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MANAGEMENT OF THE MODERNIZATION OF THE AGRICULTURAL SECTOR THROUGH THE PROMOTION OF SUSTAINABILITY AND CLIMATE RESILIENCE

Olga SÂRBU, Boris COREȚCHI,
Moldova State University

Modernizing the agricultural sector by incorporating sustainability and climate resilience presents a significant challenge, particularly in the face of climate change and growing environmental pressures. This study focuses on examining management strategies that promote agricultural modernization while enhancing resource efficiency and adaptability to climate variability. Using statistical approaches, such as Pearson correlation analysis, the research assesses how average annual temperatures and precipitation patterns influence agricultural productivity. Findings reveal a strong negative correlation between temperature rise and crop yields, emphasizing the need for strategic adaptation measures. The study highlights innovative approaches such as precision agriculture, soil conservation, and irrigation efficiency to mitigate climate risks. The originality of this research lies in its integrated management framework, linking technology adoption, sustainable policies, and economic resilience. Conclusions underline the necessity of tailored agricultural policies and investment in climate-smart solutions to sustain productivity and food security. This study contributes to strategic recommendations for enhancing the resilience and sustainability of Moldova's agricultural sector.

Keywords: *agricultural management, modernization, durability, climate resilience, sustainability.*

MANAGEMENTUL MODERNIZĂRII SECTORULUI AGRICOL PRIN PROMOVAREA DURABILITĂȚII ȘI REZILIENȚEI CLIMATICE

Modernizarea sectorului agricol prin integrarea durabilității și reziliență climatice reprezintă o provocare majoră în contextul schimbărilor climatice și al presiunilor ecologice crescânde. Studiul își propune să analizeze strategiile manageriale care facilitează modernizarea agriculturii, asigurând în același timp eficiența utilizării resurselor și adaptarea la variabilitatea climatică. Cercetarea utilizează metode statistice, inclusiv analiza corelației Pearson, pentru a evalua impactul temperaturilor medii anuale și al nivelului precipitațiilor asupra producției agricole. Rezultatele evidențiază o corelație negativă puternică între creșterea temperaturilor și randamentele culturilor, subliniind necesitatea unor măsuri strategice de adaptare. Studiul prezintă abordări inovatoare, precum agricultura de precizie, conservarea solului și eficientizarea irigațiilor pentru a reduce riscurile climatice. Originalitatea cercetării constă în cadrul său integrat de management, care leagă adoptarea tehnologiilor, politicile durabile și reziliența economică. Concluziile subliniază necesitatea unor politici agricole adaptate și a investițiilor în soluții inteligente pentru climă, menite să mențină productivitatea și securitatea alimentară. Studiul contribuie cu recomandări strategice pentru îmbunătățirea rezilienței și durabilității agriculturii din Republica Moldova.

Cuvinte-cheie: *management agricol, modernizare, durabilitate, reziliență climatică, sustenabilitate.*

Introduction

A key component of food security and a major force behind economic growth, agriculture is also one of the industry's most susceptible to the consequences of climate change. Modernizing the agricultural sector has become a global necessity in recent decades, with an emphasis on increasing production, maximizing the use of natural resources, and minimizing environmental damage. Building a robust and environmentally friendly agricultural framework requires the adoption of cutting-edge technologies, the application of agroecological practices, and the creation of sustainable regulations.

At the heart of this transformation lie sustainability and climate resilience. Sustainability emphasizes the responsible management of natural resources to sustain agricultural productivity over the long term, while climate resilience refers to the capacity of farming systems to adapt to and withstand the effects of a

changing climate. Issues like increasing temperatures, changing precipitation trends, a higher occurrence of extreme weather phenomena, and the deterioration of soil quality demand creative solutions and strong adaptive measures to safeguard the future of agriculture. In the current context, nations face significant challenges regarding agricultural sustainability, and public policies in developed countries prioritize the modernization of the agricultural sector, with the primary objective of integrating environmental protection principles and strengthening climate resilience [1-4]. In a post-industrialized world, agricultural modernization can no longer be conceived solely through the lens of productivity growth and intensive mechanization; instead, it must adopt a more reflexive approach that incorporates ecological factors, social equity, and long-term economic sustainability.

According to reflexive modernization theories [5], contemporary society should not rely exclusively on technological progress and economic expansion but must integrate adaptation mechanisms to ecological risks and ensure the sustainable development of agriculture. This theory argues that modernization must go beyond the classical industrialization paradigm and embrace policies focused on resource efficiency and minimizing environmental impact. Applied to agriculture, reflexive modernization involves the implementation of managerial strategies based on precision farming, water consumption optimization, biodiversity conservation, and the promotion of the circular economy. In this regard, the need for integrated agricultural policies is emphasized, supporting farmers in the transition towards sustainable practices and ecological technologies.

