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Conference Paper

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Provided in Cooperation with:
The Research Institute for Agriculture Economy and Rural Development (ICEADR), Bucharest

Suggested Citation: Ilie, Diana Maria (2024) : The impact of climate changes on the vegetable sector, In: Rodino, Steliana Dragomir, Vili (Ed.): Agrarian Economy and Rural Development - Trends and Challenges. International Symposium. 15th Edition, The Research Institute for Agricultural Economy and Rural Development (ICEADR), Bucharest, pp. 85-90

This Version is available at:
https://hdl.handle.net/10419/319509

THE IMPACT OF CLIMATE CHANGES ON THE VEGETABLE SECTOR

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Summary: *Vegetable crops are strongly affected by extreme weather phenomena (for example drought and floods), which disrupt the technological production process and favor the spread of diseases and pests, thus creating an unstable agricultural environment. In addition, these climate changes directly affect farmers who are forced to change the way they plan their crops, adopt sustainable agricultural practices and implement the links of advanced technologies. At the same time, it is essential that together with the application of sustainable agricultural practices in vegetable farms, there are also support policies that come to the aid of farmers to guarantee the success of these changes. The article aims to analyze the impact of climate change on the vegetable sector and provide a vision of how it can survive in a constantly changing climate.*

Key words: *vegetable sector, climate change, market, support policies*

JEL classification: Q13,Q15,Q54

INTRODUCTION

The subject of climate change is very often addressed in scientific papers, which highlighting its significant impact on agricultural crops and the major challenges it brings to farmers. These phenomena not only directly influence production by destroying plants, but also increase the proliferation of diseases and pests, creating an unstable agricultural environment.

In recent decades, climate change has clearly made its effects felt in Romania and in the world, through extreme weather phenomena such as drought, floods, heat waves and sudden temperature fluctuations(www.presidency.ro). These changes have considerably affected the sector, and vegetable crops, due to their biological characteristics and ecological needs, are among the most vulnerable (Kondinya A. et all, 2014). These changes disrupt both the technological processes of production and the natural ecosystems in which vegetables are grown, which directly affects farmers, agricultural production and the agri-food economy (Rurac M. et all, 2021; Manzoor M. A. et al., 2024).

One of the most common phenomena is drought, which affects plants by reducing water availability, causing water stress. This leads to decreased productivity and, in severe cases, to the compromise of crops.

On the other hand, flooding can damage the roots, leading to plant asphyxiation and massive losses. The soil soaked with water also favors the development of pathogenic fungi, which can destroy crops in a short time.

From the perspective of the risk associated with hail, which can cause severe damage, the most exposed are the areas where the land is used for vegetable crops and fruit or vineyard plantations (Mihăilă D., 2006).

These phenomena have a devastating impact on farmers, affecting not only crop yields, but also products, as well as the income they can obtain.

MATERIALS AND METHODS

The research method used is quantitative analysis, which involves the collection and analysis of meteorological data (precipitation, temperatures) and agricultural production, in order to establish possible correlations between climatic variations and vegetable production. This type of research helps to identify trends and assess the impact of environmental factors on crops. The data collected are obtained from official sources (INS) for the period 2014-2023.

The statistical indicators used in the analysis and interpretation of the data (Țimiraș Laura Cătălina, 2016) were:

1. *The average* – represents the average annual value of each indicator in the period 2014-2023. Media provides a reference point for interpreting variations.
2. *The coefficient of variation* (C%) given by the formula: C%= σ/ x *100;

where: x = the average value of the analyzed indicator in the analyzed period;

σ = standard deviation of the analyzed data string $\partial = \sqrt{\frac{\sum(\bar{x}-xi)\wedge 2}{n-1}}$.

The coefficient of variation measures the significance of the degree of variation in relation to the mean.

Interpretation: *small variation* (< 10%) - relatively stable data; *medium variation* (10.1 % - 20 %) - moderate variability; *high variance* (> 20.1%)- high variability, which may indicate instability in the trends of the analyzed indicator.

3. *Average annual growth rate(r)* shows us what is the annual growth of the analyzed phenomenon *:* $r = \sqrt[n-1]{\prod\left(\frac{p\,n}{p\,n-1}\right) - 1}$*,* where*:* ∏pn/pn-1 = indicators of chained growth
4. Adjusting the trend by trend equation, parabola type, of the form: Y= ax2+bx+c

With the help of the FORECAST statistical function in EXCEL, forecasts of the temperature and the amount of average annual precipitation for the next 5 years were made, based on statistical data. It provides estimates of how weather conditions will change.

RESULTS AND DISSCUSION

In Romania, agriculture depends to a large extent on climatic conditions, and these changes negatively influence both production and food security of the population.

As the temperature rises, extreme weather events, such as prolonged droughts, floods and early frosts, become more frequent altogether. Vegetables, especially those grown in the field, are crops that are very sensitive to environmental conditions (Mehdi B. B.et all, 2018), and such phenomena greatly affect its production and quality. For Romanian farmers, temperature variations directly influence planting and harvesting periods, amplifying the risks associated with pest and disease attacks. These changes affect the stability of supply and increase uncertainties in the vegetable market (Mattos Leonora M. et all, 2014).

