

Economic assessment of the impact of climate change on agriculture in Albania and Ukraine

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Abstract. This study aimed to provide a comparative analysis of the impacts of climate change on the agricultural sector in Albania and Ukraine, with a focus on identifying key challenges and opportunities for adaptation. The study analysed statistical data from 2010 to 2023 on climate change and its impact on agriculture and assessed the consequences. The results of the study showed that changes in temperature regimes are a key factor that directly affects agriculture. An increase in average annual temperatures leads to a change in the growing season of plants, which has both positive and negative consequences. Changes in precipitation patterns are another key mechanism of climate change impact on agriculture. Reduced precipitation and frequent droughts can lead to significant crop losses, requiring the introduction of irrigation systems and other water-saving technologies. Economic risks associated with climate change are a serious challenge for agriculture. Reduced yields, higher production costs and the need to adapt to new conditions can threaten the stability of farms, especially small ones. The analysis for Albania showed that rising temperatures and decreasing precipitation pose challenges for agriculture, particularly for cereal and vegetable production. In Ukraine, with its large area of arable land, there is scope to compensate for the decline in yields by expanding the area under cultivation, but investment in new irrigation technologies and agronomic practices is needed to improve efficiency. Both countries face the need to introduce new plant varieties, modernize irrigation systems, and develop agricultural innovation and precision farming. Effective adaptation strategies, including international cooperation and support for research, are key to ensuring the sustainability of the agricultural sectors in both countries. The findings of the study can be applied in practice to government agricultural support programmes and international climate change adaptation projects

Keywords: temperature regime; water resources; productivity; investments in infrastructure; comparative analysis

INTRODUCTION

Climate change is a major global challenge that affects agriculture, a key sector for food security and economic stability, by altering critical climatic factors such as temperature and precipitation, resulting in reduced production in the short and long term. Impacts vary across geographical boundaries. In Albania and Ukraine, unique

climatic conditions and agricultural practices lead to specific manifestations. Albania is facing rising temperatures, changing precipitation patterns and increasingly frequent severe weather events such as droughts and floods, which have a significant impact on crop yields and vital water resources required for agricultural

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activities. Ukraine has huge agricultural resources and is among the world's largest grain exporters. Nevertheless, the agricultural industry faces serious challenges related to climate change, including higher average annual temperatures, reduced precipitation in some areas, and increased extreme weather events. These challenges require adaptation measures to maintain exceptional agricultural productivity and competitiveness in the global market.

The significance of the study stems from the need to assess the economic impacts of climate change on the agricultural industry in Albania and Ukraine in order to develop effective adaptation measures to changing climatic conditions. Although each country has its own characteristics and obstacles, the main common factor is that climate change affects the ability of the agricultural sector to guarantee sustainable food production. The potential consequences of this could be significant for the economies, social progress and food security of countries.

G.S. Malhi *et al.* (2021) studied the global impact of climate change on agriculture, focusing on changes in grain productivity. They found that rising temperatures can lead to a decrease in wheat yields in regions where temperature increases are not accompanied by increased precipitation. D. Müller & M. Hofmann (2022) conducted a study on the example of Southern European countries, including Albania, and concluded that the decline in precipitation and the increase in the frequency of droughts pose significant challenges to the production of olive oil and other traditional crops. A. Skrynyk *et al.* (2021), in turn, focused on Ukraine, where he analysed the impact of climate change on grain production. Authors concluded that, despite the increase in the growing season, a decrease in precipitation in the southern regions of Ukraine could significantly reduce yields without proper irrigation. N. Khan *et al.* (2021) studied adaptation strategies in agriculture, emphasizing the importance of integrating modern agricultural technologies, such as the use of drought-resistant plant varieties. S. Skendžić *et al.* (2021) noted in their work that climate change contributes to the spread of new pests and diseases that can threaten crop production, and stressed the need to develop new plant protection products. N.T.L. Huong *et al.* (2019) also conducted a study on the economic impact of climate change on agriculture and concluded that climate change will lead to the need for significant investment in irrigation systems to maintain sustainable agricultural production. E. Zhilima *et al.* (2022) analysed climate risks for agriculture in Albania. They found that the Mediterranean climate of the region is becoming more arid, which leads to a reduction in fruit crop yields. A.A. Chandio *et al.* (2020)

studied the impact of climate change on the economy of the agricultural sector and pointed to the growing risks for corn and sunflower production. Authors noted that without adaptation measures, significant losses in yield and profitability are possible. A. Raza *et al.* (2019) studied the global impacts of climate change, in particular the impact on agricultural prices. The authors highlighted that climate change has the potential to result in increased food prices. The study conducted by R. Anderson *et al.* (2020) highlighted the need of international collaboration and knowledge sharing across nations in developing adaptation methods for agriculture in response to climate change.