The idea of climate resilience, which is increasingly applied in the study of agricultural systems, highlights their capacity to adapt to climate change impacts and mitigate its adverse effects [6-7]. In this framework, contemporary management approaches must incorporate proactive measures to lessen agriculture's susceptibility to climate-related risks. These measures include:

- diversifying crops and using drought- and disease-resistant varieties to prevent losses caused by extreme climate changes;
- developing efficient irrigation systems and water management technologies to reduce unnecessary resource consumption;
- implementing regenerative agriculture, which focuses on restoring agricultural ecosystems and reducing the carbon footprint;
- ensuring access to agricultural insurance against climate risks to mitigate the economic impact on farmers.

These measures are supported by economic theories that highlight the importance of adaptive planning and risk mitigation mechanisms in the sustainable development of agriculture.

In advanced economies, agricultural policies and managerial strategies are designed to support farmers in implementing sustainable practices and increasing their ability to adapt to new climate conditions [8-9]. The European model of the Common Agricultural Policy is a concrete example of this approach, emphasizing organic farming, soil protection, and the reduction of greenhouse gas emissions.

Thus, internationally promoted agricultural modernization strategies are based on three main directions:

- economic sustainability, by promoting investments in efficient technologies and ensuring fair market access for farmers;
- ecological sustainability, by reducing agricultural pollution and protecting natural resources;
- social sustainability, by developing rural communities and ensuring equity in the distribution of agricultural resources.

Contemporary theories on reflexive modernization, climate resilience, and sustainability emphasize the importance of a holistic approach to agricultural management [10, p. 221]. The process of modernization should extend beyond mechanization and productivity gains; it must also incorporate strategies for adapting to climate change, safeguarding the environment, and strengthening the resilience of farmers. Public policies should support the transition toward a sustainable and innovative agricultural model capable of addressing current climate and economic challenges.

The Republic of Moldova, with an economy heavily dependent on agriculture, is particularly affected by climate change. Prolonged droughts, soil erosion, and declining water resources significantly impact crop yields, posing a threat to food security and farmers' incomes. Without effective modernization and adap-

tation strategies, the agricultural sector risks becoming increasingly vulnerable, making urgent measures necessary to ensure its sustainability and competitiveness.

Agricultural modernization is a complex process that involves adopting advanced technologies, optimizing agricultural practices, and implementing efficient management strategies to ensure sustainable production. The management of agricultural modernization encompasses all decision-making, technical, and economic processes aimed at optimizing the use of natural, human, and financial resources for a high-performing agricultural sector.

This study aims to analyse agricultural modernization strategies through the lens of promoting sustainability and climate resilience, highlighting innovative solutions and public policy measures that can contribute to the development of a sustainable and adaptable agricultural sector in the face of current climate challenges.

Materials and methods

The research aims to identify how climate variability influences agricultural yields and to propose solutions for modernizing agricultural management by promoting sustainability and climate resilience. The study is based on economic and climatic data collected from reliable sources, such as the National Meteorological Agency and the National Bureau of Statistics of the Republic of Moldova. A thorough, long-term assessment of climatic trends and their impact on agricultural productivity is made possible by the analysis, which covers the years 2010-2024.

To assess the connections between climatic factors and agricultural productivity, the Pearson correlation method was applied [11]. This statistical tool quantifies the strength and direction of a linear relationship between two continuous variables.

The formula used to calculate this relationship is [11]:

$$r = \frac{\sum^{n}_{i=1} (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum^{n}_{i=1} (X_i - \bar{X})^2 \sum^{n}_{i=1} (Y_i - \bar{Y})^2}}$$

where:

r - is the Pearson correlation coefficient;

n - represents the number of observations;

X_i, Y_i - are the individual values of the two variables (temperature and precipitation);

$\bar{X}$, $\bar{Y}$ - are the arithmetic means of the variables;

$\sum$ - represents the sum of all observations.

The Pearson correlation coefficient *(r)* [11] is a statistical metric that evaluates the strength and direction of a linear association between two continuous variables. Its values range from -1 to +1:

+1 indicates a perfect positive correlation, meaning that both variables increase simultaneously;

0 indicates no linear relationship between the variables;

-1 indicates a perfect negative correlation, meaning that as one variable increases, the other decreases.

The coefficient, which ranges from -1 to 1, reflects the degree to which the data points on a scatter plot conform to a straight line.

Results and discussions

Given agriculture's critical significance in the country's economic structure, its modernization and transformation are essential to the Republic of Moldova's economic and social advancement. A sizable portion of the rural workforce finds their major source of employment in agriculture, which also makes a substantial contribution to the GDP. However, it faces numerous challenges, driven by both climate change and the need to align with international sustainability and competitiveness standards. In this context, managerial strategies applied to agricultural modernization must focus not only on increasing productivity but also on integrating sustainability and climate resilience principles to ensure that the agricultural sector can respond effectively to current and future challenges.

