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RELATIONSHIP BETWEEN CLIMATE CHANGE AND AGRICULTURE AT THE EU LEVEL

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Abstract: The purpose of this study is investigating the homogeneity of the European Union countries (hereinafter: EU countries) according to the achieved level of environmental performance in agriculture and climate change in 2020. The data used for this study are from an internationally comparable database. For the purpose of validation of the laid hypothesis, methods of statistical analysis were employed. The study focuses on Climate change and Agriculture, two factors of the Ecosystem Vitality component, which will be considered in more detail, as well as the indicators included in the Environmental Performance Index (hereinafter: EPI) structure. The empirical findings revealed the existence of a medium and a positive quantitative agreement between the two environmental policy areas, agriculture and climate change. Also, the cluster analysis showed that most of the countries selected for the research apply agricultural production with controlled use of nitrogen, which further affects the reduced emissions of greenhouse gases and thus minimally contributes to climate change.

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1. Introduction

For many years, the world has faced many problems such as: economic and financial crises, population growth, inequality, poverty, migration, environmental problems and unemployment. Global environmental problems are caused by economic development. Large-scale global economic activity is changing climate, water cycle and biodiversity. Therefore, people with great influence on the world economy cause great disturbances of physical and biological systems.

Climate change is becoming increasingly apparent. The sudden rise in temperature on the entire planet, and with it the droughts, floods, heat waves, forest fires, will be even more extreme and more frequent throughout Europe. Due to their complexity, unpredictability, as well as the huge potential cumulative impact on all sectors of social and economic life, climate change deserves the most serious treatment and the urgent need to find ways to adapt. By transforming the economy into a "green", innovative, profitable and socially cohesive economy, adaptation to climate change will be made to a level that is possible at the achieved level of technological development.

The particular importance of the impact of climate change is seen in the 2030 Agenda, adopted in 2015. Climate change is seen as a special goal of this Agenda, which emphasizes the need to take urgent measures to combat climate change and its impact. With the increase in greenhouse gas emissions, climate change is happening faster than predicted, and the effects are clearly being felt around the world. In addition to the 2030 Agenda, the Paris Agreement was adopted, committing the signatory countries to take important steps in reducing greenhouse gas emissions and strengthening the resilience and ability of countries to adapt to climate change and take joint climate action (United Nations, 2020).

Adapting different economic sectors to the effects of climate change is considered inevitable. One of the sectors is certainly agriculture, which will suffer a significant impact from the effects of climate change. Agriculture is directly exposed to the effects of climate and weather changes, and indirectly through the global nature of the agricultural market, because climate impacts in one region have a far-reaching effect on market prices around the world. Due to climate change in agriculture, numerous transformations need to be made depending on the degree of action (degree of warming) (Tripathi et al. 2016). Also, agriculture contributes to climate change by releasing greenhouse gases into the atmosphere.

Having in mind the sensitivity of agriculture to climate change, the subject of this study is the analysis of the degree of manifestation of climate change and the challenges that arise. Countries face these challenges differently, and thus each country's contribution to climate change is different. Accordingly, the study is structured as follows. After the introduction, the literature review of the most influential studies about the connection between climate changes and agriculture are elaborated. This is followed by an explanation of the methodology and the database used for research purposes. After this part discussion of the empirical results is presented. Finally, in concluding remarks the main findings of the research are presented and recommendations for the necessary measures of the EU policy makers in this field are given.

2. Literature Review

Today, the world is facing a severe reality, that is, the need to deal more seriously with the ecological crisis that has taken on global proportions and threatens to endanger the survival of humanity. According to Petrović-Ranđelović et al. (2019) degradation of environment is a direct result of climatic changes, primarily, global heating. The climate is constantly changing, and the signals that indicate that changes are taking place can be assessed in different temporal and spatial terms. Climate change is recognized as one of the biggest and most serious challenges for the planet. High concentrations of greenhouse gases that cause the greenhouse effect lead to global warming. Most of the global warming is the result of human activity, especially changes in land use through deforestation, as well as the burning of fossil fuels (European Commission, 2006).

Climate change refers to changes beyond the average atmospheric condition that are caused both by natural factors such as the orbit of earth's revolution, volcanic activities and crustal movements and by artificial factors such as the increase in the concentration of greenhouse gases and aerosol (Chang-Gil, 2011). They occur due to changes in every component of the climate system, such as atmosphere, hydrosphere, biosphere, cryosphere and lithosphere, or complicated interactions between them. Global warming has serious effects on the planet and it is likely that rising greenhouse gas emissions will cause global warming. It not only causes a change in average temperature and precipitation, but also increases the frequency of floods, droughts, heat waves, typhoons and hurricanes.

