RESEARCH ON THE ADAPTATION OF AGRICULTURE TO THE EFFECTS OF CLIMATE CHANGE

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Abstract: *Climate change is the most serious environmental crisis that humanity faces today. Agriculture is more vulnerable to climate change than any other economic sector because it is the economic activity most dependent on climate variations as diverse as they are: temperature, precipitation, evapotranspiration, extreme weather conditions and other extreme phenomena, which can affect the agricultural sector's production and hence farmers' incomes. As far as the research methodology was concerned, the information analysed was collected through a documentary study of the literature on the subject. The authors analyse the influence of climate change on agriculture, attempting to identify possible downside risks to the sector, such as environmental incidents, natural disasters and other impacts of climate change: floods, drought, landslides, erosion, storm damage, disease outbreaks. At the end of the paper, the main measures are proposed by the authors to mitigate the effects of climate change are presented.*

Key words*: climate change, agriculture, effects, adaptation*

INTRODUCTION

Climate change is the most serious environmental crisis facing humanity today. It is attributed directly or indirectly to human activity that alters the composition of the global atmosphere. [2] Recycling and reducing air pollution means consuming less entropy, but not from the Earth's rapidly depleting supply [3].

Since 1962, the European Union has created the Common Agricultural Policy, a political-financial mechanism at European level, which aims not only to increase agricultural productivity or promote jobs in the agricultural sector, **but also to adapt agriculture to climate change and combat it by reducing greenhouse gas emissions (such as carbon dioxide or methane)**. The European Union is thus promoting agricultural adaptation measures in the Member States by supporting financial investments in improving irrigation infrastructure, irrigation techniques or the conservation of water resources [8,9].

The European Union Strategy on Adaptation to Climate Change of 2013 **is another important vehicle through which the European Union is working to adapt agricultural systems to climate change**. Another important contribution of the EU in this respect is the establishment in 1990 of the European Environment Agency, which now provides decision-makers with relevant information for more effective implementation of adaptation measures in agriculture and other sectors [13].

The main cause of the high vulnerability of the agricultural sector to climate change is related to the **direct dependence of agriculture on climatic conditions**. Of all economic sectors, agriculture is the most dependent on various climatic variations (in temperature, rainfall, evapotranspiration, extreme weather conditions and others), which can significantly affect agricultural production and, of course, farm financial income.

In Europe, climate change is affecting all regions of the continent, and the effects of these changes are increasingly visible in our country, where, in recent years, **disastrous phenomena of particular magnitude have occurred, such as: heat and severe drought, heavy rainfall and catastrophic floods, extreme weather phenomena (tornado type), alteration of traditional seasons**. All these disasters have had a strong impact on the

socio-economic life of our country, with numerous victims and significant material damage both among the population and at community level, in terms of economic and social units and infrastructure.

In the context of climate change, agriculture will be severely disrupted amid the impending warming of the climate this century, which will be the root cause of the expansion of global aridity. "Most of the increase in global temperature, starting in the mid-20th century, is very likely to occur as a result of increased atmospheric carbon dioxide concentrations from human, anthropogenic activities" [1,12].

This is why action is needed to counter climate change, by limiting carbon emissions, decarbonising the atmosphere or aggressively promoting renewables. As far as renewable energies are concerned, the possibilities for exploiting them on a global scale are huge: solar energy - which has huge resources on a planetary scale, in terms of extent and intensity [13,15].

Romania's climate is temperate continental, with significant regional variations (8-12 months per year with positive temperatures in the southern and coastal areas compared to 4 months in the high mountain areas). There are frequent heat waves, with extreme temperatures above 40°C (three such waves in Bucharest in summer 2007) and cold waves, with temperatures below -30°C, especially in the intramontane depressions. Precipitation, with a multiannual average of 640 millimetres across the country, also varies considerably between regions (between 1,200 and 1,400 mm per year in the high mountain areas and 400-500 mm in the main agricultural areas of the Romanian Plain) and over time, with periods of dryness and severe drought alternating, sometimes even during the same year (autumn 2011, spring 2013), with periods of excessive humidity causing significant damage (floods, landslides). The existence of areas where the average annual wind speed exceeds 4 metres per second and of large areas where the sunshine duration exceeds 2 000 hours per year indicates considerable potential for using these renewable energy sources [6].

For Romania, meteorological studies indicate a 0.5°C increase in the average annual temperature in the country over the last century, with some regional differences.

Even if policies and efforts to reduce greenhouse gas emissions are adopted worldwide, some climate change is inevitable. This is why there must be measures to adapt to climate change, especially in the agricultural sector, as it is one of the most vulnerable sectors of activity.

MATERIALS AND METHODS

In terms of research methodology, the scientific documentation went through several stages such as: informing about sources, collecting data, studying the sources of documentation and grouping them, evaluating and processing them thoroughly. The main method used is content analysis. Another method used is the comparative method, used to highlight the characteristics of concepts and notions under analysis.

