Journal of Agriculture and Rural Development Studies
Volume 1 – Issue 1
ISSN – Online 3061-2756
www.imadr.jards.ugal.ro

DOI https://doi.org/10.35219/jards.2024.1.04

Assessing the Resilience and Adaptability of Romanian Agriculture to Climate Change

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ARTICLE INFO

Article history:
Accepted July 2024
Available online August 2024

JEL Classification:
Q15, Q18, Q54

Keywords:
global warming, climate change, agriculture, resilience, Romania

ABSTRACT

The research provides an analysis of the effects of climate change on the agricultural sector in Romania. Global warming is a phenomenon currently being acutely felt in our country, with implications for both the population and economic activities. Open access sources from major online scientific databases were used for documentation. The research was conducted using information from national and European statistics. The data were selected, systematized, statistically processed, and interpreted. The increasing frequency and intensity of extreme events have a significant impact on the Romanian agricultural sector. Among the national measures proposed to mitigate climate change, the study analyzed land improvement works to reduce erosion and soil degradation, the development of irrigation infrastructure, and the planting of forest belts for the protection of agricultural lands and localities. The research results indicate a low level of these actions, with Romania currently unprepared to face the challenges posed by global warming. Urgent and comprehensive measures by the authorities are needed, including the effective access and use of national and European funds, and the development of public-private partnerships to increase the volume and frequency of actions aimed at mitigating the impact of global warming.

1. Introduction

Due to global warming, climate change is a phenomenon with effects felt on economic activities and the well-being of populations, particularly in low-income countries.

The terms "climate change" and "global warming" are often used incorrectly, according to the material published by the Ministry of Environment, Waters, and Forests (MMAP) (2024). Climate change refers to long-term and significant alterations in the Earth's climate, including variations in temperature, precipitation, and wind, occurring over several decades or more. On the other hand, global warming focuses solely on the increase in the Earth's average surface temperature over a specific period. This phenomenon has been documented since the industrial period (1850-1900), largely due to human activities, particularly the increase in greenhouse gas emissions from burning fossil fuels (for transport, industry, and electricity), changes in land use (such as deforestation), and waste management.

Agriculture is one of the sectors most sensitive to climate change. Rising temperatures, extreme weather events, reduced precipitation, and soil degradation have direct effects on production, including reduced crop yields, limited adaptation capacity of certain crops and animals, and increased frequency of epidemics in the plant and animal sectors. The speed at which these climatic phenomena occur

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directly impacts the human species, whose long-life cycle does not allow new generations to adapt quickly to these changes. While global implementation of effective measures may mitigate this trend, long-term effects are difficult to predict. Some species and terrestrial life may adapt in the future, but it is highly probable that the human population may not. Against the backdrop of recent demographic explosions, climate change poses existential challenges for humanity, particularly concerning the agro-food sector and food security.

2. Literature review

The use of fossil fuels for energy production leads to the emission of greenhouse gases (GHG), which is one of the main causes of global warming. According to the World Meteorological Organization, as cited by the European Union (EU) (2020), the level of CO2 in the atmosphere has increased by 150% compared to 1750. The planet's precarious balance requires a stable composition of atmospheric gases to ensure the continued existence of the human species. Industrial evolution has been accompanied by an increase in the average annual temperature of approximately 1.1°C compared to the pre-industrial period. If this rapid warming trend continues, global temperatures could rise by 3-5°C by 2100, equivalent to the normal temperature change expected over about 10,000 years (EU, 2020).

Most countries worldwide will experience extreme temperatures in the coming years, according to a study cited by DIGI24 (2022). The report states that 92% of the 165 countries studied will experience extremely high temperatures at least once every two years. Although the Paris Agreement (2015) aimed to reduce GHG emissions by 50%, researchers predict an increase of 13.7% by 2030.

A study by Andre et al. (2024), based on a sample of approximately 130,000 people from 125 countries, highlights the need for global cooperative actions to reduce the impact of global warming. However, it also indicates a relatively low personal willingness among individuals to act in this direction. Of the surveyed population, 69% would contribute 1% of their personal income to climate action, 86% support climate-friendly social norms, and 89% call for intensified political action from policymakers. A global common response to climate action must be supported by public awareness efforts regarding long-term impacts.

