public Health*, *28*(5), 955-961. Doi: 10.1093/eurpub/cky113.

Romanelli, M., & Giovanardi, O. (2023). Commentary on Italy's international seafood trade and its impacts. *Economia agro-alimentare / Food Economy*, *24*(3), Art. 2, 1-24. Doi: 10.3280/ecag2022oa14835.

Santeramo, F.G., Lamonaca, E., Contò F., Nardone G., & Stasi, A. (2018). Drivers of grain price volatility: a cursory critical review. *Agric. Econ. - Czech.*, *64*(8), 347-356. Doi: 10.17221/55/2017-AGRICECON.

Saboori, B., Radmehr, R., Zhang, Y.Y., & Zekri, S.A. (2022). New face of food security: A global perspective of the Covid-19 pandemic. *Prog Disaster Sci.*, Dec, 16, 100252.Doi. 10.1016/j.pdisas.2022.100252.

Serrano, M.P., Chonco, L., Landete-Castillejos, T., García, A., & Lorenzo, J.M. (2021). Food legislation: Particularities in spain for typical products of the mediterranean diet. *Sustainable production technology in food* (pp. 203-215). Doi: 10.1016/B978-0-12-821233-2.00013-7.

Smutka, L., Maitah, M., & Svatoš, M. (2019). Policy impacts on the EU-Russian trade performance: The case of agri-food trade. *Journal of International Studies*, *12*(2), 82-98. Doi: 10.14254/2071-8330.2019/12-2/5.

Tosti, V., Bertozzi, B., & Fontana, L., MD, (2018). Health Benefits of the Mediterranean Diet: Metabolic and Molecular Mechanisms. *The Journals of Gerontology*, Series A, *73*(3), March, 318-326. Doi: 10.1093/gerona/glx227.

Vollrath, T.L. (1991). A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage. *Weltwirtschaftliches Archiv*, *127*(2), 265-280.

Yazbeck, N., Mansour, R., Salame, H., Chahine, N.B., & Hoteit, M. (2022). The Ukraine-Russia war is deepening food insecurity, unhealthy dietary patterns and the lack of dietary diversity in Lebanon: Prevalence, correlates and findings from a national cross-sectional study. *Nutrients*, *14*(17). Doi: 10.3390/nu14173504.

Zarbà, A.S., Bucca, M., & Pappalardo, G. (2011). Principali cause di squilibrio negli scambi commerciali dei prodotti agricoli mediterranei tra Unione europea e Marocco, Paper presented to XLVIII Congress of SIDEA, Udine (Italy), 29-30 September 2011.

Zarbà A.S., Allegra V., Pappalardo G., (2013): Current scenarios in the Romanian agro-food trade inside the EU. *Quality-Access to Success Journal*, *14*, S1, March.

Zarbà, C., Chinnici, G., La Via, G., Bracco, S., Pecorino, B., & D'Amico, M. (2021). Regulatory Elements on the Circular Economy: Driving into the Agri-Food System. *Sustainability*, 13, 8350. Doi: 10.3390/su13158350.

Zarbà, C., Chinnici, G., & D'Amico, M. (2020). Novel Food: The Impact of Innovation on the Paths of the Traditional Food Chain. *Sustainability*, *12*(2): 555. Doi: 10.3390/su12020555.

Zarbà, C., Chinnici, G., D'Amico, M. (2023). Moving Through the New Trends of the Novel Foods in the Agri-Food System: The Case of Algae. *Reference Module in Food Science*. Doi: 10.1016/B978-0-12-823960-5.00037-8.

Zupančič, M., Možic, V., Može, M., Cimerman, F. &, Golobič, I. (2022). Current Status and Review of Waste-to-Biogas Conversion for Selected European Countries and Worldwide. *Sustainability*, *14*, 1823. Doi: 10.3390/su14031823.