RESEARCH RESULTS

Climate variability affects all sectors of the economy, **but agriculture remains the most vulnerable**, and its impact is more pronounced today as climate change and variability are becoming more pronounced. Agriculture is a basic occupation for our country as 20.6% (year 2019) of the population, is still employed in this field, being highly dependent on weather conditions. As a result, agriculture *is* ***the most vulnerable branch of the economy*** **to drought, excessive rainfall, hail, etc. These phenomena affect, in**

particular, crop production, the problems of which are also transferred to animal husbandry. The most important losses are linked to the destruction of cereal crops.

In Central and Eastern Europe, the scenarios **show a clear decrease in precipitation**, particularly in the summer season, and therefore a rainfall deficit that will affect all areas of activity, **mainly agriculture**.

All long-term forecasts predict that Romania will experience **radical climate change - extremely dry summers, sudden temperature changes and heavy rainfall (over 150 litres per square metre) followed by floods.** In Romania, it will get hotter, rain less and less frequently and extreme weather events will intensify. By 2030, an average annual warming of between 0.5 and 1.5 degrees is expected. Precipitation deficits will increase, particularly in the south and south-east of the country [10].

By the end of the 21st century, global temperatures are expected to rise by 4 degrees Celsius above the current situation. Romania will basically be divided into two distinct zones - **the northern half will be affected more by rain and low temperatures, while the south will experience high temperatures, causing desertification in some areas.** Forecasts show that the area of desertification could triple in the next 20 years if action is not taken [7].

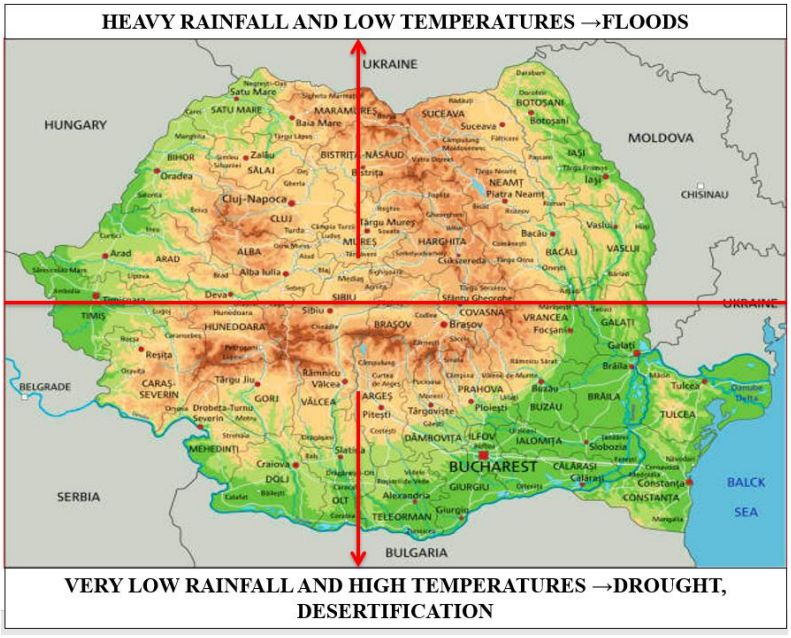

Figure 1. Climate change projections for Romania

Source: Own processing after https://harta-romaniei.org/harta-geografica-a-romaniei.html, Stanciu M. si altii, 2010 [16,7]

In Romania, a more pronounced warming (0.8°C) has recently been observed in the south and south-east of the country, where the average annual temperature has reached 11°C, more than three degrees higher than in the north of the country. The last few years have been the warmest since 1950. Romania's population has experienced quite a few major climate events over the last two decades, but they have become much more frequent since 2000:

- **heatwave and severe drought** (in 2003, 2005 and 2007);
- **heavy rainfall and catastrophic flooding** (in 2005 and 2006);
- **extreme weather events** (tornado-type in 2002);
- **changes in the main characteristics of the seasons,** etc. [7].

In Romania, there is a clear trend of intensification and extension of the phenomenon of *drought and desertification* due to natural causes, but also due to

anthropogenic causes (deforestation, destruction of the irrigation system, etc.). Of the 14.7 million hectares of agricultural land, about 7 million hectares (48% of the total) are affected by drought over long periods and in consecutive years [11].

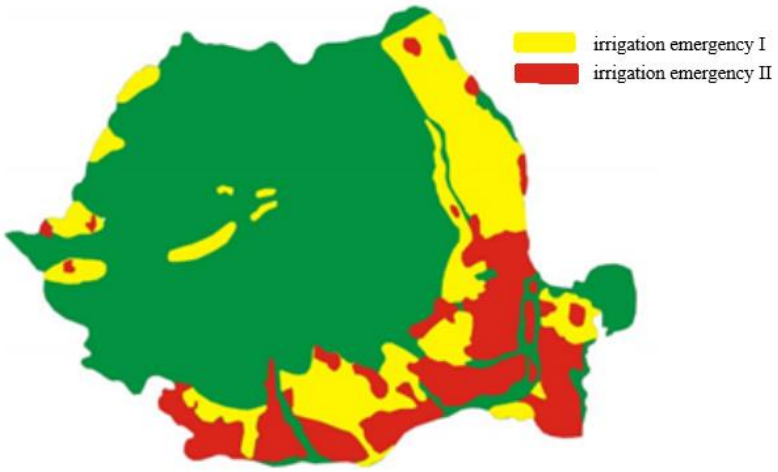

Figure 2. Drought-affected areas requiring irrigation
Source: OTIMAN P. I.. si colab., 2011, [4,5]

The desertification phenomenon in our country covers an area of about 350 000 hectares. Experts in the field believe that failure to take the necessary measures in time will put ten southern counties at risk of desertification. The most affected areas are the southern and south-western part of Oltenia, the south-eastern part of Banat, southern Moldavia (Hanul Conachi sandy area) and Dobrogea.

