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European Green Deal: Threats Assessment for Agri-Food Exporting Countries to the EU

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Abstract: This article is devoted to assessing and substantiating the threats for countries/exporters of agricultural products to the EU under conditions of the European Green Deal. The revealed comparative advantages index (RCA), comparison method, correlation and regression analysis, and taxonomic method have been applied. According to the RCA index the main causes for the relatively significant volume of agri-food exports by some countries to the EU have been identified; using the comparison method it was found that among the leading countries by agricultural products export to the EU, many states do not meet the European Green Deal target criteria for agriculture. Correlation and regression analysis has revealed that among the chosen factors only the volume of fertilisers use per cropland has direct and strong influence on CO2eq emissions; by a taxonomic method the threats value for the leading agri-food exporters to the EU has been calculated. The major agri-food exporters to the EU under conditions of the European Green Deal targets till 2030 have a high threat regarding reduction of their supply to the Member States in the case of a possible Carbon Border Adjustment Mechanism or the introduction of other import restriction mechanisms in future. The results of the study can be used by the government and other executive bodies of the analysed countries to make adequate and rapid decisions to avoid the threats of possible agri-food exports reduction to the EU under the further European Green Deal implementation.

Keywords: European Green Deal; agri-food export; threats; taxonomic method; correlation; regression; reveled comparative advantages; carbon border adjustment mechanism; GHG emissions; fertilisers

1. Introduction

The European Green Deal was adopted on 11 December 2019 and aims to make Europe the first climate-neutral continent by 2050. Moreover, the Deal anticipates accelerating the economic growth, improving people's health and quality of life, cares for nature, and will leave no one behind. Despite the priority of responding to COVID-19, the European Commission emphasised that recovery should focus on a more resilient, greener, and digital Europe, solutions that not only benefit the economy but also the environment [1–3]. Generally, the European Green Deal covers all sectors of the economy, particularly transport, energy, buildings, industries such as steel, cement, ICT, textiles, chemicals, and agriculture [4]. It should be noted that agriculture occupies a significant place in the EU policy regarding overcoming the threats from climate change. Particularly, the Farm to Fork Strategy is at the heart of the Green Deal. Furthermore, it comprehensively addresses the challenges of sustainable food systems and recognises the inextricable links between healthy people, healthy societies, and a healthy planet Generally, the European Commission intends to reduce the GHG emission towards 50 or 55% compared with the 1990 levels [5–9]. In turn, the Farm to Fork Strategy proposes a new approach to ensure that agriculture, fisheries, aquaculture, and the food value chain contribute appropriately to this process [10]. This sector of economy should lead to a decrease in carbon dioxide equivalent emissions by reducing by the use and risk of chemical pesticides by 50%, by decreasing nutrient losses by at least 50% (while ensuring no deterioration on soil fertility), by reducing fertiliser use by at least 20%, by decreasing by the sales of antimicrobials for farmed animals and in aquaculture by 50% and by increasing up the total farmland under organic farming by up to 25% by 2030 [11]. Obviously, the Green Deal requirements will influence not only the European producers and exporters of agricultural products but also foreign suppliers of agri-food. It should be underlined that a significant threat concerns the possible introduction of a Carbon Border Adjustment Mechanism [12,13]. Despite the mechanism actively being used regarding paper products, aluminum, petroleum and coal products, steel and ferrous metal, cement and glass, chemical fertilisers, and electricity [14] the agri-food sector remains in terms of implementation threat [15–20]. Moreover, the EU can also apply other mechanisms of agri-food import restriction.

Despite the short period since the adoption of the European Green Deal, many scientific papers have already been published on its impact on international merchandise trade [21–30]. In turn, the problem of the European Green Deal influencing the international agri-food trade has been reviewed in the next few articles. Thus, Alessandra Kirsch [31], Director of strategic agriculture studies, confirms that Europe limits its imports from countries that do not apply its new environmental standards by 50% and therefore this would lead to decrease in exports for the United States, and the worst in terms of agricultural income for the US. The results of research by Beckman, J. and Ivanic et al. [32] have shown that there will be a general reduction in trade activities in the agri-food industry, particularly: a decrease in agri-food production, increasing food prices, increasing imports, reduction in exports, decrease in the farmer's gross income, increasing food costs, increasing food insecurity, and reduction in the gross domestic product. Moreover, it was predicted that all world regions would experience a decline of 2–4% as the result of the Green Deal. In turn, Sihlobo, W. and Kapuya, T. [33] have described a potential threat for South Africa in the case of agri-food export to EU. Particularly, the researchers indicate that due to the lack of financial and technical capacity of farmers in region they will be left out of the new "sustainable agro-food system". The smallholder's resource-poor African farmers also will not be able to afford the high costs of adopting new regulations and certification. As the result, without financial support, most of them will inevitably be excluded from participating in export markets. Moreover, food producers who cannot comply with the provisions of the Farm to Fork strategy could potentially relocate parts of their value chain to South Africa, targeting exports to the Middle East, and the Far East and Asia where food standards are far less stringent.

Thus, most researchers studying the impact of the European Green Deal on international merchandise trade clearly point to the threat of a possible slowdown in agri-food trade with the EU. However, in their papers, they do not estimate this threat level and do not provide a clear explanation of how it can be distributed among the leading food-exporting countries to the EU and which of them are likely to suffer the most from declining demand in the Union's member states due to environmental import restrictions.

Therefore, the purpose of the article is to assess and substantiate the threat for major countries/exporters of agricultural products to the EU in terms of the European Green Deal (particular, the Farm to Fork Strategy).

2. Materials and Methods

To calculate the revealed comparative advantage (*RCA*) of agricultural products in the EU and the major EU trade partners, the method based on Ricardian trade theory was used in the article. The method provides which patterns of trade among countries are governed by their relative differences in productivity. Although such productivity differences are difficult to observe, a *RCA* metric can be readily calculated using trade data to "reveal" such differences [34]. Thus, the *RCA* can be estimated by formula:

$$RCA_{Ai} = \frac{X_{Ai}}{\sum_{j\in P} X_{Aj}} : \frac{X_{Wi}}{\sum_{j\in P} X_{Wj}} \geq 1, \tag{1}$$

where: P is the set of all products (with $i \in P$); X_{Ai} is country A's exports of product i; X_{Wi} is the world's exports of product i; $\sum_{j\in P} X_{Aj}$ is country A's total exports (of all products j in P); $\sum_{j\in P} X_{Wj}$ is the world's total exports (of all products j in P).