The average annual temperature in Romania has increased significantly in recent decades, and seasonal variations have major consequences on agricultural production, including horticulture. In the analyzed period 2014-2023, the average annual temperature registered an increase of 1ºC in this interval, from 10.4 ºC in 2014 to 11.56 ºC in 2023. The year

2021 presented unusual weather conditions, recording a significant drop in temperature, up to 9.9 ^{oC} (Table 1).

The vegetable sector is strongly influenced by the rainfall regime, given that vegetables require a constant supply of water for optimal growth and development. In dry periods, farmers are forced to use the irrigation system more frequently, which leads to an increase in production costs. Fluctuations in the rainfall regime also have a major impact on production, which can have significant negative effects on the vegetable market. As a rule, in dry years the production is lower, which leads to an increase in imports and prices of domestic products (www.cotidianul.ro).

In recent years, Romania has recorded significant variations in the rainfall regime, a phenomenon aggravated by climate change. The IPCC (Intergovernmental Panel on Climate Change) analyses have identified an increase in the amount of precipitation in the autumn season in most regions, but also a decrease in the winter-summer periods, especially in the East and South-West regions of the country(www.mmediu.ro).

From the statistical data of the last 10 years, there is a significant variation in the average annual amount of precipitation, with a maximum of 806.4 mm in 2014, and a minimum of 553.2 mm in 2022, the latter being a year with difficult climatic conditions for agriculture(www.agerpres.ro).

In 2023, the amount of precipitation increased slightly to 629.76 mm, but remains about 21.9% lower than the level of 2014. The data reflect a trend of decreasing rainfall, which puts additional pressure on agriculture and requires adaptation of agricultural practices to counteract water scarcity (Table 1).

Table 1. Dynamics of temperature and average annual precipitation in Romania in the period 2014-2023

Indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average	C%	Annual rhythm
Average annual air temperature (^{oC})	10,4	10,8	10,3	10,2	10,7	11,2	11	9,9	10,6	11,56	10,67	4,66%	1,18%
Average annual amount of precipitation (mm)	806,4	622,9	766,1	670,4	684,9	601	636,7	699,6	553,2	629,76	667,10	11,42%	-2,71%

Source: INS data processing – TEMPO ONLINE – matrix code - TOX1332, TOZ1334 - Target 3 - Environment accessed on 29.10.2024.

The climate changes observed during the last decade in Romania (Table 1), are characterized by an increase in temperature with an average annual rate of 1.18% and a decrease in precipitation by -2.71%, indicating a significant impact on the country's agriculture, environment and economy. The constant decrease in rainfall represents an important challenge for the vegetable sector, especially for those grown in the field. This puts increasing pressure on farmers, leading them to invest in modern technologies for monitoring and optimizing irrigation.

As climatic factors play an important role in the success of agricultural crops, it is necessary for farmers to use weather data to be able to adapt their production strategies. Using statistical data from 2014-2023, it was possible to create forecasts, using the Forecast function

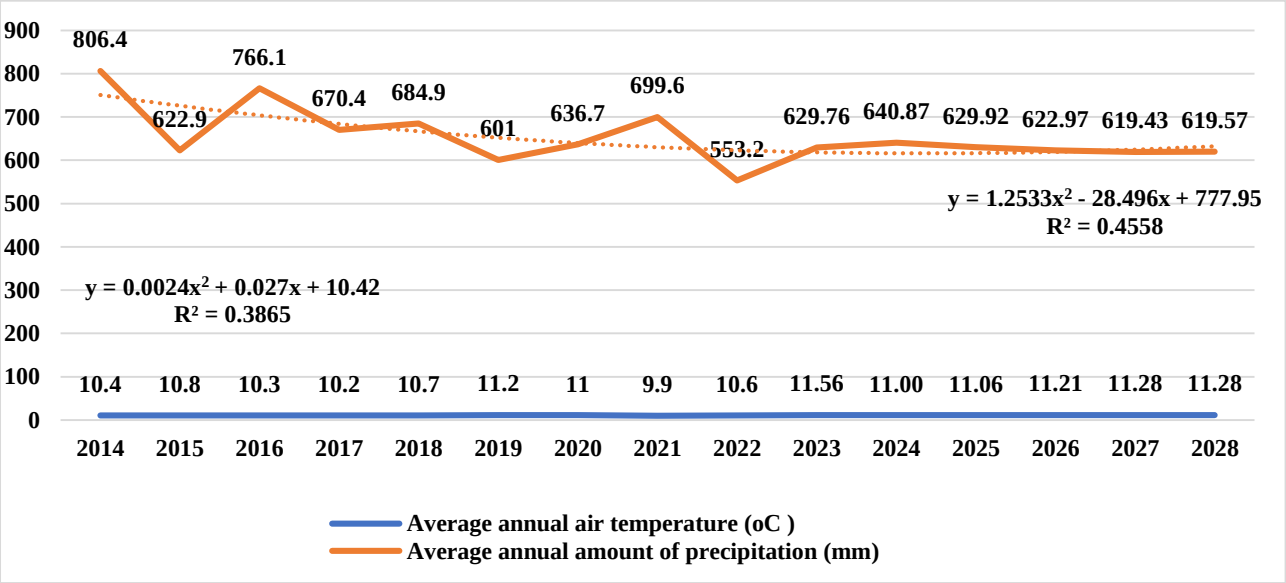
in Excel, for the temperatures and amount of precipitation in the next 5 years, which can be used for efficient planning of agricultural activities. Knowing the temperature and precipitation forecasts can be useful to farmers to be able to choose the best periods for sowing, planting, carrying out works or treatments during the vegetation period.