The Republic of Moldova faces significant vulnerability to climate change, evidenced by increasing

average annual temperatures, declining precipitation levels, and a rising occurrence of extreme weather phenomena, including droughts and late frosts. These shifts directly influence agricultural productivity, impacting both smallholder farmers and larger agribusinesses. Therefore, modern managerial strategies must incorporate adaptive and innovative measures, such as the use of precision technologies, the implementation of efficient irrigation systems, the promotion of organic farming, and the development of sustainable agricultural policies.

Sustainability in agriculture emphasizes the efficient use of natural resources, lowering harmful environmental impacts, and ensuring long-term soil health. To achieve this, adopting conservation farming methods, cutting down on pesticide usage, and integrating crop rotation are vital strategies for effective agricultural management [12-13]. The ability of agricultural systems to endure and adapt to the effects of climate change while maintaining economic viability and output is known as climate resilience.

The Republic of Moldova's agricultural transformation calls for a comprehensive management strategy that incorporates technological innovation with the flexibility to adjust to changing economic and climatic conditions. Using digital tools to monitor weather and soil trends, like artificial intelligence and precision farming, provides cutting-edge ways to increase agricultural productivity and lower losses. Equally important are financial and support mechanisms for farmers, including government subsidies and agricultural insurance programs, which are vital for building a resilient and competitive agricultural sector.

Agriculture holds a strategic position in Moldova's economy, significantly contributing to food security, rural employment, and income generation through agricultural exports. The sector's contribution to the Gross Domestic Product (GDP) serves as a critical measure of its performance, reflecting the influence of climatic conditions, agricultural policies, domestic and international market demand, as well as investments in infrastructure and farming technologies. This indicator fluctuates annually, shaped by a combination of these factors.

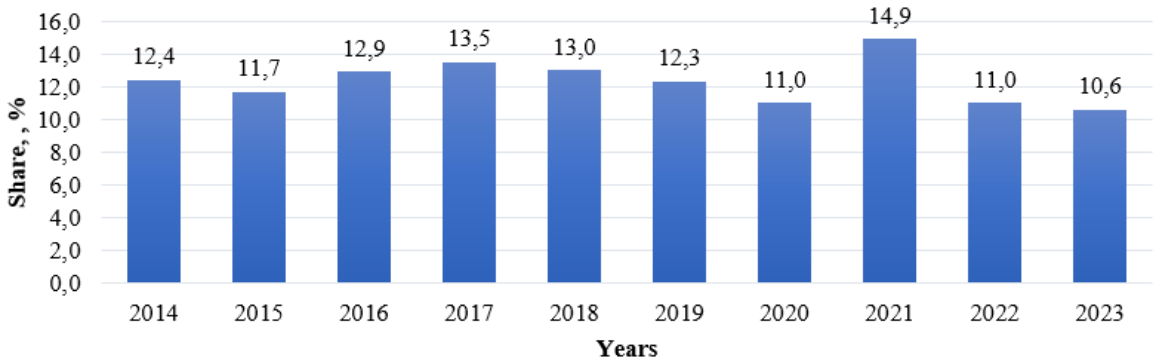


Figure 1. Dynamics of agriculture's share in the GDP of the Republic of Moldova, %
Source: *Elaborated by the authors based on statistical data from the NBS [14]*

The analysis of the evolution of agriculture's share in GDP between 2014 and 2023 reflects significant fluctuations caused by both extreme weather conditions and internal and external economic factors. These changes highlight the need for effective adaptation strategies that ensure the stability of the agricultural sector and its contribution to the country's economic development. Between 2014 and 2017, the agricultural sector experienced a fluctuating yet overall positive trend. In 2014, agriculture accounted for 12.4% of GDP, but this share declined to 11.7% in 2015 due to unfavourable climatic conditions and economic factors that affected agricultural production. Between 2016 and 2017, the sector's share increased significantly, reaching 13.5% in 2017. This growth can be attributed to favourable climatic conditions, increased productivity, and the expansion of agricultural exports. This period demonstrated the importance of a stable climate and effective policies in maintaining agricultural competitiveness. In 2018 and 2019, agriculture's share in GDP remained relatively stable at 13.0% and 12.3%, respectively, indicating a period of relative stability in agricultural production. However, in 2020, the agricultural sector was severely affected by extreme drought and adverse weather conditions, leading to a significant decline in its GDP share, which dropped to 11.0%. This evolution underscores the sector's vulnerability to climate change, emphasizing the

need for investments in irrigation systems and sustainable agricultural technologies to mitigate the negative impact of drought on production.

The year 2021 was exceptional for agriculture, with a significant increase in its GDP share, reaching 14.9% – the highest level recorded during the analysed period. This growth was driven by favourable climatic conditions, increased agricultural exports, and high productivity across all agricultural sectors (cereals, vegetables, fruits, vineyards). This example highlights the importance of stable climatic conditions and effective policies in supporting agricultural production. After the peak year of 2021, 2022 marked another decline in agriculture's share of GDP, dropping to 11.0%, followed by another decrease to 10.6% in 2023. This downward trend can be attributed to severe drought, which affected maize, sunflower, and other strategic crops, as well as economic factors such as market instability and declining demand for agricultural exports.