Carla Zarbà
Department of Agriculture, Food and Environment (University of Catania) - Via Santa Sofia, 98-100 - 95123 Catania, Italy
E-mail: carla.zarba@unict.it
She holds a degree in Law (2009) and she got a Doctoral Degree in Food Economics (2013) at University of Catania. She got a Master in Business Administration at LUISS Business School (2015). In 2011, she spent six months at the (UF) Warrington College of Business Administration (WCBA - University of Florida's)- as a PhD visiting Student.
In 2012, she spent two months in Brussels where she conducted some research at the European Commission.
She obtained the National Scientific Qualification for the positions of university associate professor for the Sector 07/A1 - Agricultural Economics and Valuation.
She has been Research Fellow and currently she is a Researcher at University of Catania. Current research interests include economic and law profiles (agri-food trade, consumers preferences, food and nutrition, sustainability, safety and security, innovation and digitalization, food legislation). She teaches "Food legislation" at University of Catania.

Gioacchino Pappalardo
Department of Agriculture, Food and Environment (University of Catania) - Via Santa Sofia, 98-100 - 95123 Catania, Italy
E-mail: gioacchino.pappalardo@unict.it
He graduated in Agricultural Science (cum laude) in 1993 at Agricultural Faculty of the Catania University.
From October 2018: Associate Professor at the Department of Agriculture, Food and Environment (Di3A), University of Catania. From January 2018 to May 2018: Visiting Research Scholar in the Department of Agriculture Economics and Agribusiness (AEAB) at University of Arkansas (USA) where he deepened the research methods on consumer behavior through Experimental Auctions techniques. From 15-01-2015 to the 30-04-2015: Visiting Research Scholar in the Department of Agricultural Economics at Oklahoma State University (USA) where is collaborating with faculty in the areas of food policy, consumer research and other agricultural economics topics. From 11-10-2014 to 07-11-2014: Visiting Research Scholar in the Center for Systems Integration and Sustainability at Michigan State University (USA) where he participated in the course Introduction to the Models, Clustering and Graphical Representations for Social Network Analysis Social Networks Seminar/CEP991B held by Prof. Kenneth Frank. He also met with faculty in Fisheries and Wildlife, Sociology and throughout the university who are engaged in similar pursuits.

Roberta Selvaggi
Department of Agriculture, Food and Environment (University of Catania) - Via Santa Sofia, 98-100 - 95123 Catania, Italy
E-mail: roberta.selvaggi@unict.it
In 2012, she received her master's degree in Agricultural Science and Technology, with a graduation grade of 110 cum Laude. In February 2021, she became Ph.D. in Agricultural Food and Environmental Science - Cycle XXXIII, discussing the thesis titled "Testing Commitment Costs theory in the purchasing process of Digestate: Empirical evidences from an economic experiment", at the Department of Agriculture, Food and Environment, University of Catania. From February 2021 to January 2023, she holds the position of research fellow for the sector 07/A1, scientific sector AGR/01, within the project "DRASTIC - Driving the Italian agri-food system into a circular economy model" funded by the PRIN 2017 program, at the Di3A Department of University of Catania. Specifically, the title of the research activity was "Driving the olive oil entrepreneurship into a circular economy model".
In January 2022, she obtained the National Scientific Qualification for the positions of university associate professor for the
Sector 07/A1 - Agricultural Economics and Valuation.

Biagio Pecorino
Department of Agriculture, Food and Environment (University of Catania) - Via Santa Sofia, 98-100 - 95123 Catania, Italy
E-mail: biagio.pecorino@unict.it
He is a full professor in the University of Catania. He teaches "Agribusiness Economics" and "Food Safety Policies and Regulations". He has been chairman of graduate courses and responsible for educational activities and university master's degrees. He has coordinated research projects of national and international interest, funded by various public and private entities. He is the head of the Rural Economics and Estimate section of Di3A at the University of Catania. He was a member of the committee for the National Scientific Qualification for the positions of university professor of first and second rank, concurrency sector 07/A1 - Agricultural Economics and Estimate.