The United Nations Intergovernmental Panel on Climate Change (IPCC) was established in 1998 to assess the state of the Earth's climate system. Climate warming is an unequivocal fact, and many of the changes since the 1850s have been unprecedented for decades. The atmosphere and oceans are warmer, large amounts of snow and ice have disappeared, sea levels have risen and the concentration of greenhouse gases in the atmosphere has increased (IPCC, 2014). The IPCC reports have identified changes due to global warming and frequent projections of current climatic conditions.

The last IPCC report, the fifth in a row, was issued in 2014, and it points out that each of the last three decades has been successively warmer than any previous one since 1850. Period from 1983-2012 was the warmest 30-year period in the last 1400 years. The global average earth temperature increased by 0.85 ºC in the period from 1880 to 2012, as did ocean warming, which is increasing globally (IPCC 2014).

Atmospheric CO2 concentration increased sharply and exceeded the pre-industrial level, with a tendency to further increase until the end of this century (Raupach et al. 2007). Further rise in greenhouse gases will have a significant impact on the global climate since the conditions of current energy use are not changing. Therefore, the average annual air temperature may rise due to greenhouse gas emissions by 1.5 - 4 ºC (about 0.2 ºC every decade) (Wheeler & von Braun, 2013). This will have far-reaching consequences for every type of ecosystem on earth, including agroecosystems, and is therefore dangerous to the food safety necessary for the growing world population.

Agriculture is an industry that is very sensitive to climate change (IPCC, 2014). At the same time, it is one of the socio-economic sectors that is most dependent on climate, because most agricultural productivity and quality directly depend on various climatic factors (McArthur, 2016). Climate change has been affecting agriculture for a long time, and the effects are unevenly distributed in different regions of the world. Agricultural production faces the double challenge of adapting to the expected consequences of climate change and reducing greenhouse gas emissions.

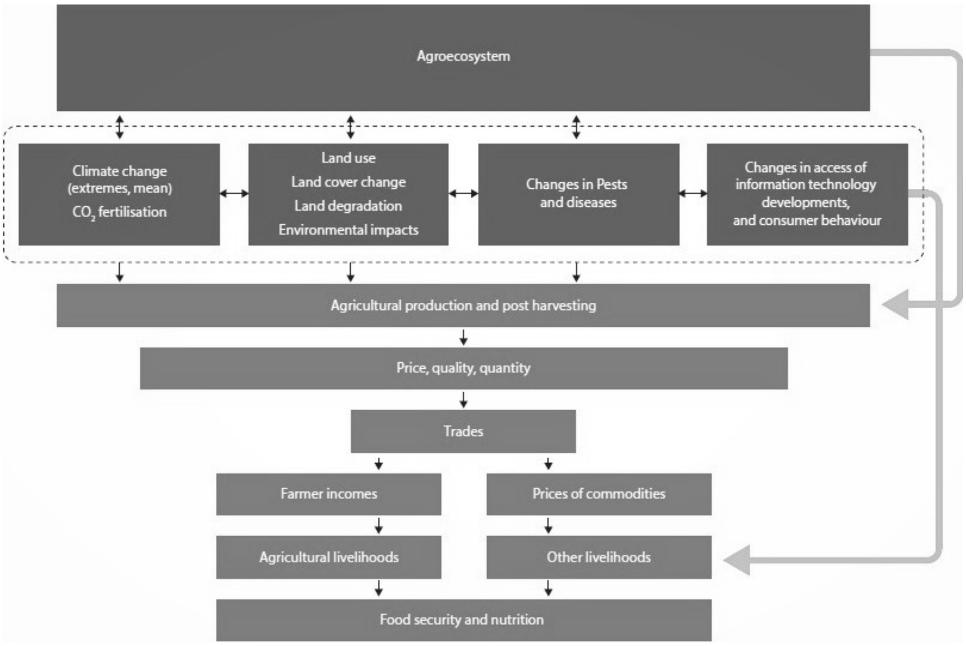
Focusing on crop yields, numerous scientific evidences point to the negative impact of climate change on agriculture and its threat to food safety in the future (Gammans et al. 2017; Schauberger et al. 2017). Concerns for the future in this area are even more pronounced if the minimum climate adaptability regarding crop yields is taken into account. However, climate change is changing the comparative advantages in agriculture and induced crop relocation can potentially mitigate the overall impact of climate change (Cui, 2020). Deeper transformation is more likely to be needed in regions with higher warming, but changes in agricultural practice will be inevitable everywhere. The extent to which agriculture will adapt to the resulting climate change depends on a designed regional policy.