The evolution of agriculture's share in Moldova's GDP is strongly influenced by two key factors: climatic conditions and the economic and political context. These factors directly determine agricultural productivity, sector profitability, and farmers' ability to maintain production stability in the face of external challenges. Climatic variability is one of the main determinants of agricultural performance and, consequently, the sector's contribution to GDP. Years with balanced precipitation levels and moderate temperatures have favoured agricultural production growth, ensuring a significant contribution to the national economy. For example, 2017 and 2021 were years with favourable climatic conditions, reflected in the increase in agriculture's GDP share to 13.5% in 2017 and 14.9% in 2021. Conversely, years marked by severe drought had a negative impact on agricultural yields, affecting both domestic production and agricultural exports. The droughts of 2015, 2020, 2022, and 2023 led to significant declines in the production of cereals, vegetables, and oilseeds, thus reducing agriculture's contribution to GDP. For instance, in 2020, agriculture's share in GDP dropped to 11.0%, and in 2023, it further declined to 10.6%, confirming the sector's vulnerability to extreme weather events. These variations show how reliant agriculture is on the weather, underscoring the necessity of preventative measures to lessen the adverse effects of climate change on agricultural output.

Beyond climatic influences, economic and political factors play a crucial role in determining the sustainability of agriculture and its contribution to GDP. The lack of investment in agricultural infrastructure and irrigation systems limits farmers' ability to counteract drought effects and maintain stable production levels. In the absence of modern water resource management technologies, drought periods have a devastating impact on agriculture, significantly reducing the sector's added value. Additionally, fluctuations in external market demand and trade restrictions directly affect the competitiveness of Moldovan agricultural exports. Dependence on regional markets and exposure to geopolitical instability can generate economic uncertainties, negatively influencing agricultural investments and sector stability. Furthermore, underfunded or ineffective agricultural policies can reduce agriculture's resilience to climatic and economic changes. The absence of long-term support strategies for farmers, such as well-targeted subsidies or programs for modernizing agricultural technologies, limits the sector's capacity to adapt to new economic and climatic realities.

Climate change is one of the most significant challenges facing the agricultural sector globally, influencing both crop productivity and the sustainability of natural resources. Changes in precipitation patterns and rising average annual temperatures alter vegetation cycles, reduce soil fertility, and increase the frequency of extreme weather events such as droughts, floods, and heatwaves. These changes have significant economic consequences, leading to reduced agricultural yields, as well as social impacts by increasing the vulnerability of farmers and rural communities that depend on agriculture [15, p. 192].

In the Republic of Moldova, these effects are already evident, reflected in annual variations in air temperature. The progressive increase in average annual temperature and the growing frequency of drought periods necessitate the urgent adaptation of agricultural systems. Analysing the annual evolution of average temperatures in Moldova provides a clear picture of climate trends in recent decades, allowing for the identification of risks and the development of effective adaptation strategies aimed at maintaining agricultural productivity and preserving natural resources.

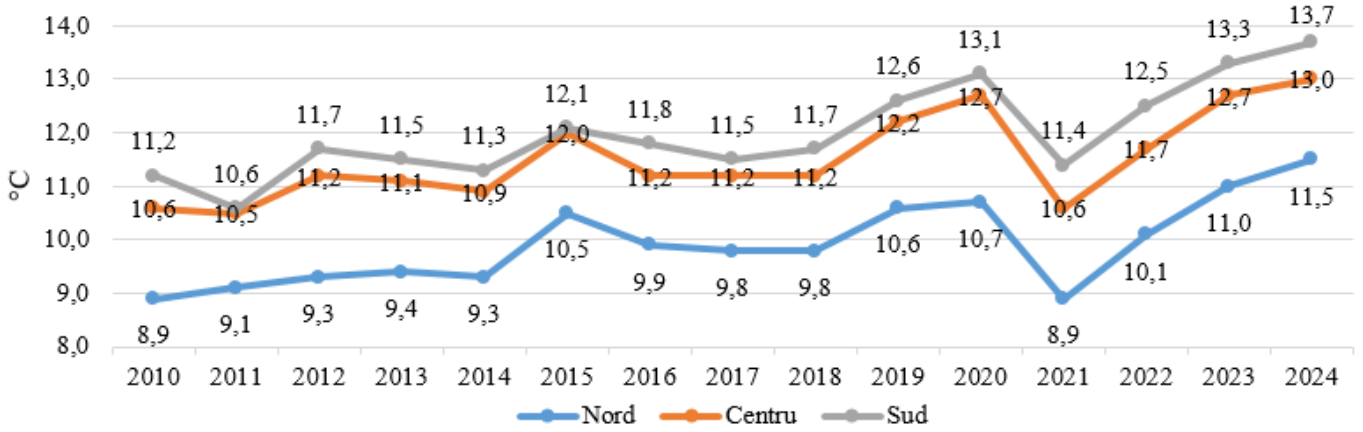


Figure 2. Annual trend of average air temperature by region in the Republic of Moldova
Source: *Elaborated by the authors based on statistical data from the NBS [14]*

An examination of the average yearly air temperatures in the Republic of Moldova's three regions – North (Briceni), Center (Chișinău), and South (Cahul) – from 2010 to 2024 shows a steady increase everywhere. This increasing tendency points to a pattern of regional warming that could have an impact on environmental changes, agricultural productivity, and climatic stability.