The examination of researches indicates that climate change exerts a substantial influence on agriculture. Consequently, it becomes imperative to formulate and execute adaptation measures that are designed to mitigate risks and guarantee the sustainable growth of the agricultural industry. While prior research has made a substantial contribution to comprehending the influence of climate change on the agricultural sector, there are numerous areas that have not been well investigated. A notable deficiency exists in the thorough comparative examination of the effects of climate change on agriculture in two nations characterised by distinct meteorological circumstances and economic frameworks, namely Albania and Ukraine. Furthermore, there is a lack of focus on evaluating the economic consequences of climate change on specific crops that are crucial for both nations. The purpose of the study was to perform a comparative examination of the influence of climate change on agriculture in Albania and Ukraine, with an emphasis on pinpointing particular obstacles for important cereal crops.

MATERIALS AND METHODS

In order to study the impact of climate change on agriculture in Albania and Ukraine, a range of materials and methods were used, including both qualitative and quantitative data. Primary sources of information consist of statistical data, published climate reports and agronomic research. The study of climate change impacts on agriculture in Albania and Ukraine involved a thorough examination of climate data, crop yields and production in both countries. To study climate change, authors used data from the Climate Change Knowledge Portal (n.d.a; n.d.b), which covers average annual temperatures and precipitation in Ukraine and Albania. Specifically for this study, changes in average annual temperature and precipitation were analysed for the period from 2010 to 2022. The graphical display of these data allowed to identify the main trends in climate change in both countries.

A statistical analysis of the yields of several crop groupings was used to evaluate the influence of climate change on agricultural productivity. For Albania, data were obtained from Food and Agriculture Organization (n.d.) and National Institute of Statistics of Albania (n.d.). In Ukraine, data from the State Statistics Service of Ukraine (n.d.) were used. The information included yields from 2016 to 2022 in Albania and 2023 in Ukraine for different types of crops, such as cereals, vegetables, fruits, and industrial crops. In addition, data on production volumes of these crops from 2016 to 2023 were collected. The data analysis allowed to assess how changes in climate conditions have affected crop yields and production in both countries. Analysis methods included correlation analysis to determine the relationship between climate change and yields, as well as regression analysis to determine possible directions for future changes in crop production.

Furthermore, significant focus was given to the examination of advancements in irrigation, agronomy, and agronomic techniques that enhance the ability of agricultural produce to withstand influences from climate change. The study examined contemporary irrigation systems, the use of drought-tolerant crop types, and the use of sophisticated agronomic practices to mitigate the effects of unfavourable climatic conditions. To study the economic impact of climate change, authors took into account aspects such as adaptation costs, reduced profitability and risks associated with extreme weather conditions. The economic impact assessment included an analysis of changes in production costs, in particular the costs of irrigation systems and crop protection, as well as the impact on farm profitability. In particular, the costs of adopting new technologies, such as drip irrigation systems, and changes in agricultural prices were considered. The study also conducted a comparative analysis of the effects of climate change on agriculture in Albania and Ukraine. This encompassed an examination of the various meteorological conditions and their influence on agricultural output in both nations, taking into account the particularities of agricultural methods and economic circumstances.

RESULTS

Climate change presents substantial obstacles to agriculture, the industry most reliant on natural environments, by impacting it through intricate and varied processes that encompass both direct and indirect consequences on production. Influential variables such as increasing temperatures modify the periods of plant growth, which may lead to higher yields in certain areas but often result in reduced production due to heat stress and increased insect activity, especially in dry

climates (Aragón *et al.*, 2021). Alterations in precipitation patterns have a second in importance effect on agriculture; decreased rainfall and more frequent droughts result in decreased crop yields necessitating water conservation techniques, while excessive or uneven precipitation can lead to flooding and soil erosion, so adversely affecting agricultural production (Siddig *et al.*, 2020).

Changes in the frequency and intensity of extreme weather events, such as hurricanes, floods and droughts, are another crucial mechanism of climate change impacts. Such events can lead to sudden crop losses, infrastructure damage and significant economic losses. The increasing frequency of extreme weather events creates additional risk for farmers and forces them to look for new risk management strategies, such as crop insurance or the introduction of climate-resistant plant varieties. In addition, climate change is affecting water resources, which are critical for agriculture. Changes in the water balance can lead to water shortages, especially in regions where water is already a limited resource. This is forcing farmers to look for new approaches to water management, such as reducing water consumption or adopting more efficient irrigation technologies.

The phenomenon of climate change poses many risks to the agricultural sector, with both immediate and long-term consequences for agricultural production. A clear threat to agriculture is the reduction in yields of major crops. Climate change, characterized by higher temperatures, reduced precipitation and more frequent extreme weather events, poses challenges to maintaining traditional production levels. Another significant risk is the change in geographical areas of agricultural production. Due to climate change, some regions may become unsuitable for growing certain crops. For example, in regions where olives or grapes were previously successfully grown, the conditions may become too harsh for these crops due to rising temperatures and decreasing rainfall (Shahzad *et al.*, 2021). This may lead to the need to change the specialization of regions, which in turn requires significant investments in new infrastructure, changes in growing technologies and adaptation of farmers to new conditions. Climate change also increases the risk of pests and diseases. Warming may help to expand the habitat of some pests that were previously restricted to warmer regions.