The unbreakable link between climate change and agriculture indicates that sudden changes in climate conditions threaten food safety globally. The 2018 World Food Program (WFP) report states that the increase in crop yield per hectare is significantly slower compared to the population growth rate (World Food Programme [WFP] 2018). It is estimated that the rise in mean temperature by 1 ºC decreases yield of wheat by 6%, rice by 3.2% and corn by 7.4% (Zhao et al. 2017). The 2016 Food and Agriculture Organization (FAO) data indicates that if the situation with greenhouse gas emissions and climate change continues, by 2100 there could be a decline in the production of major cereals (20-45% in corn yield, 5-50% in wheat and 20-30% in rice) (FAO 2016). If the prevailing trends continue, crop losses may increase in the near future, which will result in a significant reduction in production, high food prices and it will be difficult to meet the needs of the growing population.

In addition to this, climate change greatly affects soil degradation. Land degradation results in the abandonment of agricultural land, and further to significant social and environmental constraints. Extreme drought and flood, which are a consequence of climate change, worsen crop productivity, lead to economic losses and ultimately jeopardize food quality (Arora, 2019). Also, climate change has a wide range of impacts on the rural economy, including agricultural productivity, agricultural household income and property value, and also affects agricultural infrastructure through changes in water sources available to agriculture.

The impacts of climate change on agricultural production and agroecosystems can be direct and indirect. Direct impacts relate to changes in phenology, relocation of arable land and loss of soil suitable for agricultural production as well as changes in water supply and irrigation. Indirect effects occur as a result of direct effects that may have additional negative effects on agricultural production. Furthermore, the impacts of climate change on agricultural production can lead to economic and social consequences (Jacobs et al. 2019).

Figure 1. Cascading impact of climate change on agriculture



Source: Jacobs, C., M. Berglund, B. Kurnik, T. Dworak, S. Marras, V. Mereu, and M. Michetti. 2019. "Climate change adaptation in the agriculture sector in Europe". European Environment Agency (EEA), 4.

Given all these impacts, there is a cascade of climate change impacts that affect agroecosystems and agricultural production, which affects prices, product quantity and quality, product placement patterns, agricultural income and food prices (Figure 1). These cascading impacts affect food safety and nutrition, mainly for those directly dependent on agriculture as an activity that provides them with food and livelihoods (FAO, 2016).

Agriculture contributes a significant part of greenhouse gas emissions that cause climate change (17%) directly through agricultural activities and additional 7-14% through land use change (OECD 2016). During agricultural production, different types of greenhouse gases are released. Of the six official greenhouse gases covered by the International Climate Change Treaty, the United Nations Framework Convention on Climate Change counts methane (CH4) and nitrous oxide (N2O) only as agricultural emissions (UNFCCC, 1992). These gases are emitted during activities such as livestock production (release of large amounts of methane by storage of mineral fertilizers) and distribution of mineral and nitrogen fertilizers in fields for crop nutrition (nitrogen oxide emissions) (Tilman, 2002; European Commission, 2019). Both of these gases have a significantly higher global warming potential than carbon dioxide.

Agriculture is a source of emissions of carbon dioxide, nitrogen oxides and methane emitted as a result of activities such as plowing the land and draining wetlands that will be used for agricultural production (Underwood et al. 2013). In addition to greenhouse gas emissions from agriculture, it is estimated that deforestation for agricultural expansion will add additional 20-50% to this emission (Poore et al. 2018; World Resources Institute, 2018). However, these direct emissions from agriculture are relatively small, accounting for only about 1% of global greenhouse gas emissions caused by human activity. Besides, agriculture is also responsible for a long list of negative environmental impacts. Some of these impacts are endangering aquatic ecosystems by water pollution, loss of biodiversity through the use of pesticides, herbicides and monocultures in production, destruction of natural ecosystems by expanding agricultural land at the expense of forests and meadows.

The role of agriculture as a source of greenhouse gases varies significantly due to different agricultural practices, different natural and climatic conditions such as soil characteristics and temperature. Reducing greenhouse gas emissions can be achieved by changing the demand for high-emission food production and adopting the safest practices of agricultural production and land management (Springmann et al. 2018). The interdependent impact of climate change and agricultural production is obvious, so measures must be taken to adapt agriculture to climate change and reduce greenhouse gases from agricultural production.

3. Data and Methodology

Agriculture is one of the largest economic sectors in the European Union, as a result of which it has a great impact on the economic development of member states. Agriculture and food industry provide about 44 million jobs in the EU, with 22 million people directly employed in the agricultural sector itself. Agricultural land occupies as much as 40% of the total land belonging to the European Union (Jacobs et al. 2019). Favorable climatic conditions, technical skills and quality of agricultural products make the European Union one of the world's leading producers and exporters of agricultural products. Of all the economic sectors in the European Union, agriculture is the most dependent on climate and thus highly vulnerable to climate change.