When a country has a revealed comparative advantage for a given product ($RCA > 1$), it is a competitive producer and exporter of that product relative to a country producing and exporting that good at or below the world average. A country with a revealed comparative advantage in product i is considered to have an export strength in that product. The higher the value of a country's RCA for product i, the higher its export strength in product i [34]. However, when $RCA \leq 1$ it means a country does not have a revealed comparative advantage for a given product i.

In turn, correlation analysis was used to calculate the nature and closeness of the relationship between carbon dioxide (equivalent) emissions per agricultural land and pesticides, fertilisers use and soil nutrient budget per cropland area. By the objective of the study 28 countries were selected—the current major agri-food exporters to the EU market. The calculations were performed in the *STATISTICA program*, a universal package of statistical analysis which allows us to perform various procedures for statistical data processing, and it is included by Dell company in its own line of software for big data.

The data came from *Faostat* databases. Independent variables introduced in the regression were pesticides use per cropland (*PEST*), fertilisers use per cropland (*FERT*), soil nutrient budget per cropland (*SOIL*). Thus, carbon dioxide equivalent emission is thought to be directly related to this function:

$$\text{CO2eq} = f\ (PEST, FERT, SOIL), \tag{2}$$

Statistically, the following model is run:

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + u, \tag{3}$$

where Y—represents carbon dioxide equivalent emissions per 1 hectare of agricultural land; X_1—pesticides use per cropland, X_2—fertilisers use per cropland, X_3—soil nutrient budget per cropland, u—known as the disturbance, or error, term, is a random (stochastic) variable that has well-defined probabilistic properties.

Finally, to estimate the threat for agri-food exporters to the EU according to possible Carbon Border Adjustment Mechanism (CBAM) introduction in future (or other import restriction mechanisms) a taxonomic method was used in the article. It is a generalisation of the distance method, which is based on operations with matrices. The source is the matrix X, which consists of a set of values of n indicators for a group of m countries. The matrix of initial data has been formed and included information from 28 countries—major exporters of agricultural products to the Member States based on two basic indicators: carbon dioxide equivalent per agricultural land and fertilisers uses per cropland.

$$X = \begin{pmatrix} x_{11} & \dots & x_{1j} & \dots & x_{1n} \\ \dots & \dots & \dots & \dots & \dots \\ x_{i1} & \dots & x_{ij} & \dots & x_{in} \\ \dots & \dots & \dots & \dots & \dots \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{pmatrix}, \tag{4}$$

where: $i = 1, \dots, m$—the rank of the country; $j = 1, \dots, n$—the rank of the indicator

As all indicators have a different nature and incomparable values, the next step should be the rationing of indicators and standardization of the matrix X. It should be noted the matrix X is standardised and transformed to matrix Z by the following Formula (6):

$$Z = \begin{pmatrix} Z_{11} & \dots & Z_{1j} & \dots & Z_{1n} \\ \dots & \dots & \dots & \dots & \dots \\ Z_{i1} & \dots & Z_{ij} & \dots & Z_{in} \\ \dots & \dots & \dots & \dots & \dots \\ Z_{m1} & \dots & Z_{mj} & \dots & Z_{mn} \end{pmatrix}, \tag{5}$$

$$z_{ij} = \frac{x_{ij} - \overline{x_i}}{\sigma_i}, \tag{6}$$

where: $\overline{x_i}$—is the arithmetic mean of all levels of indicator i; σ_i—standard deviation of i;

The next step in ranking is to define a "reference country". To do this, in any column the lowest value of the corresponding indicator depending on its optimal value is chosen. The characteristic of the "reference country" is a matrix line:

$$(\mathrm{Z_1}^e \dots . \mathrm{Z_n}^e), \tag{7}$$

The calculation of quasi-distances R_{ij} from any country to the standard makes it possible to conduct a ranking for all countries included in the study. The country with the best indicators regarding fact and potential carbon dioxide equivalent emissions is selected by using the least squares method.

$$R_j = \sum_{j=1}^{n} \left(Z_{ij} - Z_i^e\right)^2 \tag{8}$$

A country with a minimum value of R_j should be considered preferred [35].

3. Results

It is well known that the European Union has remained one of the biggest exporters and importers of agricultural products worldwide. In particular, the member states have imported (extra-EU import) agricultural products valued at 180 billion US dollars that equaled 10.1% in world agri-food import in 2019 [36]. It has ensured the second position for the EU after China (like the USA) among the top-10 exporters of agricultural products. Furthermore, the EU's agri-food import is diversified because no one country partner has over 10% here (Figure 1). Brazil, USA, Norway, and China are the major food, drinks, and tobacco suppliers to the member states market. Further, together with Turkey, Argentina and Switzerland, Ukraine has occupied the eighth rank among twenty-eight EU trade partners by agricultural products.