Similar conclusions are drawn by an IPSOS study (2024), which shows that although the global climate crisis is worsening, there is a decline in public interest in global warming issues. The cited research involved a sample of 24,290 adults from 33 countries (500 from Romania). Highly developed countries should take more vigorous action to reduce the impact of global warming (as they are also responsible for the phenomenon due to higher GHG levels). Over 30% of men from Generations Y and Z believe it is already too late to make a difference, whereas older men and women are less pessimistic. Although the majority of IPSOS respondents expressed a desire to contribute to climate action, there is no clear method for effective action. Respondents tend to overestimate the importance of recycling and underestimate the impact of more drastic measures, such as switching to a vegetarian diet or giving up personal car use.

The EU is one of the major global economies committed to mitigating global warming by reducing GHG emissions. In 2020, GHG emissions at the European level were reduced by approximately 31% compared to 1990 levels, thus surpassing the proposed target (20% reduction). In line with international agreements, EU authorities have implemented various climate policies, including the emissions trading scheme (Ionescu et al., 2021).

In 2019, the European Commission launched the European Green Deal, adopting new measures to intensify the reduction of GHG emissions at the European level. According to the Paris Agreement, a 55% reduction in GHG emissions is proposed by 2030, with a total decarbonization of the European economy by 2050 (European Parliament, 2024).

Agriculture, alongside industrial production, is also considered responsible for greenhouse gas emissions, which have direct effects on global warming. Many agricultural practices are associated with methane emissions, such as livestock farming (animal digestion and manure management) and rice production. Nitrous oxide, another greenhouse gas, originates from the use of organic or mineral nitrogen fertilizers on agricultural lands or from poor manure management. For a long time, the expansion of agricultural land relied on deforestation through various methods, including burning. Voluntary burning of savannahs is still common worldwide, and in Romania, the burning of stubble is still practiced in some areas, despite being legally prohibited. The disposal of animal waste on land or its incineration, as well as improper wastewater management, are additional sources of greenhouse gas emissions, according to the MMAP Report (2023).

Global warming leads to a series of changes in many areas of the Earth, such as increased frequency and severity of storms and hurricanes, floods, landslides, extreme heat or cold waves, droughts, water shortages, wildfires, and other natural disasters. Additionally, rising temperatures contribute to slower processes with long-term effects, such as rising sea levels, coastal erosion, soil salinization, gradual changes in precipitation patterns, permafrost thawing, and shrinking ice caps and glaciers. The increasing frequency and intensity of extreme weather events pose one of the greatest threats to agricultural production. In Romania, the agricultural sector is most affected by rising temperatures at the national level, uneven distribution of precipitation, and severe soil drought (Boboc, 2022).

Currently, agriculture can be considered a true industry, involving the interests of landowners, suppliers of inputs (funds, agricultural equipment, seeds, fertilizers, and other necessary inputs), sector employees, intermediaries, and beneficiaries of agricultural products (including the food processing industry, animal husbandry, and the general population), as well as tax and revenue beneficiaries.

Global food security, including the development and survival of the human species, depends on the evolution of the agri-food sector and its related branches. The agricultural production system is directly influenced by weather and climate conditions. Temperature and precipitation, frost occurrence, growing season duration, soil moisture, pest pressures, and other climatic variables can significantly affect agricultural productivity and management aspects related to agriculture.

In the short term, decisions regarding the planting of new crops or the harvesting of mature production require the most accurate climatic information. In the medium term, climatic impact might influence the choice of plant varieties for the next season. In the long term, capital investment decisions (such as developing irrigation infrastructure, installing underground drainage systems, or implementing forest shelterbelts) are dependent on global climate trends (Walsh et al., 2020). The U.S. Department of Agriculture (USDA) report provides a series of indicators related to the impact of climate change on agriculture, categorized as follows: physical indicators (extreme precipitation, soil moisture, precipitation, nighttime temperature, heatwaves, atmospheric humidity); indicators for crops and livestock (thermal stress in animals, migration of agricultural zones due to climate, free moisture in vegetation); biological indicators (pesticide use, presence of insects, types of insects and their impact on crops, pathogen infestations, etc.); phenological indicators (flowering times in fruit trees, pollinator management, plant exposure to extreme winter temperatures, insect development/season, animal disease vectors); socio-economic indicators (crop insurance payments, overall productivity, mortality of agricultural workers due to extreme temperatures).