The impact of climate change on agriculture varies across Europe. The projected rise in the number of extreme weather events across Europe is expected to further increase the risk of crop loss and impose a range of risks on livestock. Changes in mean climate variables as well as extreme weather and climate events directly affect the agricultural sector by reducing yields and product quality. In addition to these physical consequences, there are also socio-economic consequences of climate change for the agricultural sector that extend to the entire economy, whereas in macroeconomic terms this affects the price of agricultural products, agricultural income and ultimately food safety at the local, regional and national levels.

Although agricultural sector of the European Union participates with only about 10% in the total greenhouse gas emissions (EEA, 2019), it contains hidden emissions attributed to other sectors, such as CO2 emissions from fossil fuels and electricity used for agricultural machinery, crop drying and fertilizer production related to the energy sector (Paloviita & Järvelä 2015). Good progress has been made in reducing emissions between 1990 and 2016, and, in that time interval, greenhouse gas emissions from agriculture dropped by about 20%, thus contributing to the European Union's 2020 target. Significant efforts are still needed in order to achieve the 2050 goal, which is zero greenhouse gas emissions at the European level (European Commission, 2018).

Constant climate changes are not only a challenge for agriculture, but also for the agricultural policy. The Common Agricultural Policy offers a range of instruments to overcome the challenges of climate change and make the European Union's agriculture more resilient. The policy promotes sustainable methods of agricultural production and warns farmers to take actions to mitigate and adapt to climate change. Sustainable management of natural resources and climate action is one of the three main objectives of the Common Agricultural Policy.

Having in mind all the above, the aim of this study is to determine the homogeneity of the EU countries according to the achieved level of environmental performance in agriculture and climate change in 2020. Data employed in this study are from the Environmental Performance Index 2020 report of Yale Center for Environmental Law & Policy.

The EPI was created with the aim of carefully measuring environmental performance trends and progress, which is the basis for effective policy making. At the same time, it offers a scoreboard that highlights leaders and those lagging behind in environmental performance, provides insight into best practices, and provides guidance for countries striving for sustainability leaders (Environmental Performance Index, 2018). The EPI seeks to meet the governments' needs to monitor environmental performance and offers a method for assessing the effectiveness of environmental policies. It ranks countries' performance according to high-priority environmental issues in two areas: human health protection and ecosystem protection (Environmental Performance Index, 2016). To monitor the achievement of these two environmental policy goals, EPI considers 11 key categories (issue areas) and 32 indicators classified in two key index components, Environmental Health and Ecosystem Vitality (Environmental Performance Index, 2020).

The Environmental Health component includes the most important categories – air quality, sanitary and drinking water, heavy metals and waste management. The Ecosystem Vitality considers the following issue areas: Climate Change, biodiversity and habitats, fishing, ecosystem services, Agriculture, pollution emissions and water resources (Environmental Performance Index, 2020).

The paper focuses on Climate Change and Agriculture, two factors of the Ecosystem Vitality component, which will be considered in more detail, as well as the indicators included in the EPI structure. The name of Climate Change has undergone several changes depending on the year, but its essence has not changed. It has always observed climate and energy. The structure of Climate Change as one of the EPI issue areas has changed over the years.

The Climate Change measures progress to combat global climate change and it is composed of eight indicators. Adjusted emissions growth rate for carbon dioxide, Adjusted emissions growth rate for methane, Adjusted emissions growth rate for F-gases, Adjusted emissions growth rate for nitrous oxide and Adjusted emissions growth rate for black carbon, as EPI indicators, show the share of 4 gases that lead to the greenhouse effect and affect climate change and one pollutant. The CO2 growth rate accounts for about 55% of emissions affecting climate change, while other greenhouse gases account for the remaining percentage, with a CH4 growth rate of 15%, an F-gas growth rate of 10%, an N2O growth rate of 5% and a black carbon growth rate of 5%. All rates are calculated as average annual rates of increase or decrease of the observed gas emission. Growth rate in carbon dioxide emissions from land cover is a new indicator that estimates CO2 emissions depending on changes in land cover. The greenhouse gas intensity growth rate indicator serves as a signal of the country's progress in terms of economic growth and greenhouse gas emissions. It is calculated as the annual average growth rate of greenhouse gas emissions per unit of GDP. Greenhouse gas emissions per capita, as an EPI indicator, point to emission of gases with greenhouse effect per capita. The indicator that monitors the realization of the Agriculture issue area is the Sustainable Nitrogen Management Index (SNMI) (Environmental Performance Index, 2020).