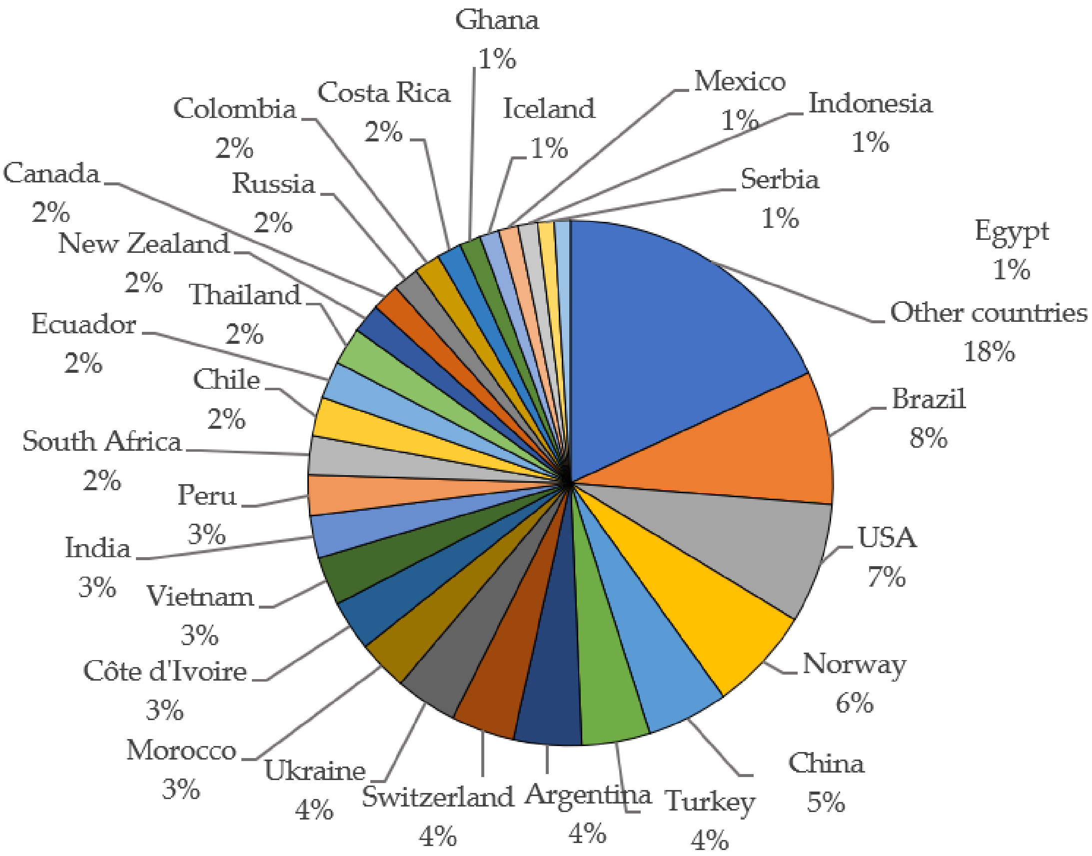

Figure 1. The share of the main exporters of food, drinks, and tobacco to EU-28 in 2019 (%). Source: compiled by the authors based on [37].

The leading position of the biggest food, drinks, and tobacco suppliers (in particular, Brazil and the United States) to the European market is explained by revealed comparative advantages availability (Table 1). Moreover, these countries are the powerful players into the world agri-food market. At first glance, the import position of China and Switzerland looks strange because both countries have a RCA index below the necessary level (RCA < 1). However, the significant role of Switzerland as an EU food importer can be explained by a unique profitable geographical location (between the EU member states) and bilateral trade agreement between participates.

In turn, China imported to the EU agri-food value approximately EUR 5.1 billion in 2020. It should be noted that mainly, the Asian country exports to the EU include offal, animal fats, and other meats, fresh, chilled and frozen food—EUR 482 million; pet food—EUR 449 million; vegetables, fresh, chilled and dried—EUR 445 million and tropical fruit, fresh or dried, nuts and spices—EUR 439 million [38].

Table 1. Revealed comparative advantages of the main countries–importers of agri-food to the EU in 2019.

n_o	Country	Export of Agricultural Products, Million USD (X_{AI})	Total Exports of All Products, Million USD ($\Sigma j \epsilon p X_{Aj}$)	The World's Export of Agricultural Products, Million USD (X_{WI})	The World's Total Export of All Products, Million USD ($\Sigma j \epsilon p X_{Wj}$)	Revealed Comparative Advantage Index (RCA_{AI})
	1	2	3	4	5	6
	EU-28	640,755	5,825,085	×	×	1.17
1	Brazil	89,098	225,383	×	×	4.22
2	USA	164,803	135,950	×	×	12.93
3	Norway	13,814	102,799	×	×	1.43
4	China	81,676	2,499,457	×	×	0.35
5	Turkey	20,284	180,833	×	×	1.20
6	Argentina	38,999	65,116	×	×	6.39
7	Switzerland	9,836	313,934	×	×	0.33
8	Ukraine	22,900	50,066	×	×	4.88
9	Morocco	6394	29,132	×	×	2.34
10	Côte d'Ivoire	8062	12,629	×	×	6.81
11	Vietnam	29,943	264,268	×	×	1.21
12	India	37,371	324,340	×	×	1.23
13	Peru	10,826	47,690	×	×	2.42
14	South Africa	11,285	90,016	×	×	1.34
15	Chile	23,051	68,763	×	×	3.57
16	Ecuador	11,835	22,329	×	×	5.65
17	Thailand	42,982	246,269	×	×	1.86
18	New Zealand	29,343	39,517	×	×	7.92
19	Canada	65,045	446,585	×	×	1.55
20	Russia	33,722	419,850	×	×	0.86
21	Colombia	7360	39,489	×	×	1.99
22	Costa Rica	4687	11,712	×	×	4.27
23	Ghana	3871	15,668	×	×	2.63
24	Iceland	2471	5223	×	×	5.04
25	Mexico	39,746	460,704	×	×	0.92
26	Indonesia	42,953	167,683	×	×	2.73
27	Serbia	3792	19,630	×	×	2.06
28	Egypt	5592	28,993	×	×	2.06
	World	×	×	1,783,648	19,019,026	×

Source: compiled by authors based on [37,39].

The European Green Deal aims to increase the EU's greenhouse gas emission reductions target for 2030 to at least 50%, and towards 55% compared with the 1990 levels, in a responsible way [40]. According to the general aim, the target level of carbon dioxide (equivalent) emissions in the EU's agriculture should be decreased up to 244.9 million tonnes (1.35 tonnes per hectare of agricultural land). In 2019 the EU's average indicator equaled 2.44 tonnes per 1 ha of agricultural land. It should be underlined that in most agri-food exporters to the EU today's GHG emissions exceeds the target level. Among the top 10 exporters of agricultural products to the Member States Brazil, Norway and Switzerland can fall into the outsiders list. In contrast, probably the United States, Ukraine, Morocco, and Côte d'Ivoire (which have a high RCA level) will avoid the threat to possible agri-food import restriction by European Commission in future by introduction of the Carbon Border Adjustment Mechanism (CBAM) (Figure 2). Still, it is unclear whether the CBAM will include agricultural products later. The current EU Emissions Trading Scheme (EU ETS) does not include agriculture. However, in 2026, the Commission will evaluate whether to extend the scope to include other products [41].

Furthermore, the EU member states pay constant attention to the problems of food stability and security [42]. As mentioned earlier, according to the Farm to Fork strategy, the European Commission will take action to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030. Additionally, the nutrient losses will be reduced by at least 50%, while ensuring that there is no deterioration in soil fertility. This will decrease the use of fertilisers by at least 20% by 2030 [10]. As the result, the final chemical pesticides use level will be approximately 1.57 kg per 1 hectare of cropland while the soil nutrient budget (equivalent of the nutrient losses) and synthetic fertilisers use will achieve 48.4 and 112.34 kg per 1 hectare of cropland, respectively (Figures 3–5).