Economic risks associated with climate change are among the most serious challenges facing modern agriculture. These risks not only affect the profitability of agricultural production, but can also threaten the stability and viability of farms, especially small ones. The main economic challenges posed by climate change include higher production costs, reduced profitability, the need to adapt to new conditions, and the risk of farm

retrenchment (DeFries *et al.*, 2019). Increased costs of agricultural production are one of the most obvious consequences of climate change. For example, farmers are forced to invest in irrigation systems to provide water for crops in drought conditions. The cost of installing and maintaining such systems can be significant, especially for small farms (Kolstad & Moore, 2020). The introduction of new agricultural practices, such as climate-resilient plant varieties or tillage methods, also requires additional financial resources. In addition, farmers are forced to spend more money on protecting plants from pests and diseases, which are becoming more prevalent as temperatures rise and rainfall patterns change. The cost of pesticides, herbicides, and other plant protection products is rising, which significantly increases the cost of production. In some cases, this may require farmers to implement integrated crop protection systems, which requires additional knowledge and skills, as well as even greater financial investment.

Reduced yields due to climate change are another serious economic risk. Fluctuations in plant growth period, reduced rainfall and increased incidence of severe weather events lead to uncertainty in agricultural production. Farmers may face volatility in yields from year to year, making their income unpredictable. Declining yields directly affect the profitability of farms, especially those that are already operating at the margins of profitability (Ray *et al.*, 2019). This can have catastrophic consequences for small farmers who do not have the financial reserves to overcome such losses. In the face of low profitability, many farmers may be forced to leave agriculture or change their specialization. This is especially true for small farms that do not have sufficient resources to invest in new technologies and adaptation measures. For example, farmers who produce certain crops may find that these crops are no longer economically viable due to climate change (Ojo & Baiyegunhi, 2020). This may force them to switch to other activities, which in turn may lead to the loss of

traditional agricultural practices and knowledge. In addition, it is important to recognize that farm closures resulting from economic problems can have significant socio-economic consequences. A reduction in agricultural production as a result of fewer active farmers can lead to higher food prices and increased food insecurity. The depletion of farms can negatively affect rural populations by reducing employment opportunities and incomes in geographic areas already facing economic challenges (Guth *et al.*, 2020).

Thus, economic risks associated with climate change pose a serious threat to the agricultural sector. Increased production costs, lower yields and reduced profitability could force many farmers to leave agriculture, with far-reaching consequences for food security and economic stability. To address these challenges, effective strategies to adapt and support farmers are needed, including through financial assistance, educational programmes and the development of new agricultural technologies. Agriculture in Albania is an important factor in economic development and employment. Currently, the sector accounts for about 18.6% of the country's gross domestic product (GDP) and employs more than 40% of the population. In addition, agricultural and food products make up a significant share of exports, accounting for 11.3% of the total (National Institute of..., n.d.). However, Albania, as a country with a developed agricultural sector, faces many challenges posed by climate change, which requires a deep understanding and appropriate adaptation strategies. Albania has a diverse climate, ranging from Mediterranean to continental, which determines the cultivation of different crops. Climate change, such as frequent droughts in summer and increased rainfall in autumn and spring, can cause significant fluctuations in crop yields. This, in turn, leads to unpredictability in production volumes, which creates risks for farmers and may lead to higher agricultural prices. Figure 1 shows changes in average annual temperature and precipitation.

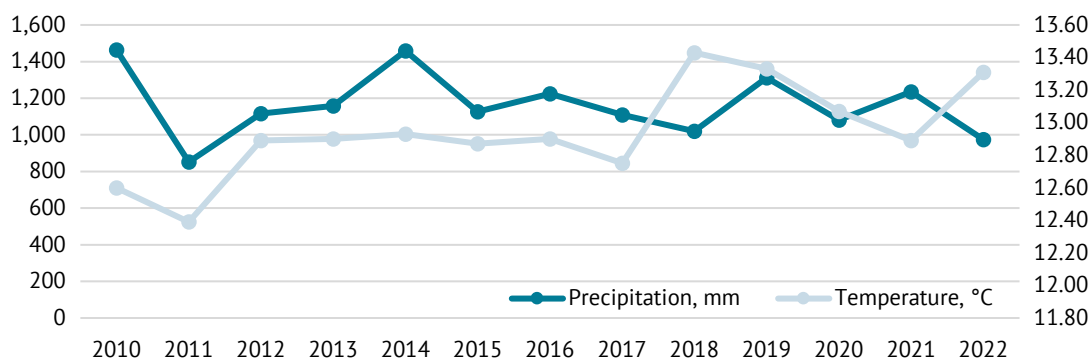


Figure 1. Dynamics of climate change in Albania from 2010 to 2022

Source: developed by the author based on data from the Climate Change Knowledge Portal (n.d.a)