Greenhouse gases greatly affect climate change by changing the air temperature and leading to global warming, which certainly causes glacier melting and an increased amount of water on earth. The double impact that occurs between agriculture and greenhouse gas emissions is becoming more pronounced over time. First, agricultural activities contribute 10-14% of global anthropogenic greenhouse gas emissions, mainly by enteric fermentation (methane), application of mineral fertilizers (nitrogen oxide) and tillage (carbon dioxide) (Field et al. 2012). The global reduction of methane in agriculture by 2030 to 48% compared to 2010 and nitrogen oxide emissions to 26% is needed to limit global warming by 1.5 C^o (IPCC 2018). Second, agriculture is extremely dependent on climate change, primarily on changes in air temperature and water quantity, which affects the quality and safety of agricultural products, and ultimately leads to instability of the system of providing sufficient food on earth.

In accordance with the research subject and the related objective, the basic hypotheses from which the research is based are as follows:

1. There is a correlation between the environmental performance of the agricultural sector of the European Union and climate change.

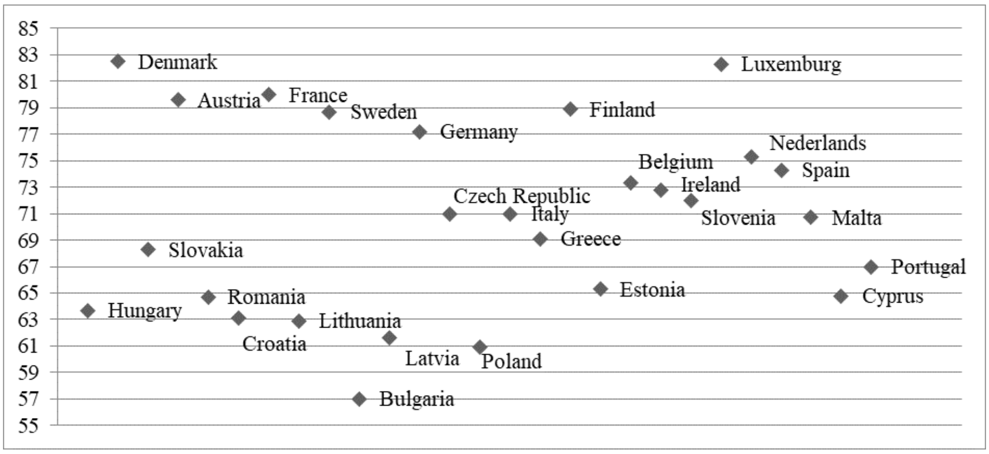
2. Higher level of environmental performance of the agricultural sector of the European Union also means higher level of environmental performance at the level of climate change.

For the purpose of validation of this hypothesis the methods of statistical analysis were used in the study. Special emphasis is on the application of cluster analysis, which make it possible to determine the homogeneity of countries according to the achieved level of environmental performance in agriculture and climate change.

4. Results and Discussion

The 2020 Environmental Performance Report covers 180 countries around the world. Of the EU countries that are the subject of interest in this paper, the best ranked country in the list of countries ranked according to the EPI index is Denmark, which is in the 1st place. In contrast, the bottom of the list of countries is reserved for Bulgaria, which is in the 41st place. Most of the EU countries are highly ranked in the list with a slightly lower percentage of achieving the required level of environmental performance. Accordingly, Luxembourg, France, Austria, Finland, Sweden, and Germany are among the top ten countries in the world. Other countries among the ones analyzed in the paper have the EPI value ranging from 60 to 80, which indicates a significant degree of environmental protection over the years (Figure 2).

Figure 2 Position of European Union countries according to the total EPI value in 2020



Source: Authors' presentation according to the Environmental Performance Index, 2020

The EPI, as an aggregate indicator, includes a number of factors in its structure, so further analysis focuses on the subject of the paper, namely Climate Change and Agriculture, two issue areas of Ecosystem Vitality. According to the Climate Change issue areas, Denmark is the best ranked among all analyzed countries, followed by the countries of the European Union, Romania, France, Luxembourg, Sweden, Finland and the Czech Republic. These countries are leaders in the fight against global climate change, which exacerbates other environmental threats and endangers human health and safety. The remaining EU countries are mostly ranked high in the list according to the Climate Change issue area (the average value is around 70), more precisely, they are all in the first half of the list of all countries covered worldwide. Estonia pays least attention and efforts to combat climate change, and has the highest greenhouse gas emissions per capita. Following the EU countries score in the field of Agriculture, Hungary, Denmark, Slovakia and Austria are the world leaders in terms of maximum environmental protection when performing agricultural activities. Other countries subject to analysis exhibit a large range of values that characterize Agriculture as one of the environmental policy issue areas. The weakest environmental protection in agricultural production is recorded in Portugal, where nitrogen is used quite uncontrollably, which is considered an environmental pollutant with harmful effects on water, air and soil.