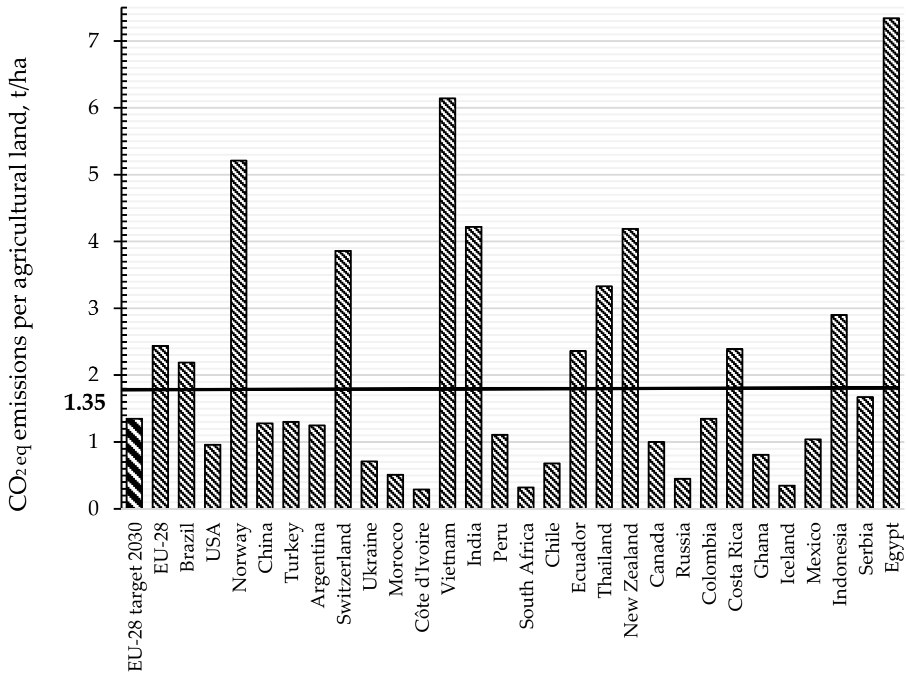

Figure 2. CO2eq emissions per agricultural land in the EU (including target 2030) and major agri-food exporters to the Member States in 2019. Source: compiled by the authors based on [43].

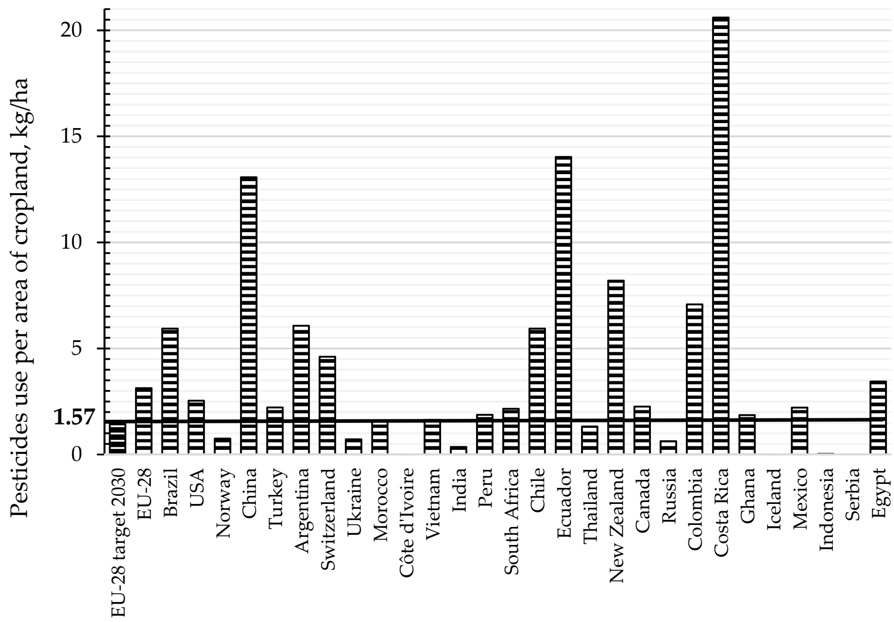

Figure 3. Pesticides use per area of cropland in the EU (including target 2030) and major agri-food exporters to the Member States in 2019. Source: compiled by the authors based on [43].

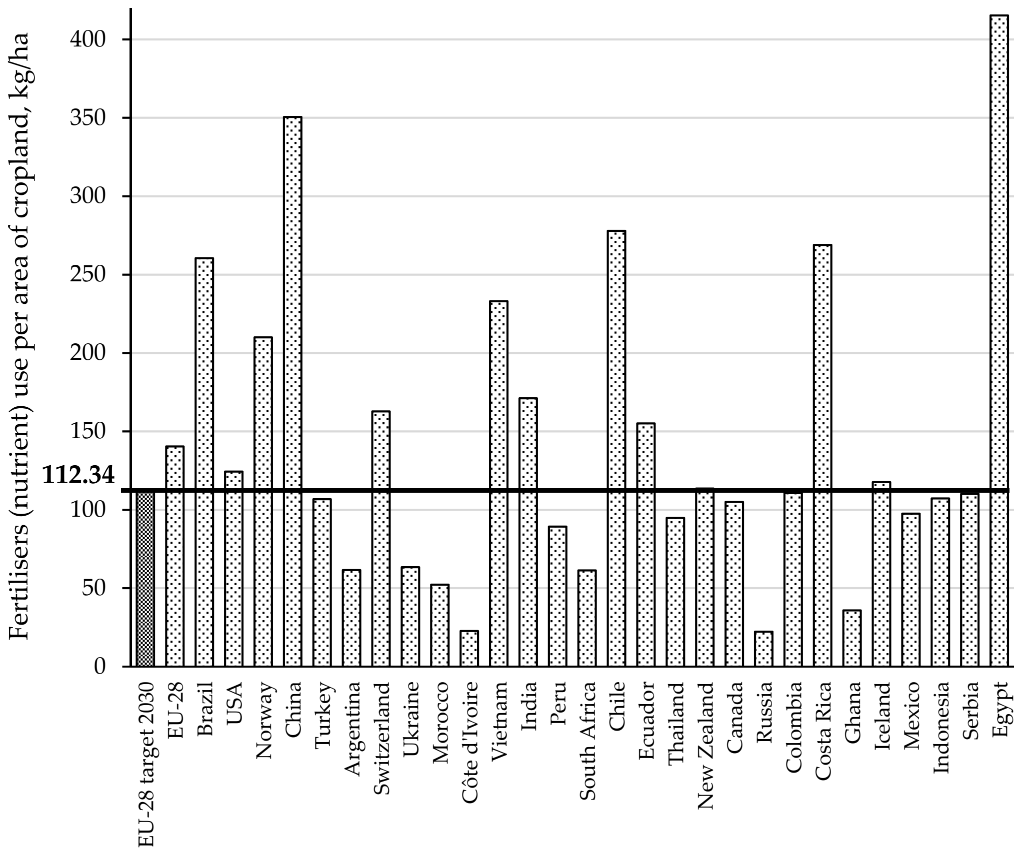

Figure 4. Fertilisers (nutrient) use per area of cropland in the EU (including target 2030) and major agri-food exporters to the Member States in 2019. Source: compiled by the authors based on [43].