In Romania, with an average temperature of 12.5 degrees Celsius, 2023 was the hottest year in the country's history, recording a deviation of 2.3 degrees compared to the 1981-2010 average. According to the National Meteorological Administration, cited by MMAP (2024), the period from 2012 to 2023 became the warmest 12-year span ever recorded nationally. On a global scale, the reduction in Romania's industrial production has had an insignificant impact on global warming. The ministry estimates that only 0.3% of the world's GHG emissions originate from Romania, representing less than 3% of the total emissions at the community level. Among the total GHGs, CO2 is the most predominant, followed by CH4 and nitrous oxide.

Analysis of precipitation on Romanian territory after 1980 highlights a series of dry years caused by a significant reduction in precipitation and an increase in the average annual temperature. Climate changes are especially evident in the Romanian Plain and the Bârlad Plateau. This reduction in precipitation volume has led to decreased flow rates for most rivers, particularly those in the southern and southeastern regions of the country. Specialists' estimates suggest that in the medium term, winters in Romania will become wetter, while summers will be drier, with a tendency for increased precipitation in the fall but a significant decrease in winter, spring, and summer in certain areas. These climate changes will significantly affect the quality of life and various economic sectors in the country.

Agriculture is a crucial economic sector in Romania, providing jobs and income for a large part of the rural population. Climate change can affect the economic stability of agricultural communities, leading to increased rural-urban migration or migration to more developed European states, with a rise in the poverty index in rural areas (Working Group on "Combating Climate Change: An Integrated Approach," 2023). According to the Green Report (2023), climate change can affect the duration and timing of the growing season for plants in local agriculture, directly influencing sowing cycles and harvest periods. For certain crops, the growth cycle could shorten, negatively impacting agricultural yields.

Rising temperatures and changes in natural precipitation systems can favour the development of pests and diseases that were previously limited by cooler climatic conditions. For farmers, these threats can lead to more intensive use of pesticides and fungicides, with negative effects on the environment and human health (Bojariu, 2015).

Climate change can influence both the availability and quality of water resources, which are essential for crop irrigation. Prolonged droughts can deplete local water reserves, while extreme precipitation events can lead to floods, affecting both crops and agricultural and road infrastructure (Revista Fermierului, 2024). To address these challenges, adaptation solutions focus on implementing sustainable agricultural practices, such as crop rotation and expanding vegetated areas, as well as efficiently managing water resources. This includes both natural and artificial water retention in the soil through conservation techniques that maintain reasonable soil structure. The cited study recommends the use of "no-till" agricultural technology (reduced soil tillage), which has led to positive effects on soil structure and biosystem abundance, significantly impacting organic carbon storage in the soil and increasing water retention capacity.

Soil erosion, caused by severe weather events such as heavy rains and storms, can lead to the loss of the nutrient-rich topsoil layer. In the context of climate change, along with other geomorphological processes, soil erosion leads to quantitative and qualitative changes, influenced by the spatio-temporal evolution of control factors.

The study conducted by Patriche et al. (2023) proposed some forecasts regarding potential erosion rates in various areas of Romania under different climate change scenarios. The research results showed that under the impact of climate change, there is a trend of increasing erosion rates in the coming decades at the national level. The general trend of increase is projected for 84-90% of the territory. For most of the studied areas, erosion rates will increase by approximately 1 t/ha/year, but locally this could exceed 5-10 t/ha/year over an estimated area of more than 8,000 km². The most affected soils will be those in the hill and plateau regions, where the negative impact on fertility will be most significant, directly affecting agricultural productivity.

Research and innovations in agricultural biotechnology are essential for developing crop varieties more resistant to climatic stresses such as drought and extreme temperatures. The Food and Agriculture Organization of the United Nations (FAO), cited by the European Climate Adaptation Platform Climate-ADAPT (EU, 2024), suggests the use of climate-smart crops and varieties as a practice to reduce risks, better conserve soil, and efficiently manage water resources. According to the cited report, plant breeding often involves multi-location studies aimed at developing crop varieties resistant to climatic stress factors. These can adapt better and optimize resource use, reducing the negative impact on the environment. The most frequently researched characteristics related to climate change include drought resistance, increased soil salinity, and flood resistance. In Europe, the diversity of regions requires cultivated crops adapted to different stress factors. Thus, in certain regions, crops resistant to drought and/or extreme temperatures are needed, while in other agricultural areas, the main stress factors may be pest attacks and diseases.