The average annual temperature in Albania for the period from 2010 to 2022 showed a gradual increase. While in 2010 the average temperature was 12.6°C, in 2022 it reached 13.31°C. This temperature increase is a sign of global warming, which can have a significant impact on the country's agriculture. Changes in precipitation are another critical factor that has a direct impact on agriculture. Figure 1 shows significant

fluctuations in precipitation. Particularly noteworthy are the recent years: from 2019 to 2022, there has been a decline in precipitation, most notably in 2022, when the amount of precipitation was only 973.69 mm. This decline can pose serious challenges for farmers, including the need for increased irrigation costs and lower yields. Table 1 shows the yields of different crop production groups.

Table 1. Crop yields in Albania from 2016 to 2022, t/ha

Product groups	2016	2017	2018	2019	2020	2021	2022
Cereals	4.7	4.8	4.8	5	5.2	5.1	5.2
Citrus fruits	27.8	29.6	38.5	35.8	37	37.8	39.7
Fibre crops	0.39	0.39	0.38	0.38	0.39	0.39	0.4
Fruit	22.9	22	22.3	22.6	22.7	23.8	24
Oilseeds (oilcake)	1.02	0.81	0.92	0.87	0.84	0.8	0.92
Oilseeds (oil)	0.56	0.52	0.55	0.46	0.6	0.5	0.69
Root vegetables and tubers	24.6	25.1	26.2	25.6	26.3	24.9	26.5
Sugar crops	30.4	33.8	39.2	38.1	32.2	32.3	32.3
Nuts	4.8	4.7	4.1	4.2	4.4	4.3	4.9
Vegetables	27.3	28.1	27.7	28.4	28.5	29.1	29.6

Source: developed by the author based on data from the Food and Agriculture Organization (n.d.)

Agriculture in Albania shows changes in the yields of different crops, which can be attributed to various agronomic, technological and climatic factors. Despite the negative changes in climatic conditions, positive trends and stability are observed in most

crops, which indicates the effectiveness of agronomic practices, while the decline in yields of certain crops may indicate the need for additional research and adaptation strategies. Table 2 shows the volume of crop production.

Table 2. Crop production in Albania from 2016 to 2023, thousand tonnes

Product groups	2016	2017	2018	2019	2020	2021	2022	2023
Cereals	698.4	701.7	678.2	666.1	684	691.4	690.8	701.3
Vegetables	1,129.1	1,151.9	1,166.3	1,258	1,295.7	1,338.2	1,357.8	1,384.5
Potatoes	238.3	249.8	254.5	260.7	254.8	258.9	262.7	274.2
White beans	25	21.2	24.5	24.8	25.8	22.4	21.8	23.3
Industrial crops	-	32.7	30.8	33.7	30.1	27.3	24.5	23.4
Medicinal crops	10.6	12.8	12.5	12.9	14.4	16	16.4	17.8
Feed	6,144	6,688.6	7,050.1	7,115.2	7,170.5	7,054	7,138.8	6,940.3
Fruit trees	261	262.6	274.3	272.6	273.7	287.2	295.4	281.9
Olives	99	107.8	117.6	98.3	131.9	110.2	157.7	117.6
Citrus fruits	40	41	45.5	46.9	49.2	50.5	55.1	56.7
Grapes	205.1	202.9	189.8	189.8	199.1	212	211.2	179.7

Source: developed by the author based on National Institute of Statistics of Albania (n.d.)

The agricultural commodity production in Albania has exhibited either growth or stability, suggesting the efficacy of climate change adaptation strategies and the conservation of the nation's agricultural capacity. Nevertheless, certain commodities, including industrial crops and grapes, are seeing a decrease in productivity, underscoring the necessity for additional study and the adoption of novel approaches to sustain their competitiveness.

At the macroeconomic level, climate change impacts Albania's international economic operations. Given the significance of agriculture as an export industry, any decrease in crop production could result in a decrease in the nation's ability to export. This can potentially have an adverse effect on Albania's trade balance, further augmenting its reliance on food imports and exacerbating the country's economic stability. Furthermore, an increase in pricing for agricultural

commodities on the local market can result in inflation, therefore adversely affecting the buying power of the populace.

The agricultural industry in Ukraine, which constitutes a significant portion of the national economy (7.8% of GDP), is facing a growing and complex challenge posed by climate change (State Statistics Service..., n.d.). Given its status as a major global producer and exporter of grains and oilseeds, Ukraine relies

heavily on consistent meteorological conditions to maintain its agricultural output. Nevertheless, climate change, characterised by the observation of elevated average yearly temperatures, altered precipitation patterns, and a heightened occurrence of severe weather phenomena, can exert a substantial influence on the productivity of agricultural land and the economic viability of farms. Figure 2 illustrates variations in mean yearly temperature and precipitation.