In order to examine the quantitative relationship between environmental performance of the Europena Union agricultural sector and Climate Change issue areas, correlation analysis was applied. Preliminary analyses were performed to prove that the assumptions about normality, linearity, and homogeneity of variance were met. There is a moderate positive correlation between these two variables, with Pearson's correlation coefficient 0.530 and a significance level of 0.004. This link suggests correlation between the overall environmental performance of EU countries and Climate Change, so a higher level of environmental performance of EU countries is associated with the degree of combating climate change as one of the factors of overall performance. In addition to Pearson's coefficient, Spearman's correlation coefficient was calculated, to obtain values similar to Pearson's, and conclude the same of the observed variables.

The relationship between the two environmental policy areas, Climate Change and Agriculture, was investigated using Pearson's linear correlation coefficient. The observed two variables have the value of the positive correlation coefficient of 0.515, while the realized level of significance is Sig. 0.006 (Table 1). Based on this, the relationship between the variables is statistically significantly different from zero, while the strength of the correlation, or the degree of quantitative agreement between them, is moderate. Spearman's correlation coefficient of Climate Change and Agriculture shows the result approximate to the Pearson's correlation coefficient, while the relationship between the variables is of medium intensity. The obtained results of the correlation analysis confirm the first hypothesis that there is a positive correlation between the environmental performance of the agricultural sector of the European Union and climate change.

Table 1 Correlation of two environmental policy areas – Climate Change and Agriculture

		Agriculture	Climate Change
Agriculture	Pearson Correlation	1	.515
	Sig. (2-tailed)		.006
	N	27	27
Climate Change	Pearson Correlation	.515	1
	Sig. (2-tailed)	.006	
	N	27	27

Source: Author's presentation

After determining the relationship between the selected variables, it was analyzed the EU country clustering. In order to classify countries into homogeneous clusters according to the value of the two selected areas of EPI the Ward hierarchical clustering method (method of variance) was used. Based on the square of the Euclidean distance between the EU countries according to the value of the Climate Change issue area given in the agglomeration scheme, the countries are classified into two homogeneous clusters, while for Agriculture the classification is into three homogeneous clusters.

The first cluster according to Climate Change includes: Denmark, Slovenia, Romania, France, Sweden, Finland, the Czech Republic and Luxembourg, i.e., they are among the leading countries in the world in terms of combating climate change. The average value of Climate Change within the first cluster is 80. Most of the countries taken for analysis are in the second cluster, which has a medium degree of involvement in combating damage caused by climate change. The second cluster includes countries whose average value of Climate Change is around 67, namely: Croatia, Hungary, Bulgaria, Germany, Belgium, Italy, Austria, the Netherlands, Ireland, Spain, Poland, Slovakia, Portugal, Lithuania, Malta, Estonia, Cyprus, Greece and Latvia. Specifically, these are countries whose value of Climate Change ranges from 59 to 71 (Table 2).

Table 2 Position of EU countries by clusters according to the value of environmental policy issue area – Climate Change

Cluster	Frequency	Mean of Climate Change	Countries
1	8	80.59	Denmark, Slovenia, Romania, France, Sweden, Finland, Czech Republic, Luxembourg
2	19	67.42	Croatia, Hungary, Bulgaria, Germany, Belgium, Italy, Austria, the Netherlands, Ireland, Spain, Poland, Slovakia, Portugal, Lithuania, Malta, Estonia, Cyprus, Greece, Latvia
Total	27	71.32	

Source: Author's presentation

The grouping of EU countries according to the value of Agriculture as a component of the EPI is carried out in the same way. Three clusters are singled out, which are noticeably different from each other in terms of Sustainable Nitrogen Management Index. The first cluster consists of countries with a highly balanced ratio of the use of nitrogen fertilizer as a cause of increased productivity and maximum yields in agriculture. This cluster includes: Hungary, Denmark, Slovakia, Austria, Croatia, Bulgaria, Romania, Germany, France, Italy, Sweden, the Czech Republic, Poland, Lithuania and Latvia. In contrast to this group of countries are the countries of the third cluster, Portugal, Cyprus, Malta, which excessively use nitrogen fertilizer in agricultural production and thus disturb environmental stability, to ultimately lower environmental performance, which is an important indicator of environmental protection. The second cluster is characterized by mean performance in the field of Agriculture of 46, which indicates the inefficient use of nitrogen fertilizer in agricultural production in relation to the yields. The second cluster by value of Agriculture as an environmental policy issue area includes: Slovenia, Belgium, the Netherlands, Ireland, Finland, Spain, Luxembourg, Greece and Estonia (Table 3).