The northern region, characterized by a colder climate and longer winters, recorded an increase in average annual temperature from 8.9°C in 2010 to 11.5°C in 2024, marking a rise of 2.6°C. Although it remains the coldest area of the country, this warming trend may favour the expansion of certain crops, such as corn, sunflower, and specific grapevine varieties. However, climatic fluctuations and the risk of late frosts continue to pose a major challenge for farmers.

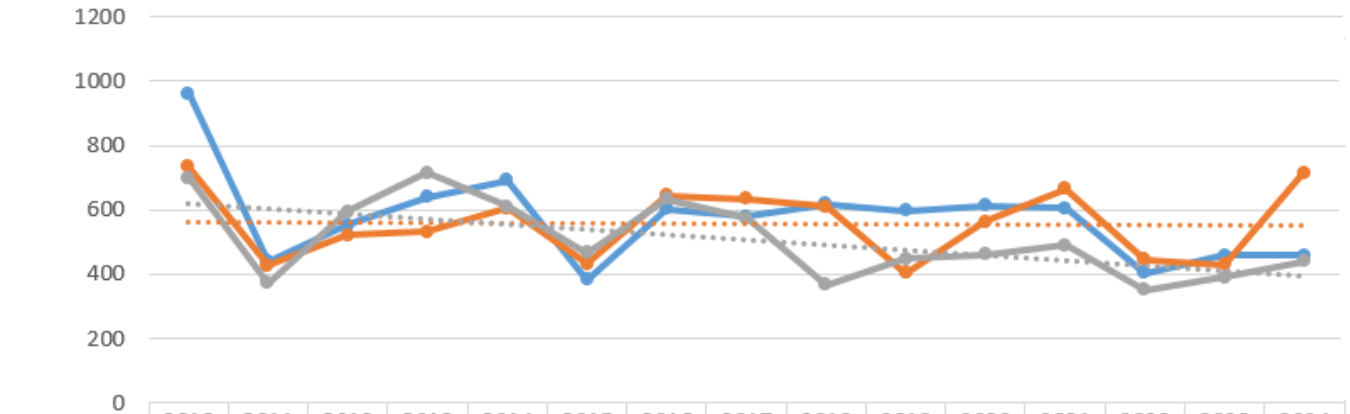
The central region, located in a transitional climate zone, experienced a temperature increase from 10.6°C in 2010 to 13.0°C in 2024, reflecting a rise of 2.4°C. This area has moderate temperatures, but constant warming may lead to changes in vegetation periods and an increased need for irrigation. Additionally, it may positively influence the expansion of vineyards and fruit orchards, though it could also intensify drought conditions during certain periods of the year.

The southern region, characterized by a warmer and drier climate, recorded an increase in temperature from 11.2°C in 2010 to 13.7°C in 2024, indicating a rise of 2.5°C. This area is the most affected by drought and thermal stress, necessitating additional measures for water management and soil protection. High temperatures may negatively impact heat-sensitive crops but could favor the expansion of drought-resistant grape varieties for winemaking and other resilient crops.

The increase in average temperatures across all regions of the Republic of Moldova confirms an ongoing climate warming process with significant implications for agriculture. While the north presents new opportunities for crop expansion, the central region requires optimal water management, and in the south, adaptation to drought becomes crucial. Implementing effective adaptation strategies, such as using heat-resistant crop varieties and optimizing irrigation systems, will be essential for maintaining agricultural productivity in the long term.

In the Republic of Moldova, rainfall is essential to preserving climate stability and boosting agricultural output. Crop performance, irrigation water availability, and soil health are all directly impacted by the amount and distribution of precipitation. Variations in rainfall patterns have the potential to cause protracted agricultural droughts, endangering the stability of the farming industry and, consequently, the economic health of the country.