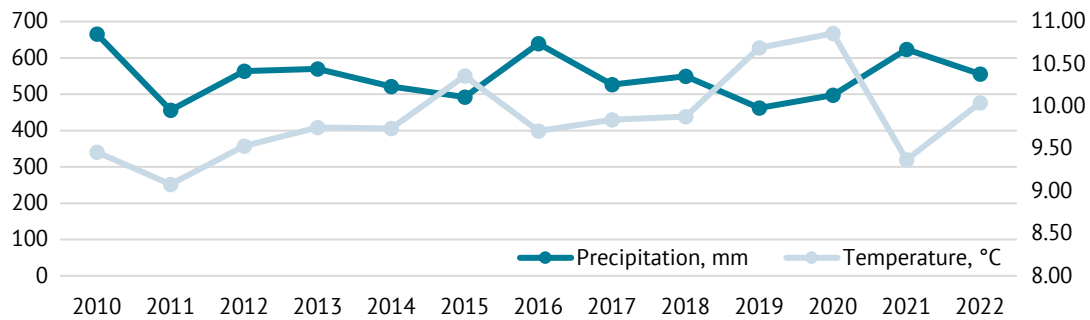


Figure 2. Dynamics of climate change in Ukraine from 2010 to 2022

Source: developed by the author based on data from the Climate Change Knowledge Portal (n.d.b)

The mean annual temperature in Ukraine has exhibited a progressive upward trend, rising from 9.46°C in 2010 to 10.86°C in 2020, and then seeing a minor decline to 10.04°C in 2022. The observed pattern suggests a general increase in temperature, which can have both beneficial and detrimental effects on agriculture. Elevated temperatures can enhance the productivity of heat-tolerant crops and extend their cultivation regions towards the northern regions. Nevertheless, an over rise in temperature could also

result in heightened evaporation and in turn, droughts, therefore adversely impacting agricultural output, particularly in the southern parts of Ukraine. Substantial variations in precipitation were observed throughout the research period. The inequitable allocation of rainfall is a significant obstacle for agriculture, since both the overall quantity of precipitation and its variation over the growing season are crucial factors. The yields of several agricultural production groups are presented in Table 3.

Table 3. Crop yields in Ukraine from 2016 to 2023, t/ha

Product groups	2016	2017	2018	2019	2020	2021	2022	2023
Cereals and pulses	4.61	4.25	4.74	4.91	4.25	5.39	4.58	5.52
Factory sugar beet	48.2	47.5	50.9	46.1	41.6	47.9	54.1	52.5
Sunflower	2.24	2.02	2.3	2.56	2.02	2.46	2.16	2.45
Potatoes	16.6	16.8	17.1	15.5	15.7	16.6	17.4	17.7
Vegetable crops	21.1	20.8	21.4	21.4	20.7	21.5	20	20.9
Cultures fruit and berry	10.2	10.3	12.8	10.8	10.6	11.7	11.6	11.9

Source: developed by the author based on data from the State Statistics Service of Ukraine (n.d.)

The dynamics of crop yields in Ukraine from 2016 to 2023 indicates a significant impact of climate change on the agricultural sector. The fluctuations in yields of different crops highlight the need to adapt to new climatic

conditions, introduce new technologies, and more precisely plan agronomic measures to minimize risks and maintain the productivity of the Ukrainian agricultural sector. Table 4 shows the volume of crop production.

Table 4. Crop production in Ukraine from 2016 to 2023, thousand tonnes

Year	2016	2017	2018	2019	2020	2021	2022	2023
Cereals and pulses	66,088	61,917	70,057	75,143	64,933	86,010	53,864	59,772
Factory sugar beet	14,011	14,882	13,968	10,205	9,150	10,854	9,942	13,130
Sunflower	13,627	12,236	14,165	15,254	13,110	16,392	11,329	12,760
Potatoes	21,750	22,208	22,504	20,269	20,838	21,356	20,900	21,359
Vegetable crops	9,415	9,286	9,440	9,688	9,653	9,935	7,512	8,297
Fruit and berry crops	2,007	2,048	2,571	2,119	2,024	2,235	1,995	1,996

Source: developed by the author based on data from the State Statistics Service of Ukraine (n.d.)

Ukraine's agricultural sector is subject to significant fluctuations in the production of different crops, which is due to climate change as well as economic and political factors. The decline in 2022 is mainly due to the outbreak of war in Ukraine. Successful adaptation of the agricultural sector to new conditions requires the introduction of innovative technologies, improvement of agronomic practices and consideration of all possible risks.