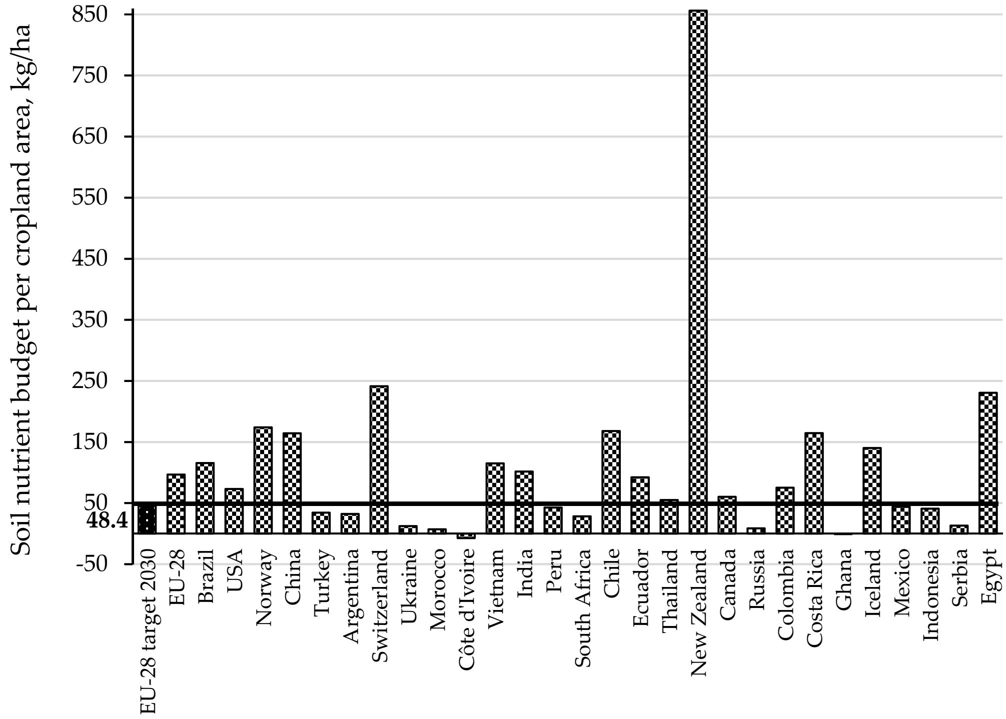

Figure 5. Soil nutrient budget per cropland area in the EU (including target 2030) and major agri-food exporters to the Member States in 2019. Source: compiled by the authors based on [43]—data 2018.

However, to more accurately assess the potential threat of future reduction of agri-food export for the major EU's exporters, the relationship between GHG emissions and the Farm to Fork strategy requirements, in particular pesticides, synthetic fertilisers, and soil nutrient budget should be calculated.

Thus, correlation analysis between carbon dioxide (equivalent) emissions per 1 hectare of agricultural land and pesticides use per 1 hectare of cropland has revealed a positive but weak relationship between them at 0.045 (Figure 6).

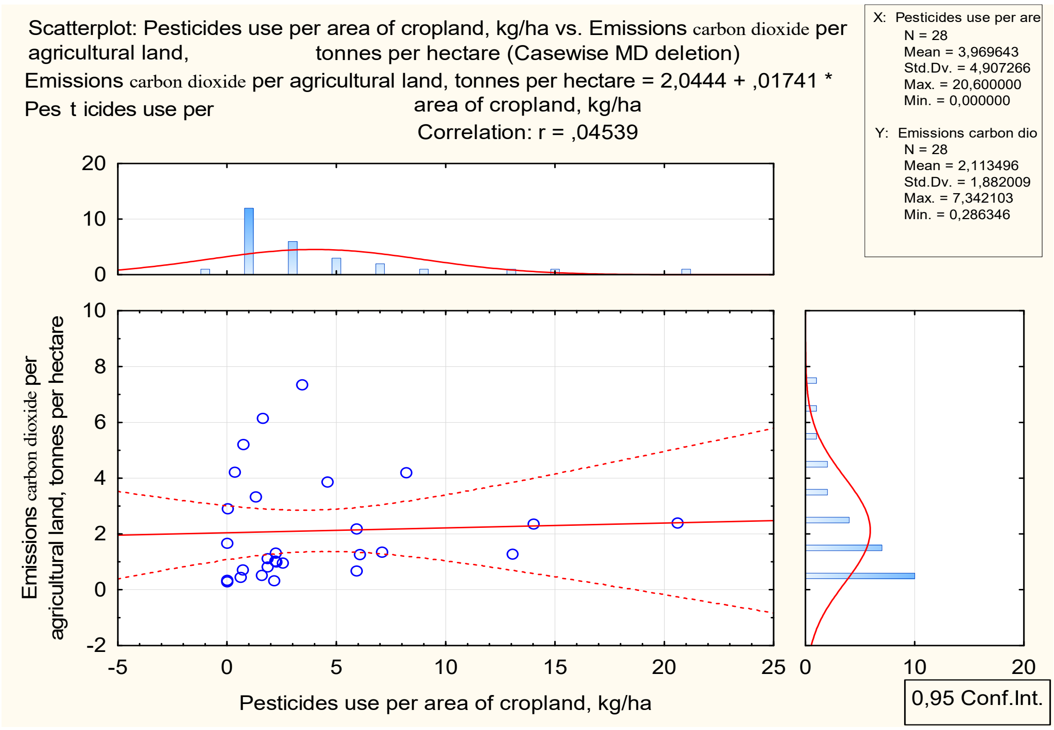

Figure 6. The observations (blue dots) and regression line (red line). The histogram shows the distribution functions and descriptive statistics for pesticides use per cropland (the histogram above) and CO2eq emissions per agricultural land (the histogram right). Source: compiled by the authors.

This statistical result has indicated that pesticides use per cropland is not an important factor to form carbon dioxide (equivalent) emissions. It can be explained by the significant scope of variation of pesticides in terms of countries at 123.6 percent (the highest level is in Costa Rica—20.6 kg per hectare of cropland while in Iceland—0.01 kg per cropland and in Serbia there are no data). Thereby, it underlines the necessity for more detailed analysis at local level.