The evolution of precipitation levels in the Republic of Moldova from 2010 to 2024 reflects significant variability, characterized by alternating periods of excessive rainfall and severe drought. This trend indicates increasing climatic instability, which directly impacts water resource management and agricultural yields. Rainfall patterns are vital for maintaining soil fertility and ensuring adequate water supplies for irrigation, and their variability underscores the need for immediate adaptation strategies in the agricultural sector.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
North	960	439	552	639	691	382	602	578	617	596	614	605	402	458	458
Center	734	428	522	531	604	431	644	635	609	403	562	666	444	430	715
South	699	371	595	716	611	466	633	574	366	448	460	490	352	389	440

Figure 3. Annual trend of precipitation levels by region in the Republic of Moldova
Source: *Elaborated by the authors based on statistical data from the NBS [14]*

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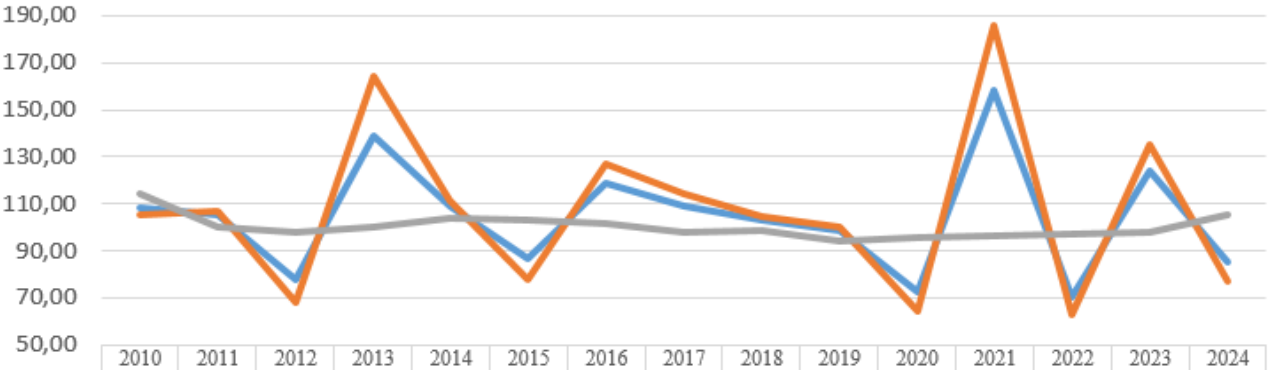
The year 2010 saw higher-than-average rainfall, with the northern region recording 960 mm, the central region 734 mm, and the southern region 699 mm. While this increased moisture boosted agricultural output, it also raised concerns about flooding and soil erosion. However, the following years, 2011–2012, experienced a significant drop in precipitation, resulting in severe droughts that heavily impacted agricultural productivity, especially in the southern and central areas. The water shortage led to reduced crop yields, lower production levels, and substantial economic damage. Between 2013 and 2017, precipitation levels showed a trend of stabilization, although with significant annual fluctuations. However, the distribution of precipitation remained uneven across regions, leading to disparities in agricultural productivity. While some areas benefited from a relatively balanced precipitation regime, others faced localized drought conditions. This uneven distribution of rainfall required farmers to implement additional water management measures, including the use of irrigation systems and the adoption of soil moisture conservation technologies.

The period from 2018 to 2023 was characterized by significant fluctuations in precipitation levels, with extremely low values recorded in 2020 and 2022. These prolonged drought periods had a severe impact on agricultural crops, reducing productive land areas and affecting agriculture’s contribution to GDP. In the southern region, where precipitation levels consistently remained below optimal thresholds, the effects of drought were particularly pronounced, putting pressure on the available water resources for agriculture. Data for 2024 indicate a slight increase in precipitation levels, suggesting a possible return to a more balanced rainfall regime. However, the high variability in precipitation remains a major concern for farmers, as its seasonal distribution may still be uneven. The increasing frequency of extreme weather events, such as prolonged droughts followed by heavy rainfall, necessitates a continuous adaptation of agricultural practices to maintain productivity and ensure food security.

This analysis highlights the growing climate volatility in the Republic of Moldova, which has significant ramifications for the country’s agriculture industry. The long-term decline in precipitation amounts and their increasing unpredictability highlight the need for effective water management techniques. These include expanding irrigation infrastructure, adopting drought-resistant farming technologies, and promoting

sustainable natural resource practices. Only through such measures can the agricultural sector maintain its competitiveness and resilience in the face of ongoing climate challenges.

The trajectory of agricultural production in the Republic of Moldova between 2018 and 2024 shows notable fluctuations, largely influenced by climatic and economic factors that have shaped the sector's productivity. The data reveal a pattern of instability, marked by periods of significant growth followed by sharp declines, illustrating the sector's susceptibility to both weather variability and market dynamics.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total agricultural production	108,00	105,00	78,00	139,00	109,00	87,00	119,00	109,00	102,90	98,40	72,80	157,90	70,20	123,60	85,40
Crop production	105,00	107,00	68,00	164,00	111,00	78,00	127,00	114,00	104,40	100,20	64,30	185,50	63,20	135,10	77,10
Livestock production	114,00	100,00	98,00	100,00	104,00	103,00	102,00	98,00	98,90	94,00	95,50	96,40	97,40	98,10	105,70