Looking at the forecasts for the period 2024-2028 regarding the average annual air temperature and the average annual amount of precipitation, we can see that (Figure 1):

1. The temperature in 2024 (11 $^{oC)}$ is slightly lower than the maximum value recorded in 2023 (11.56 oC), but higher than the average for the period (10.67 oC). In the period 2025-2028, the temperature values remain almost constant, with very small fluctuations (11.06-11.28 oC).

2. For the period 2024-2028, the forecasts indicate a decreasing trend in the amount of precipitation, with estimated values between 622 mm and 640 mm. These values are lower compared to those recorded in 2014 (806.4 mm) and 2016 (766.1 mm), but higher than those recorded in 2019 (601 mm) and 2022 (553.2 mm).

Figure 1. Forecasts for the average annual temperature (°C) and the average annual amount of precipitation (mm) in Romania for the period 2024-2028



Source: INS data processing - TEMPO ONLINE - MATRIX CODE - TOX1332, TOZ1334 - Target 3 - Environment, accessed on 29.10.2024.

Rising temperatures and reduced precipitation have a number of implications for horticulture, such as:

- The increase in temperatures directly affects the process of photosynthesis, with repercussions on the quantity and quality of production (4. Bisbis, M. B.et all, 2018; Mattos Leonora M. et al., 2014). Studies in the field show that high temperatures can cause changes in the sugar content of vegetables, the composition of fatty acids and vitamins, affecting their nutritional benefits. At high temperatures, vegetables lose their firmness, which influences the quality of production and also the resistance to transport and storage (Moretti C.L. et al., 2010).

- In addition to the effects on production, high temperatures directly influence the period of establishment of crops. Farmers can cultivate earlier in case of high temperatures, leading to an early harvest (Mattos Leonora M. et all, 2014).
- Indirectly, the increased temperatures have a negative effect on water resources, the expansion of diseases and pests as well as weeds (Mattos Leonora M. et all, 2014). Rising temperatures have a significant impact on plants, as warm air can intensify evapotranspiration, increasing plants' demand for water (Moretti C.L. et al., 2010). Vegetables such as: peppers, cucumbers, pumpkins, tomatoes, eggplant, etc., bear less fruit in conditions of heat stress, resulting in a decrease in production and a deterioration in its quality (Bisbis, M. B.et all, 2018). Experiments in different parts of the world have confirmed that increased temperatures lead to decreased yields and increased production costs, which complicates the situation of farmers, requiring additional adaptation measures (Moretti C.L. et al., 2010).
- A special impact on vegetable crops is the rainfall, which in insufficient or excess quantities influences the growth and development of plants (Enache L., 2009).
- Vegetable crops, such as tomatoes, cucumbers, cabbage, which depend on constant moisture in the soil, do not develop properly in conditions of water scarcity. In such conditions, farmers are forced to supplement the water needs through irrigation, which implies additional costs that will be reflected in the prices of vegetable recovery. On the other hand, excess rainfall has as negative an impact on vegetable crops as water scarcity (Schmidt, N. et all, 2024). Excess accumulated water causes suffocation and rotting of the roots, which leads to the death of plants. Also, excess water favors the appearance of diseases, leading to a decrease and deterioration of production. Long periods of rainfall can completely compromise the crop, affecting farmers' incomes.

CONCLUSIONS

The vegetable sector in Romania is strongly influenced by climate change, which has a negative impact on food production and security.

Rising temperatures and the increasing frequency of extreme weather events affect both the quantity and quality of production, especially in field vegetable crops.

To meet climate challenges, it is essential for farmers to adapt their crop establishment and treatment periods, diversify crops and adopt modern technologies such as efficient irrigation and soil monitoring to reduce climate risks.

Farmers must also adopt sustainable practices, such as crop rotation, the use of organic fertilizers and the implementation of soil conservation farming techniques.

It is necessary to take into account the specific climatic conditions of each area (from humid to Mediterranean influences) when choosing crops.

Agriculture is one of the sectors most affected by climate change, and in order to face these challenges, it is important that authorities, farmers and the private sector work together to overcome current vulnerabilities, transforming this sector into a modern and sustainable one.

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