Despite their differences in climate, geography, agricultural organisation, and economic development, Ukraine and Albania both rely significantly on the agricultural industry. The Mediterranean climate of Albania, situated in the southern region of Europe, is distinguished by moderate winters and scorching, arid summers. As of 2024, the nation is experiencing escalating temperatures and erratic precipitation, resulting in a notable surge in the vulnerability to drought and a reduction in readily available water supplies. These modifications exert a substantial influence on the agricultural outputs and efficiency of crops, particularly those that are exceptionally responsive to fluctuations in the water equilibrium, such as grains and vegetables. For example, cereal production in Albania has shown some stability, but climate variations could have a significant impact on future yields. Water scarcity also threatens orchards and vineyards, requiring the introduction of new irrigation systems and adaptive technologies. This requires an increase in the costs of introducing new technologies for irrigation and water management. In particular, farmers are forced to invest in efficient irrigation systems, which increases production costs. This can have a negative impact on profitability, especially for small farmers, who often do not have access to sufficient finance. Agricultural products make up a significant portion of Albania's exports. A decline in yields could affect the country's export potential, which in turn would affect foreign trade and economic growth. A decline in production of major export crops such as citrus could also reduce foreign exchange earnings from exports.

As one of the largest agricultural countries in Europe, Ukraine faces other challenges. Climate change in Ukraine, including an increase in average annual temperature and reduced precipitation in some regions, is leading to soil degradation, lower yields and overall agricultural productivity. This is particularly acute in the southern and eastern regions of the country, which face frequent droughts. However, unlike Albania, Ukraine has a larger area of arable land, which allows it to compensate for the decline in yields by expanding its sown areas. On the other hand, climate change also causes uneven distribution of precipitation, which leads to flooding in some regions and, as a result, crop losses. This requires significant investment in irrigation technologies, new agronomic practices and improved soil cover. However, large agricultural companies have more resources to implement such technologies than small farmers. Ukraine's agricultural sector is of great importance to the country's economy, particularly for exports. Climate change could reduce production of major crops, which would negatively impact export revenues and economic stability. Decreased yields of grain and oilseeds could lead to higher prices for products on the domestic market and increased import costs.

Both countries encounter difficulties associated with the necessity to adjust to changes in climatic circumstances. The aforementioned activities encompass the implementation of novel crop cultivars that exhibit enhanced drought tolerance, the upgrading of irrigation infrastructure, and the advancement of agro-innovation and precision farming technology. Furthermore, it is crucial to underscore that climate change in both nations not only entails adverse repercussions, but also presents novel prospects for the advancement of the agricultural industry (Shahini *et al.*, 2023). As an illustration, alterations in the duration of the growing season can enable the growth of novel crops that were not previously customary in these areas. Statistical analysis has demonstrated that climate change will exert a substantial influence on the agricultural industries of

both nations. However, the magnitude and nature of this influence differ based on the accessible resources, structural characteristics of the agricultural sector, and the economic conditions in each country.

Adaptation of agriculture to climate change is a key task for ensuring sustainable food production and maintaining economic stability (Cui, 2020). The decline in yields of cereals, vegetables and citrus fruits in Albania requires the urgent implementation of efficient irrigation systems (Shahini *et al.*, 2024). Modernization of irrigation infrastructure, including the introduction of drip irrigation and rainwater storage, will reduce water losses and increase the efficiency of agronomic practices. It is also critical to improve agronomic practices, including the use of drought-resistant plant varieties, crop rotation and soil cover to preserve moisture. The development of climate monitoring systems will help farmers to respond to weather changes in a timely manner and adjust agronomic practices. Education and training of farmers, investment in research and support for innovative technologies are also key factors for successful adaptation.

In Ukraine, adaptation requires improving water management by introducing modern irrigation systems, such as rainwater storage tanks and technical solutions for water reuse. Agronomic technologies, such as crop rotation, climate-resistant varieties and precision farming, will help improve yields and reduce costs. It is also important to maintain soil quality through no-till farming and the use of organic fertilizers. Investing in research and supporting innovations, such as new agronomic practices, will help farmers adapt to changing conditions. Financial support and insurance programmes can help farmers cope with economic losses due to climate change.

The combined suggestions for Albania and Ukraine encompass international collaboration to exchange knowledge and technologies, enhance infrastructure such as water storage systems and transportation networks, and formulate measures to mitigate risks linked to severe weather events. The adaptation of agriculture to climate change is an intricate and diverse process that necessitates a unified strategy and the active involvement of all sectors of society. The adoption of these suggestions will contribute to mitigating the adverse impacts of climate change, so guaranteeing the sustainable growth of the agricultural industries in both nations.