In turn, a correlation coefficient at 0.585 between carbon dioxide (equivalent) emissions per agricultural land and fertilisers per cropland has indicated the presence of a positive and medium relationship between the studied variables (Figure 7).

Thus, the fertilisers use per cropland influence on the formation of 34.3% of carbon dioxide (equivalent) emissions per agricultural land. At the same time, outsider countries were also identified in terms of fertilisers: China—350.5 kg per hectare and Egypt—415.31 kg per hectare of cropland.

Finally, the correlation analysis between carbon dioxide (equivalent) emissions and soil nutrient budget also found a direct positive relationship at the level of 0.453 (Figure 8).

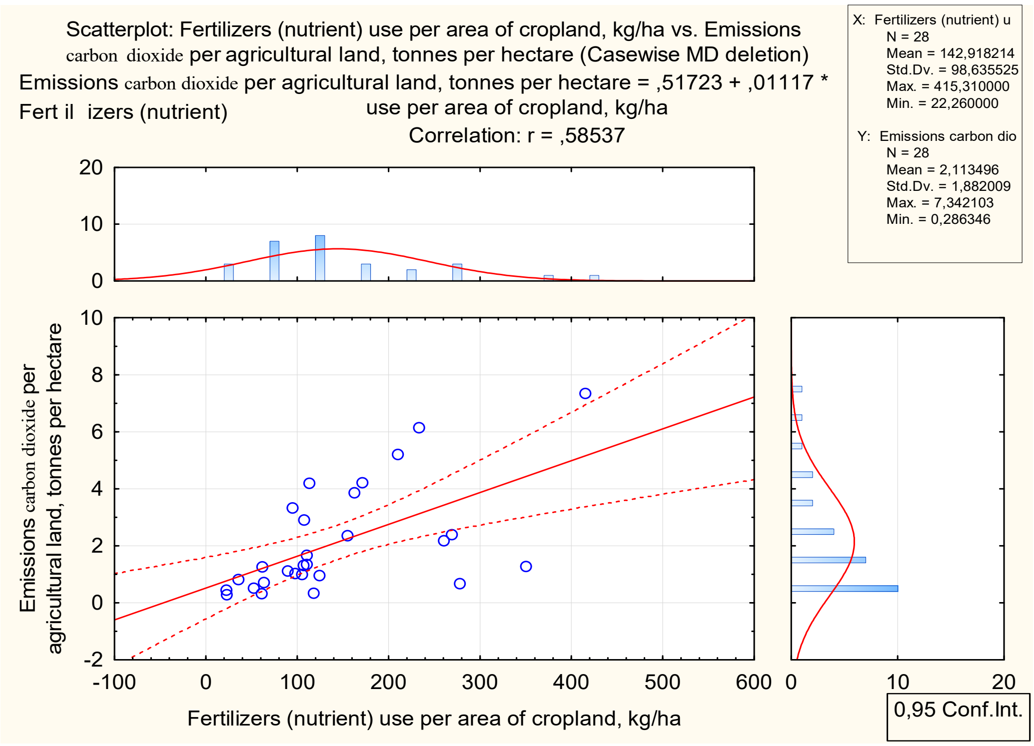

Figure 7. The observations (blue dots) and regression line (red line). The histogram shows the distribution functions and descriptive statistics for fertilisers use per cropland (the histogram above) and CO2eq emissions per agricultural land (the histogram right). Source: compiled by the authors.

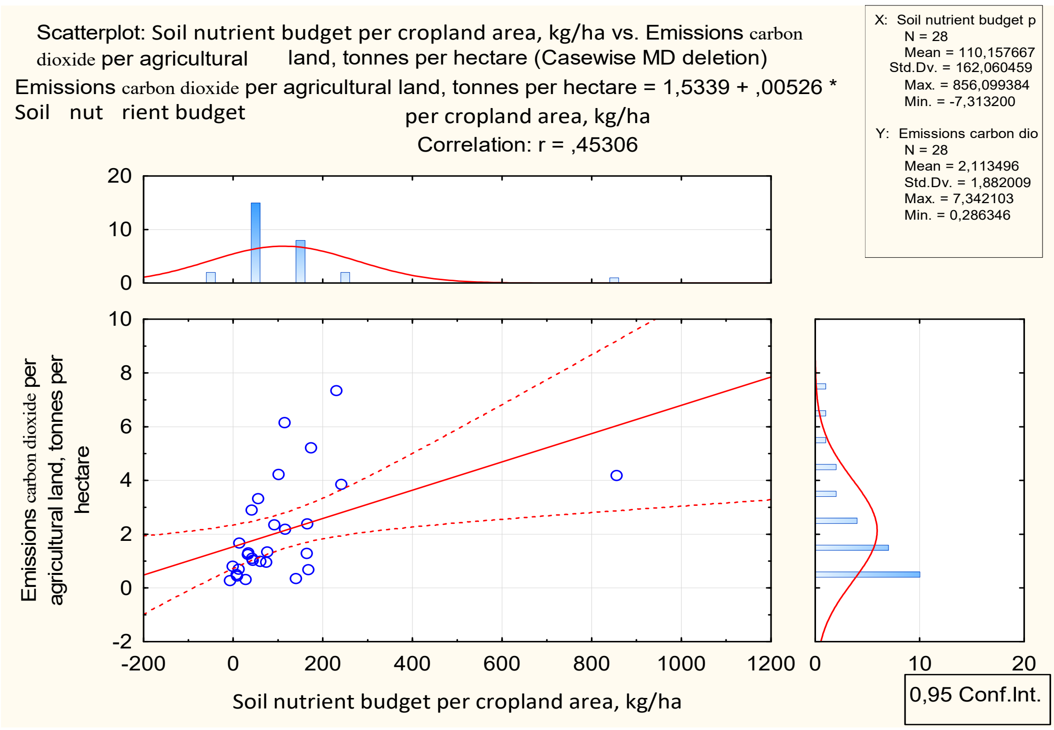

Figure 8. The observations (blue dots) and regression line (red line). The histogram shows the distribution functions and descriptive statistics for soil nutrient budget per cropland area (the histogram above) and CO2eq emissions per agricultural land (the histogram right). Source: compiled by the authors.

Therefore, this figure generates CO2eq emissions at 20.5 percent. However, the set of nutrients in the soil content is heterogeneous, because along with countries with fertile soil, such as New Zealand—856.1 kg/ha, there are countries with a negative content of nutrients, such as Côte d'Ivoire (−7.31 kg/ha) and Ghana (−0.58 kg/ha), due to their territorial location.

The generalised correlation matrix of the research results is given in Table 2.

Table 2. Correlation matrix.