Table 3. Position of EU countries by clusters according to the environmental policy issue area – Agriculture

Cluster	Frequency	Mean of Agriculture	Countries
1	15	64,54	Hungary, Denmark, Slovakia, Austria, Croatia, Bulgaria, Romania, Germany, France, Italy, Sweden, Czech Republic, Poland, Lithuania, Latvia
2	9	46,31	Slovenia, Belgium, Netherlands, Ireland, Finland, Spain, Luxembourg, Greece, Estonia
3	3	26,10	Portugal Cyprus, Malta
Total	27	54.19	

Source: Author's presentation

The second hypothesis expected the same group of EU countries to be in the first cluster by the two selected environmental policy areas. However, this is not the case, although most EU countries in the first cluster that achieve high environmental performance in terms of high control of climate change and significant efforts to mitigate it over time are in the first cluster for efficient use of nitrogen fertilizer in agricultural production. The exception is Slovenia, Finland and Luxembourg. These three EU countries respect the need to reduce greenhouse gas emissions and pollutants that significantly affect the atmosphere, while their agricultural production is characterized by high production of nitrogen fertilizers to an extent that poses a huge threat to the environment due to global warming. Accordingly, these three EU countries influence climate change through agricultural production.

Slovenia has recognized the negative aspects of agricultural production on climate and, in addition to the national agricultural production strategy focusing on climate change, developed special adaptation strategies for agriculture (Jacobs et al. 2019). Moreover, Finland has a very low share of agricultural land in use, more precisely little arable land, and to meet the needs of the population for agricultural products resorts to the use of nitrogen fertilizer that brings higher and faster yields, but also adverse climate effects (Karvonen, 2014). Luxembourg and Finland are among the EU countries that would have to reduce greenhouse gas emissions from agriculture by more than 40% in the next 10 years in order for the agricultural sector of these countries to proportionally contribute to the global goal of reducing these gases (Matthews, 2019). Due to no absolute matching of the countries' positions in clusters according to the environmental policy areas of Climate Change and Agriculture, the second hypothesis can be only partially confirmed, i.e., that a higher level of environmental performance of the agricultural sector of the European Union means a higher level of environmental performance regarding Climate Change as an issue area.

Table 4 Results of the ANOVA procedure regarding environmental policy areas – Climate Change and Agriculture

Variable		Sum of Squares	Df	Mean Square	F	Sig.
Climate Change	Between Groups	1214.101	2	607.051	46.982	0.000
	Within Groups	310.100	24	12.921		
	Total	1524.201	26			
Agriculture	Between Groups	4532.674	2	2266.337	87.107	0.000
	Within Groups	624.425	24	26.018		
	Total	5157.099	26			

Source: Authors' presentation

To check the statistical significance of the differences in the mean variable values (values of environmental policy areas – Climate Change and Agriculture) between clusters, a one-way ANOVA analysis is applied. As in both cases the significance level is less than 0.05, it can be concluded that there is homogeneity of variance for the selected variables among EU countries within the group and that there are statistically significant differences in mean variable values between clusters (Table 4).

5. Conclusion

Climate change and agriculture are strongly linked. It is clear that the rapid pace of climate change will have a far-reaching impact on agroecosystems and their productivity. The impending challenges require extraordinary efforts to combat the effects of climate change and ensure food safety not only for the human population but also for other living beings. It is important to find ways to increase agricultural productivity in the future, while exploring ways to reduce the impact of agriculture on greenhouse gas emissions and the environment.

Agriculture has additional opportunities to contribute to climate change mitigation by reducing methane and nitrogen emissions from some agricultural activities, by improving carbon sequencing systems in agricultural areas, and by providing materials for renewable energy and industrial use. Adapting to climate change in agriculture at the local level in terms of culture choices and varieties and management practices is present throughout the European Union, although the future challenges go beyond the local boundaries. Therefore, it is necessary to react at higher levels and develop policies to enable agricultural production to cope with change. A special role belongs to rural development policy, which provides support to agriculture that faces climate risks. In that regard, this paper investigates the homogeneity of the EU countries according to the achieved level of environmental performance in agriculture and climate change in 2020.