Figure 4. The Republic of Moldova's agricultural production fluctuates annually (Previous Year = 100%), %

Source: *Elaborated by the authors based on statistical data from the NBS [14]*

The analysis of total agricultural production shows that the multiannual average for the analyzed period is influenced by two major extremes. In 2021, total agricultural production reached an exceptional peak of 157.9 points, exceeding the multiannual average by +52.2 points, representing an increase of +49.4% compared to the period's average. This growth was primarily due to favourable weather conditions, characterized by adequate precipitation and optimal temperatures, which supported crop development. In contrast, 2022 was one of the most unfavourable years, recording a significant decline to 63.2 points, which represents a negative deviation of -42.5% from the multiannual average and a difference of -94.7 points compared to the 2021 peak. This sharp decline was caused by severe drought, which negatively impacted crop production, limiting agricultural yield growth.

Regarding crop production, the analysis indicates extremely high variability. The year 2021 was by far the most productive, with a record value of 185.5 points, representing a +74.9% increase above the multiannual average. In contrast, 2020 was the most affected year, with a minimum value of 64.3 points, signifying a reduction of -51.3% compared to the period's average. This dynamic shows that the crop sector is the most exposed to unfavourable climatic conditions, and its yields are directly correlated with precipitation and temperature patterns. The drastic declines in 2020 and 2022 demonstrate that the lack of precipitation and extreme temperatures directly impact the productivity of staple crops, highlighting the urgent need for adaptation measures and efficient water resource management.

Unlike the crop sector, livestock production has shown more stability, with relatively moderate variations compared to other agricultural segments. The highest value was recorded in 2023, at 98.1 points, while the lowest was in 2024, at 77.1 points, representing a negative deviation of -21.5% from the multiannual average. This relative stability suggests that the livestock sector is less sensitive to immediate meteorological variations but can be indirectly affected by feed availability and rising production costs during drought years.

The analysis highlights a strong correlation between agricultural production and weather conditions,

particularly in the crop sector. Drought years lead to drastic declines in production, significantly impacting the stability of the agricultural sector and its contribution to GDP. The increasing frequency of extreme weather events necessitates the implementation of adaptation measures, such as expanding irrigation systems, using drought-resistant crop varieties, and promoting sustainable agricultural practices. In the long run, the significant fluctuations in crop production suggest the need for an integrated climate risk management strategy to ensure agricultural production stability and minimize the negative impact of drought and extreme weather conditions on the national economy.

To determine the dependence of agricultural production volume on precipitation levels and the evolution of average annual temperature, correlation and regression statistical analysis was applied. This approach enables the assessment of the connection between climatic factors (such as precipitation and average annual temperature) and agricultural output. The Pearson correlation was utilized to gauge the strength and direction of the relationship between these variables, while linear regression models were applied to measure the extent to which climatic conditions influence agricultural productivity.

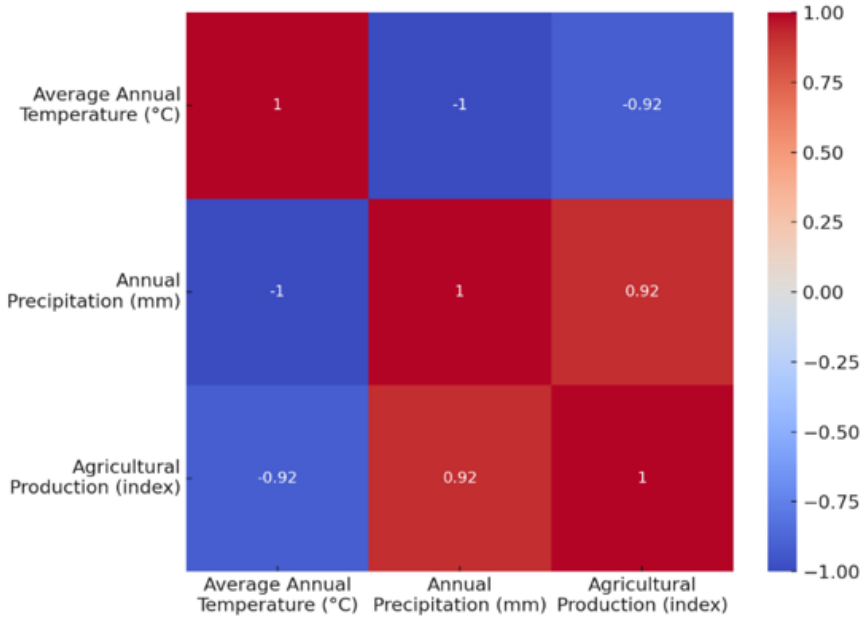


Figure 5. Pearson correlation matrix: temperature, precipitation, and agricultural production in Moldova

Source: *Elaborated by the authors based on statistical data from the NBS and [11, 14]*

Considerable correlations have been revealed by the Pearson correlation analysis of the Republic of Moldova's average annual temperature, yearly precipitation, and agricultural production volumes, underscoring the considerable effects of climate change on the agricultural sector. The average yearly temperature and annual precipitation have a perfect negative correlation (r = -1.00), indicating that these two environmental parameters are completely inversely related. This indicates that precipitation amounts steadily decline as temperatures rise. This pattern highlights how severe climate change has become in Moldova in recent decades, leading to an increase in the frequency of extreme weather events including protracted droughts and acute water shortages.