DISCUSSION

The study on the effects of climate change on agriculture in Albania and Ukraine revealed that these countries encounter distinct problems arising from both the overall pattern of global warming and particular characteristics of their local environments. Variations in

temperature are a primary determinant impacting agriculture in both nations. The rise in mean yearly temperatures in Albania and Ukraine is a clear indication of the global warming phenomenon, which can manifest in both beneficial and detrimental effects on agricultural output. On one side, increasing temperatures might enhance the productivity of heat-tolerant crops and broaden their suitable growing regions. Yet, excessive warming can result in heightened evaporation and, as a result, droughts, which pose a significant threat to agriculture in the southern parts of Ukraine. This necessitates the implementation of novel agricultural technology and adjustments, such as the use of effective irrigation strategies. B. Qian *et al.* (2019) studied the impact of climate change on wheat and corn production in the central regions of Canada. Their results showed that the increase in average temperatures had a positive impact on yields, especially in areas previously considered cool for growing these crops. Y. Yue *et al.* (2019) pointed out that due to the warmer climate, wheat began to ripen better, and the growing season was extended, which led to an increase in the amount of harvest. However, in contrast to their findings, the current study showed that in Eastern Europe, particularly in regions with a more continental climate, rising temperatures have a negative impact on wheat yields.

The study carried out by M.F. Cardell *et al.* (2019) examined the effects of climate change on viticulture in key European countries, specifically Italy, Spain, and France. An investigation revealed that higher average temperatures result in reduced acidity of grapes, therefore influencing the flavour and chemical makeup of wine. The present findings somewhat align with these results, as they also demonstrate that increasing temperatures impact the quality of crops. Nevertheless, the present investigation concentrated on cereals, namely wheat, whereby rising temperatures exert an adverse influence.

The study showed significant fluctuations in precipitation levels, which is a serious challenge for agriculture, as not only the total amount of precipitation but also its distribution over the growing season is crucial. In Albania, the decrease in rainfall in 2022 posed serious challenges for farmers, forcing them to increase irrigation costs and struggle with low yields. In Ukraine, the uneven distribution of precipitation makes it difficult to predict yields and requires more precise planning of agricultural practices. Y. Ding *et al.* (2020) studied the impact of climate change on rice production in the regions of China. Their study showed that the main factor affecting rice yields is a change in precipitation, not temperature. S. Hussain *et al.* (2020), in turn, noted that an increase in rainfall intensity, especially during the monsoon season, contributes to an increase in rice

yields by 10-12%. However, during periods of reduced rainfall, yields drop sharply due to a lack of water for irrigation. This contrasts with current results, where rising temperatures are the main factor affecting crop yields in Eastern Europe. The current study indicates that even with sufficient precipitation, rising temperatures lead to negative effects such as droughts and heatwaves, which significantly reduce yields.

Another crucial factor to consider is the variations in the frequency and severity of severe weather phenomena. The occurrence of droughts, floods, and storms in Albania and Ukraine is on the rise, thereby amplifying the vulnerabilities faced by farmers. Consequently, there is a need to devise novel risk management approaches, such as the implementation of crop insurance and the cultivation of plant selections that are resilient to climate change. D. Beillouin *et al.* (2020) examined the effects of severe weather phenomena on agricultural land in Europe. They found that frequent droughts and heat waves, which have become more common from 2000s, significantly reduce the yields of various key crops in the regions. This is comparable to the current results, which also indicate that frequent droughts in Eastern Europe have a negative impact on yields. However, unlike the author, where he noted that perennial crops were affected, the current study refers to a decline in yields of annual cereals.

The results showed that higher production costs, lower yields and reduced profitability could lead many farmers to abandon agriculture, with far-reaching consequences for food security and economic stability. The rising cost of agricultural production requires farmers to adopt costly adaptation technologies such as irrigation systems and new agricultural practices. The economic consequences of climate change on the agricultural sector worldwide, specifically on the cultivation of various crops in different geographical areas, were examined by R. Dellink *et al.* (2019). Their study demonstrated that as a result of climate change, namely the escalation of temperatures and the reduction of rainfall, farmers have seen an average revenue loss of 15-20%. A.M. García *et al.* (2019), in turn, noted that farmers are forced to spend more money on irrigation systems and sun protection, which leads to higher production costs and, consequently, lower profits. The current results also demonstrate the economic ramifications of climate change on the agricultural industry, with a focus on reduced yields and productive capacity, resulting in financial losses caused by diminished revenues from product sales.

The decline in yields caused by climate change has particularly affected Ukraine, which has seen a significant drop in grain and oilseed production. Consequently, the country's export capacity has declined, potentially

resulting in adverse consequences for its trade balance and economic stability. Moreover, the influence of climate change on agricultural yields and output volumes was investigated by M. Kalkuhl & L. Wenz (2020). Their research demonstrated that increasing temperatures and alterations in precipitation patterns resulted in a decline in agricultural productivity in various parts of the nation. A. Ortiz-Bobea *et al.* (2021) observed that a rise in the occurrence of severe weather phenomena, such as typhoons and intense precipitation, results in increased crop losses and crop damage, so diminishing total production. This is consistent with the current results, which also found a decrease in yields due to rising temperatures.

In both countries, there are changes in the geographical areas of crop production, requiring significant investments in new infrastructure, changes in cultivation technologies and adaptation of farmers to new conditions. For example, in Albania and Ukraine, climate change may make some regions unsuitable for growing certain crops, leading to a need to change the specialization of the regions.