The results of the performed analysis of the selected EPI areas in the EU countries revealed the existence of a medium and positive quantitative agreement between the two environmental policy areas, Agriculture and Climate Change. The level of achieved environmental performance in the agricultural sector is correlated with the environmental performance of Climate Change in the EU countries in 2020. Also, the cluster analysis showed that most of the EU countries apply agricultural production with controlled use of nitrogen, which further affects the reduced emissions of greenhouse gases and thus minimally contributes to climate change. Therefore, Slovenia, Finland and Luxembourg deviate from the fact that a higher level of environmental performance means a higher level of environmental performance in terms of climate change in EU countries. Although the three countries are making efforts to combat climate change, their agricultural sector is great user of nitrogen fertilizer.

Empirical findings of this study provide a basis for concluding that adapting agriculture to climate change requires adapting the ecosystems it relies on. The most appropriate adaptation measures depend on the local characteristics of climate and soil. Adaptation options include the use of new technologies such as cultivation of new varieties of crops that are more resistant to changing environmental conditions, the cultivation of new livestock gardens that are immune to heat stress or disease and the adoption of measures to reduce heat stress and cultivation in a controlled environment where heat, light, water quantity, and CO2 can be optimized for indoor crop growth and the diversification of agricultural production. Great crop diversity and mixed land use such as livestock integration increase the resilience of agricultural productivity to climate change. High diversity, low-intake approaches are broadly defined as agroecology.

In order to avoid or at least reduce the negative effects and take advantage of the possible positive effects, a number of strategies have been developed to adapt agriculture to climate change. Much of the adverse effects can be reduced or even eliminated when the adaptation is fully implemented. Proposed strategies include short-term adjustments, optimizing production without major system changes, and long-term changes in practice, major structural changes that overcome the effects of climate change.

Climate change has a different impact on agricultural production on different continents. Therefore, it is necessary to take a measure for adjustment of the adaptation strategy, which should include factors that greatly affect agriculture. To reap some of the benefits of current climate change, strategies for adapting and mitigating climate change in agriculture need to be defined for any individual crops and varieties. There are many other important adaptation strategies that should be adopted in agriculture to deal with the disadvantages of climate change.

Adaptation measures occur at different levels, individual, local, regional, national or international, depending on the problems caused by climate change. Effective adaptation should meet several conditions, including economic strength, information, infrastructure, institutions and capital. In order to be effective, it must be defined the need for adaptation measures and make a selection of the most appropriate measures by assessing the ones available. Therefore, this study can serve as a basis for further research on how countries with higher financial allocations for sustainable agricultural production contribute to climate change mitigation.

The contribution of this paper is reflected in the following. First, it aims to develop the literature on agriculture, especially those that have recently become increasingly important and relate to the problems of the relationship between climate change and agriculture. Second, a review of the existing literature found that only a small number of empirical studies relate to determining the relationship between climate change and agriculture on the example of EU countries, and especially in those studies did not apply those indicators used in this study to prove baseline hypotheses. Thus, the contribution of this paper is reflected in determining the relationship between climate change and agriculture from a new perspective and the application of those indicators that have not been used in research so far.

Finally, our research on the relationship between climate change and agriculture is still in its infancy. It requires a lot of effort in thinking of strategies and measures for their mutual harmonization depending on the specifics of a particular country or group of countries, which will be the direction of our future research.

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MEĐUZAVISNOST KLIMATSKIH PROMENA I POLJOPRIVREDE NA NIVOU EVROPSKE UNIJE

Apstrakt: Svrha ovog rada je ispitivanje homogenosti zemalja Evropske unije (u daljem tekstu: zemlje EU) prema dostignutom nivou ekoloških performansi u poljoprivredi i klimatskim promenama u 2020. godini. Podaci korišćeni za izradu rada su iz međunarodnih dostupnih baza podataka. U cilju potvrđivanja postavljene hipoteze korišćene su metode statističke analize. Rad se fokusira na klimatske promene i poljoprivredu, dva faktora komponente vitalnost ekosistema, koji će biti detaljnije razmotreni, kao i indikatori uključeni u strukturu Indeksa ekoloških performansi (u daljem tekstu: EPI). Empiriski nalazi su otkrili postojanje srednjeg pozitivnog nivoa kvantitativnog slaganja između dve oblasti ekološke politike, poqoprivrede i klimatskih promena. Takođe, klaster analiza je pokazala sa većina zemalja odabranih za analizu primenjuje poljoprivrednu proizvodnju sa kontrolisanom upotrebom azota, što nadalje utiče na smawenu emisiju gasova sa efektom staklene bašte i time minimalno doprinosi klimatskim promenama.

Ključne reči: poljoprivreda, uticaj klimatskih promena, emisija gasova sa efektom staklene bašte, adaptacija, EPI, zemlje EU.

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