The area located between Calafat-Dăbuleni and the Danube river, (with an area of 104 600 hectares) in Dolj county, is represented by sandy soils that have favoured the appearance of the **most typical semi-arid area, which shows tendencies of aridization and even desertification** in our country.

Agricultural specialists estimate that drought and other dangerous weather events can reduce Romanian agricultural production by about 30-50% annually. **Losses in the agricultural sector** are exacerbated by the lack of an irrigation system.

The most vulnerable crop species will be annual cereal and grassland crops in particular, as water shortages in the summer season, which coincides with the period of maximum water requirements, will lead to significant production losses. This calls for a **new reorientation in the crop structure**, i.e. varieties with a high tolerance to high temperatures and water stress caused by water scarcity. It is also necessary to adapt agricultural technologies to the water resource, with soil water conservation through the choice of a minimum tillage system representing a new trend in the reorientation of requirements for the quality and conservation of soil and water resources. The decrease in water resources by 10-30%, especially in deficit areas, will accentuate the consequences of water scarcity, the effects being amplified by pollution and inappropriate technologies.

Precipitation has a multiannual average of 640 mm in our country, with large differences between regions: from 1200-1400 mm/year in high mountain areas, to 400-500 mm in the main agricultural areas of the Romanian Plain. Periods of alternating dryness and severe drought alternate with periods of excessive humidity, causing significant damage to the economy (catastrophic floods, soil erosion or landslides) [6].

Most of our country is vulnerable to flooding. Areas at high risk of flooding are those in the catchment areas of large rivers such as : Mureș, Someș, Crișuri, Oltul superior,

Siret, as well as those along the Danube and the Danube Delta, but also the areas along the small rivers in central Moldova, areas permanently affected by floods.

The floods that occurred in 2005 highlighted the impact of climate change on the rainfall regime: **the increase in the duration and quantity of rainfall** (from February to September, with seven major flood waves occurring between April and September) and the **extension of the area of occurrence** throughout the country, leading to numerous losses of life and significant material damage [7].

To all these negative phenomena presented, in our country we can add the **massive uncontrolled deforestation** in recent years, which has led to the reduction of the forest area and implicitly to the reduction of air freshening possibilities, the disappearance of some ecosystems, the expansion of soil erosion.

In order to alleviate the influence of climate change on the agricultural sector, measures are needed to help mitigate or halt its effects, such as:

- **to combat drought**, creation/extension of irrigation systems;
- in the crop sector, local environmental conditions need to be **correlated with the degree of resistance of varieties or hybrids to limiting growing conditions** (drought, excess moisture, high temperatures, cold/frost, etc.).
- adjusting the sowing periods of agricultural crops according to changes in the temperature or rainfall regime,
- practising field fallowing in field crops,
- measures to prevent soil degradation due to water erosion;
- **creation of protective forestry belts** which will play an important role in improving microclimatic conditions, reducing wind speed, improving the conditions for the growth and development of agricultural crops, reducing soil erosion, etc.

CONCLUSIONS

Global warming currently poses two major challenges for mankind: **on the one hand, the need to drastically reduce greenhouse gas emissions** in order to stabilise the level of greenhouse gas concentrations in the atmosphere so as to prevent anthropogenic influence on the climate system and enable natural ecosystems to adapt naturally, **and on the other hand, the need to adapt to the effects of climate change**, given that these effects are already visible and unavoidable due to the inertia of the climate system, regardless of the outcome of actions to reduce emissions.

Despite all global efforts to reduce greenhouse gas emissions, the global average temperature will continue to rise in the coming period and urgent action is needed to adapt economic activities, especially agriculture, to climate change, both globally and nationally.

The effects of drought are much more difficult to assess than for other natural phenomena such as earthquakes, floods or tornadoes, the material damage and human casualties can be framed in a certain space and time, but in the case of drought they cannot be framed in space and time. **Drought sets in gradually and develops over time, and the effects on agriculture, the population and the environment do not cease with the first significant amounts of rainfall.**

Measures to adapt agriculture to climate change are very important: adjusting the sowing periods of agricultural crops according to changes **in temperature or rainfall, planting crops with higher ecological plasticity - better adapted to unfavourable climatic conditions -, developing irrigation infrastructure, improving irrigation techniques, managing water resources more efficiently, etc., creating protective forestry belts to improve growing and development conditions for agricultural crops.**

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