Overall, the analysed results confirm the significant and multifaceted impact of climate change on agriculture, while highlighting regional peculiarities that should be taken into account when adapting agricultural practices. Overall, successful adaptation of agriculture to climate change requires innovative technologies, improved agronomic practices and consideration of all possible risks. This requires significant financial resources, education, and government support to ensure the resilience of the agricultural sector in a changing climate.

CONCLUSIONS

The main mechanisms of climate change impacts on agriculture include changes in temperature, which can both increase and decrease yields depending on the region, as well as changes in the amount and pattern of precipitation, which in some cases leads to lower yields due to droughts or soil erosion. In particular, Albania is experiencing a gradual increase in average temperature and a decrease in precipitation, which poses additional challenges for the agricultural sector, requiring the implementation of adaptation measures such as expanding irrigation systems or using climate-resistant plant varieties.

Being a major producer and exporter of grains and oilseeds, Ukraine is also confronted with substantial obstacles created by climate change. Increasing temperatures and shifting precipitation patterns have a direct impact on crop production, namely on grain and oilseed yields, as verified by comprehensive data analysis. Alterations in precipitation patterns and increasing temperatures need the adjustment of agricultural methods,

including the strategic organisation of agricultural activities to align with the changing climatic circumstances.

Furthermore, the research revealed that the economic hazards linked to climate change provide a significant peril to agriculture in both nations. Escalated production expenses, diminished crop outputs, and the necessity to adopt novel technologies may result in decreased profitability of farms and potentially a decline in their population. Consequently, this could maybe result in adverse effects on both food security and economic stability.

Nevertheless, notwithstanding the obstacles, the research also emphasises prospects for the agricultural industry to thrive in response to climate change. For instance, alterations in the duration of the growing season might enable the growth of novel crops that were not previously characteristic to certain geography. Advancements in cutting-edge technology, such precision agriculture, together with substantial investments in research and training for farmers, are crucial.

Hence, the research has demonstrated the necessity of adopting adaptation measures to guarantee the

long-term viability of food production and economic stability in response to climate change. Specifically, this encompasses the upgrading of irrigation infrastructure, enhancement of water management practices, adoption of climate-resistant agricultural types, and provision of financial and instructional assistance to farmers.

The study's limitations include the use of data that may not comprehensively represent all facets of climate change and its effects on agriculture, owing to the scarcity of accessible literature. Additional investigation should prioritise the intensive observation of the enduring consequences of climate change on many facets of the agricultural industry and the formulation of novel adaptation measures, taking into account the incorporation of innovative technologies and predictive models.

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CONFLICT OF INTEREST

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Економічна оцінка впливу зміни клімату на сільське господарство в Албанії та Україні

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Анотація. Метою цього дослідження було проведення порівняльного аналізу впливу зміни клімату на сільськогосподарський сектор в Албанії та Україні, з акцентом на визначенні ключових викликів та можливостей для адаптації. У дослідженні було проаналізовано статистичні дані з 2010 по 2023 рік щодо зміни клімату та її впливу на сільське господарство, а також оцінено наслідки. Результати дослідження показали, що зміни температурних режимів є ключовим фактором, який безпосередньо впливає на сільське господарство. Підвищення середньорічних температур призводить до зміни вегетаційного періоду рослин, що має як позитивні, так і негативні наслідки. Зміна режиму опадів є ще одним ключовим механізмом впливу зміни клімату на сільське господарство. Зменшення кількості опадів та часті посухи можуть призвести до значних втрат врожаю, що вимагатиме впровадження систем зрошення та інших водозберігаючих технологій. Економічні ризики, пов'язані зі зміною клімату, є серйозним викликом для сільського господарства. Зниження врожайності, зростання виробничих витрат і необхідність адаптації до нових умов можуть загрожувати стабільності фермерських господарств, особливо малих. Аналіз для Албанії показав, що підвищення температури та зменшення кількості опадів створюють виклики для сільського господарства, особливо для виробництва зернових та овочів. В Україні, з її великими площами орних земель, є можливість компенсувати зниження врожайності за рахунок розширення посівних площ, але для підвищення ефективності потрібні інвестиції в нові технології зрошення та агрономічні практики. Обидві країни стикаються з необхідністю впровадження нових сортів рослин, модернізації іригаційних систем, а також розвитку сільськогосподарських інновацій та точного землеробства. Ефективні стратегії адаптації, включаючи міжнародне співробітництво та підтримку наукових досліджень, є ключовими для забезпечення сталості сільськогосподарських секторів обох країн. Результати дослідження можуть бути застосовані на практиці в державних програмах підтримки сільського господарства та міжнародних проектах з адаптації до зміни клімату.

Ключові слова: температурний режим; водні ресурси; продуктивність; інвестиції в інфраструктуру; порівняльний аналіз