Variables	**Correlations (Spreadsheet1) Marked Correlations Are Significant at p < 0.05000 n = 28 (Casewise Deletion of Missing Data)**					
	Means	**Std.Dev.**	**Emissions Carbon Dioxide per Agricultural Land, Tonnes per Hectare**	**Pesticides Use per Area of Cropland, kg/ha**	**Fertilisers (Nutrient) Use per Area of Cropland, kg/ha**	**Soil nutrient Budget per Cropland Area, kg/ha**
Emissions carbon dioxide equivalent per agricultural land, tonnes per hectare	2.11	1.88	1.00	0.05	0.59	0.45
Pesticides use per area of cropland, kg/ha	3.97	4.91	0.05	1.00	0.47	0.33
Fertilisers (nutrient) use per area of cropland, kg/ha	142.92	98.64	0.59	0.47	1.00	0.31
Soil nutrient budget per cropland area, kg/ha	110.16	162.06	0.45	0.33	0.31	1.00

Source: compiled by the authors.

The analysis of the above pairwise correlation coefficients showed the absence of multicollinearity between the studied variables. Student's criterion with significance level $\alpha = 0.05$ and degrees of freedom n–m was used to assess the significance of the relationship (Table 3).

Table 3. Criteria for estimation the significance of correlation coefficients.

Variables	**t-Value**	**df**	p	**F-Ratio**	p
				Variances	**Variances**
Emissions carbon dioxide equivalent per agricultural land, tonnes per hectare vs. Pesticides use per area of cropland, kg/ha	1.868	54	0.067	6.799	0.000
Emissions carbon dioxide per agricultural land, tonnes per hectare vs. Fertilisers (nutrient) use per area of cropland, kg/ha	7.552	54	0.000	2746.776	0.000
Emissions carbon dioxide per agricultural land, tonnes per hectare vs. soil nutrient budget per cropland area, kg/ha	3.527	54	0.000	7414.992	0.000

Source: compiled by the authors.

Estimation of the significance of the correlation coefficients has shown that the pesticides use per cropland is an insignificant factor, as the actual value of the Student's t-test has equaled 1.868 with a normative value at 2.069.

As the fertilisers use per cropland and the soil nutrient budget per cropland have a relatively significant impact to the carbon dioxide equivalent emissions, this confirms inclusion of these variables in the regression model which allows us to calculate the influence degree of variables to result factor (Table 4).

Table 4. Regression analysis.

Variables	Regression Summary					
	b	Std.Err.	β	Std.Err.	t (25)	*p*-Value
Intercept			0.386	0.505	0.764	0.452
Fertilisers (nutrient) use per area of cropland, kg/ha	0.492	0.160	0.009	0.003	3.087	0.005
Soil nutrient budget per cropland area, kg/ha	0.301	0.160	0.003	0.002	1.887	0.071

Source: compiled by the authors.

The results of the modelling have indicated that increasing of fertilisers use per 1 kg/ha of cropland will lead to increase the CO2eq per agricultural land by 0.009 t/ha (or 9 kg per hectare). In turn, increasing of soil nutrients budget per 1 kg /ha of cropland will increase the CO2eq per agricultural land by 0.003 t/ha (or 3 kg per hectare).

The coefficient of determination at 0.424 has shown that fertilisers use per cropland and soil nutrient budget per cropland forms 42.4% of GHG emissions per agricultural land.

The significance of the regression parameter b1 (fertilisers use per cropland) is confirmed by the Student's *t*-test greater than the tabular value at a degree of significance $\alpha = 0.05$. The regression parameter b2 (soil nutrient budget per cropland) was insignificant because it equaled zero.

Therefore, by correlation and regression analysis, the variables iteration was performed, and it was revealed that fertilisers use per cropland is a decisive factor in the formation of GHG emissions. Furthermore, also there are other scientific results which indicate that agricultural productivity and economic growth significantly stimulate greenhouse emissions, particularly in the EU [44,45].

Finally, fertilisers use per cropland together with carbon dioxide equivalent per agricultural land should be included in the taxonomic method to estimate the threat for the agri-food-exporting countries to the EU according to the possible Carbon Border Adjustment Mechanism (CBAM) or other import restriction mechanism introduction in future. As a result, the matrix of initial data by 28 countries and by two basic indicators is formed in the Table 5.

Table 5. Matrix *X* of initial data.

n_o	Countries	Emissions CO2eg per Agricultural Land, Tonnes per Hectare (X_1)	Fertilisers(Nutrient) Use per Area of Cropland, kg/ha (X_2)
1	Brazil	2.19	260.50
2	USA	0.96	124.35
3	Norway	5.21	210.01
4	China	1.28	350.50
5	Turkey	1.30	106,77
6	Argentina	1.25	61.60
7	Switzerland	3.86	162.78
8	Ukraine	0.71	63.43
9	Morocco	0.51	52.30
10	Côte d'Ivoire	0.29	22.69
11	Vietnam	6.14	233.00
12	India	4.22	171.10
13	Peru	1,11	89.31
14	South Africa	0.32	61.37
15	Chile	0.68	277.92
16	Ecuador	2.36	155.08
17	Thailand	3.33	94.79
18	New Zealand	4.19	113.54
19	Canada	1.00	105.04
20	Russia	0.45	22.26
21	Colombia	1.35	110.66
22	Costa Rica	2.39	268.99
23	Ghana	0.81	35.84
24	Iceland	0.35	117.68
25	Mexico	1.04	97.56
26	Indonesia	2.90	107.22
27	Serbia	1.67	110.11
28	Egypt	7.34	415.31

Source: compiled by the authors based on [43].

In turn, the matrix X is standardised and transformed to matrix Z (Table 6).

Table 6. Standardised matrix *Z*.

n_o	Countries	Zx_1	Zx_4
1	Brazil	0.04	1.21
2	USA	−0.63	−0.19
3	Norway	1.68	0.69
4	China	−0.45	2.14
5	Turkey	−0.44	−0.37
6	Argentina	−0.46	−0.84
7	Switzerland	0.94	0.21
8	Ukraine	−0.76	−0.82
9	Morocco	−0.87	−0.94
10	Côte d'Ivoire	−0.99	−1.24
11	Vietnam	2.18	0.93
12	India	1.14	0.29
13	Peru	−0.54	−0.55
14	South Africa	−0.97	−0.84
15	Chile	−0.78	1.39
16	Ecuador	0.13	0.13
17	Thailand	0.66	−0.50
18	New Zealand	1.12	−0.30
19	Canada	−0.61	−0.39
20	Russia	−0.90	−1.25
21	Colombia	−0.42	−0.33
22	Costa Rica	0.15	1.30
23	Ghana	−0.71	−1.11
24	Iceland	−0.96	−0.26
25	Mexico	−0.58	−0.47
26	Indonesia	0.42	−0.37
27	Serbia	−0.24	−0.34
28	Egypt	2.83	2.81

Source: compiled by the authors.