Additionally, the analysis indicates a strong negative correlation (r = -0.92) between average annual temperature and agricultural production, reflecting the significant adverse impact of rising temperatures on agricultural yields. Higher temperatures exacerbate thermal stress and reduce the availability of water resources essential for crop development. This effect is particularly pronounced for drought-sensitive crops such as corn, sunflower, and winter cereals. The negative consequences are further intensified by the limited irrigation infrastructure and the lack of effective adaptation measures to the changing climatic conditions.

On the other hand, the strong positive correlation identified (r = +0.92) between annual precipitation and agricultural production highlights the fundamental importance of water resources for agriculture. This cor-

relation indicates that agricultural yields are significantly higher in years with sufficient or above-average precipitation levels, confirming the Moldovan agricultural sector's dependence on a balanced and predictable hydrological regime.

In this context, the implementation of effective water resource management strategies is essential, including the development and expansion of modern irrigation infrastructure to mitigate water deficits caused by reduced precipitation and rising temperatures. Technological adaptation, through the selection of crop varieties resistant to severe climatic conditions, represents another vital direction for ensuring agricultural sustainability. In a similar vein, strengthening Moldova's agricultural resilience in the face of fast accelerating climate change requires thorough strategic planning in both agricultural and climate policies. In order to promote the sustained expansion of the agricultural sector and guarantee food security in the Republic of Moldova, it is imperative that climatic conditions be strategically managed with the support of research and innovation.

The Pearson correlation applied in this context provides a clear perspective on how climate change affects agriculture and emphasizes the urgent need for sustainable policies to efficiently manage agricultural and environmental resources.

Conclusions

The study highlights the importance of integrating sustainability and climate resilience principles into the process of modernizing agriculture in the Republic of Moldova. The findings validate the substantial influence of climate change on agricultural productivity, showing that increasing average annual temperatures and declining precipitation levels have a direct impact on crop yields. The established correlations between climatic factors and agricultural output highlight the urgency of implementing effective adaptation strategies to mitigate the sector's vulnerability.

The Pearson correlation analysis showed that average annual temperature and annual precipitation are inversely correlated ($r = -1.00$), indicating a perfect negative relationship, where an increase in temperature is accompanied by a proportional decrease in precipitation. This trend exacerbates water deficits, significantly affecting agricultural crops, especially drought-sensitive ones such as corn, sunflower, and winter cereals. Furthermore, the strong negative correlation ($r = -0.92$) between average annual temperature and agricultural production underscores how global warming is driving a decline in crop yields. Conversely, the strong positive correlation ($r = +0.92$) between annual precipitation and agricultural production highlights the critical role of adequate moisture levels in sustaining agricultural productivity.

In this context, the implementation of effective managerial strategies becomes crucial for the modernization of agriculture and the strengthening of the sector's climate resilience. Optimizing water resource management through the modernization of irrigation infrastructure and the promotion of soil moisture conservation technologies is one of the most urgent necessary measures. The adoption of digital technologies in agriculture, including precision farming and real-time climate data monitoring, will enable the optimization of resource use and the reduction of production losses.

Furthermore, crop diversification and the use of drought-resistant varieties are essential measures for adapting to new climatic conditions. The development of public policies that support farmers in implementing sustainable practices and ensuring access to financing schemes and agricultural insurance represents another strategic pillar of agricultural modernization. In this regard, integrating a sustainable agricultural policy based on targeted financial support and climate adaptation measures can ensure the long-term stability and competitiveness of the agricultural sector.

The transformation of agriculture in the Republic of Moldova should be grounded in a comprehensive approach that integrates technological advancements, sustainable management of natural resources, and the implementation of effective adaptive measures. To address climate-related challenges, the agricultural sector must shift toward a resilient production framework capable of adapting to evolving climatic and economic conditions. Adopting these strategies will not only mitigate the adverse effects of climate change on agriculture but also enhance productivity and ensure the long-term sustainability of this crucial sector for Moldova's economy.

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Date abouth the authors:

Olga SÂRBU, PhD, Associate Professor, Faculty of Economics Sciences, State University of Moldova.
ORCID: https://orcid.org/0000-0001-6333-0101
E-mail: olga.sarbu@usm.md

Boris COREȚCHI, PhD, Associate Professor, Faculty of Economics Sciences, State University of Moldova.
ORCID: https://orcid.org/0000-0001-8841-4838
E-mail: boris.cotetchi@usm.md

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