According to the data in Table 6 the «reference country» is (−0.99 ... −1.25). The calculation of quasi-distances R_{ij} from any country to the standard has made it possible to conduct a ranking for all countries (Table 7).

Table 7. Ranking of the countries by quasi-distances R_{ij}.

n_o	Countries	$(Z_1 - Z^e)^2$	$(Z_2 - Z^e)^2$	R_{ij}	Rank
1	Côte d'Ivoire	0.00	0.00	0.00	1
2	Russia	0.01	0.00	0.01	2
3	Ghana	0.08	0.02	0.10	3
4	Morocco	0.01	0.10	0.11	4
5	South Africa	0.00	0.16	0.16	5
6	Ukraine	0.05	0.18	0.23	6
7	Argentina	0.27	0.16	0.44	7
8	Peru	0.20	0.48	0.68	8
9	Mexico	0.16	0.60	0.77	9
10	Canada	0.15	0.73	0.88	10
11	Iceland	0.00	0.97	0.97	11
12	Turkey	0.30	0.76	1.07	12
13	Colombia	0.33	0.83	1.16	13
14	USA	0.13	1.11	1.24	14
15	Serbia	0.56	0.82	1.38	15
16	Indonesia	2.00	0.77	2.77	16
17	Ecuador	1.26	1.88	3.14	17
18	Thailand	2.71	0.56	3.27	18
19	New Zealand	4.47	0.89	5.36	19
20	Switzerland	3.74	2.10	5.84	20
21	India	4.52	2.36	6.88	21
22	Chile	0.04	6.97	7.01	22
23	Brazil	1.06	6.05	7.11	23
24	Costa Rica	1.29	6.49	7.78	24
25	Norway	7.11	3.76	10.87	25
26	China	0.29	11.48	11.77	26
27	Vietnam	10.05	4.73	14.78	27
28	Egypt	14.58	16.47	31.04	28

Source: compiled by the authors.

4. Discussion

It should be emphasised that topic of the impact of agri-food production on carbon dioxide emissions is very worrying and needs to be addressed. In particular, chemical pesticide application not only increases crop yields, but also plays an important role in increasing greenhouse gas emissions into the atmosphere [46]. In contrast, there are scientific results which indicate that pesticide manufacturing represents only about 3% of the 100-year Global Warming Potential (GWP) from crops while about 50% of the GWP from arable crops is due to the field emissions of nitrous oxide from the soil, which has a very large GWP [47]. Moreover, some scientists confirm that an important source of agricultural pollution is the emission of GHG from the soil as a result of mineralisation of dead organic matter and humus compounds [48]. Additionally, certain results point to the manufacture and application of synthetic N fertilisers for crops growing as a major source of agricultural GHG emissions [49]. Furthermore, the efficiency of fertiliser nitrogen use is an important element shaping the level of agricultural carbon dioxide equivalent emissions [5]. However, there are opposite results regarding chemical fertilisers' influence on atmosphere pollution. Thus, some Chinese researchers gained a 95% confidence interval for national GHG emissions from each agricultural activity and came to conclusion that chemical pesticides use and nitrogen fertiliser use does not significantly influence GHG emissions [50]. Additionally, some scientists consider that the amount of carbon dioxide equivalent emissions is directly dependent on the amount of energy consumption and the structure of the energy carriers use [51].

Our research based on correlation and regression analysis has proved that only chemical fertiliser use per hectare of cropland is a decisive factor in the GHG emissions formation in agriculture. According to this there is a reason to confirm that the most agri-food-exporting countries to the EU are at high threat of possible food import reduction within the European Green Deal. However, it is most likely among the states, Côte d'Ivoire, Russia, Ghana, Morocco, South Africa, Ukraine, Argentina, Peru, Mexico, Canada, Iceland, Turkey, and Columbia will be able to avoid this threat because their current level of CO2 (eq) emissions per agricultural land and fertiliser use per cropland will not exceed the target EU indicators until 2030. It has been determined by graphical method in Figures 2 and 4. Moreover, this conclusion has been obtained by the author according to the minimum volume of calculated quasi-distances (from 0.00 to 1.16).

Unlike the US, the significant global and EU agri-food market player (RCA equals 12.93) occupies medium rank (quasi-distance is 1.24) in the group of studied countries by possible threat value. The obtained results have proved the fear of Alessandra Kirsch [31], director of strategic agriculture studies, that European Green Deal environment standards implementation will lead to a decrease in the US agri-food exports.

In turn, another significant agri-food exporter to the EU, particularly Brazil, despite of competitive own agriculture (RCA = 4.12) has not much opportunity to keep its leading position among competitors in terms of future trade changes (only 23rd rank by the taxonomic results). There is also a high possibility that China and Norway will not be able to save their current share of the EU agri-food market because the countries have relatively big size of quasi-distances—11.77 and 10.87 (26th and 25th ranks). Moreover, if Norwegian agriculture has low comparative advantages index in foreign trade (1.43) then Chinese food exporters are deprived the competitive positions at all (RCA = 0.35).

5. Conclusions

This article assesses and substantiates the threat for major countries–exporters of agricultural products to the EU in terms of the European Green Deal (in particular, the Fork to Farm Strategy). The results indicated that among the top five leading agri-food exporters to the EU, it is likely that only Turkey has the best opportunities to minimise losses from threat of possible introduction of import restrictions until 2030. In turn, for Brazil, the US, Norway, and China it will be difficult to keep their existing shares on the EU agri-food market. Thereby, the governments of these states must take urgent measures to encourage farmers to use widely sustainable management practices, especially regarding GHG emissions reduction.

In turn, by graphical method, correlation and regression analysis, and taxonomic method it was found that African countries—food exporters to the EU (excluding Egypt) which are characterised by comparative advantages in agriculture—have a minimum threat regarding reduction of their supply to the Member States in the case of a possible Carbon Border Adjustment Mechanism (CBAM) or introduction of another agri-food import restriction mechanism later. However, the authority in agrarian sector of the states should monitor the use of chemical fertilisers and GHG emissions to avoid their increasing.

Thus, due to the European Green Deal, the least developed and primarily developing countries will probably obtain the opportunity to increase their agri-food production and export which means rapid economic growth, going up the incomes of poor farmers and improvement of human well-being.

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