Developing species and varieties that can withstand these conditions could represent the most effective strategy for adapting to climate change (Dincă et al., 2019). In this direction, high-throughput genotyping and phenotyping platforms are used at the European level to accelerate the development processes of new crop varieties, including reducing preliminary growth stages (EU, 2024).

3. Materials and methods

For documentation, open access articles available in Google Scholar, ResearchGate, and Clarivate databases were used. Legislative regulations were selected from the websites of the European Commission and the Government of Romania. The research utilized information from the National Institute of Statistics (NIS), Eurostat, FAOSTAT, and reports from the relevant ministries in Romania. The information was systematized and processed using spreadsheet-based methods. The results were analysed and interpreted. For validation, the research findings were compared with other specialized studies.

4. Results

4.1 National Actions for Combating Erosion and Land Improvement

Romania's territory is currently considered to be in an area with an excessive continental climate, characterized by prolonged soil droughts. According to a study conducted by a team of authors coordinated by the National Institute for Research and Development in Forestry "MARIN DRACEA" INCDS (INCDS et al., 2023), for the National Strategy on Preventing and Combating Desertification and Land Degradation (2019-2030), in the last decade, average annual temperatures have increased by 0.2 - 0.6℃, while precipitation has decreased by 10 - 15 mm compared to multi-annual averages.

These changes, against the backdrop of the current decline of the geosystem, indicate a clear trend of intensification and expansion of desertification and land degradation phenomena, especially in the southern and eastern regions of the country. Approximately one-third of Romania's territory (about 7 million hectares) and 40% of its agricultural land are at risk of desertification.

The most exposed regions are the southern Romanian Plain, Dobrogea, and southern Moldova. Data provided by the National Institute of Statistics (NIS, 2024) show a relatively constant level of areas subjected to soil erosion control and land improvement works (Figure 1).

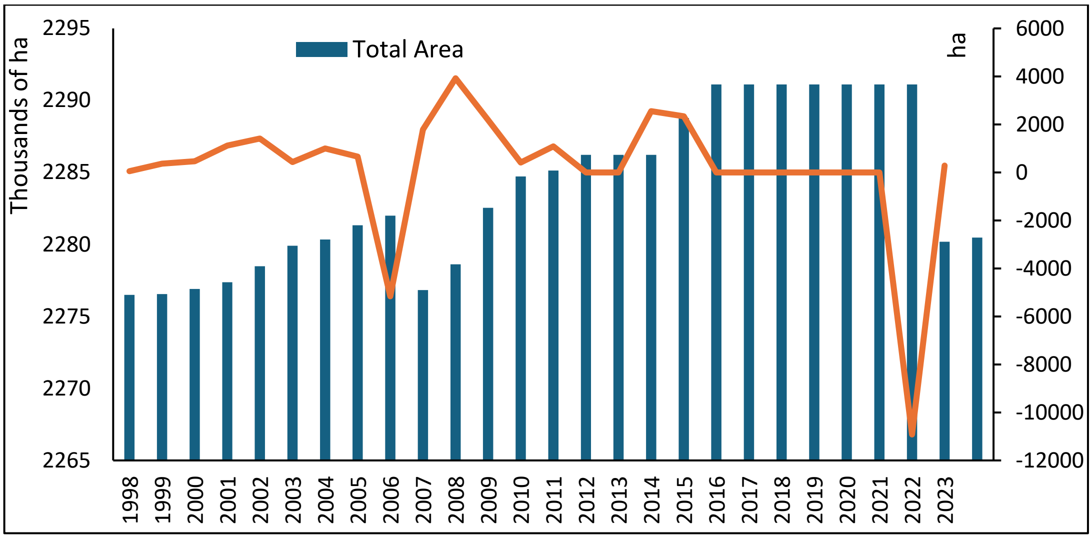

Figure 1. Works for Erosion Control and Land Improvement

Source: Author, by using NIS (2024)

According to the definition provided by the National Institute of Statistics (NIS, 2024), soil erosion control works encompass a set of hydrotechnical activities designed to reduce or halt soil degradation. These efforts primarily focus on preventing the removal of the fertile soil layer due to external geographic agents and implementing regulatory measures to prevent rainwater runoff from slopes, thereby avoiding flood damage to the land at the base of these slopes. The restitution of property following the political regime change in 1990 led to the deforestation of approximately 30,000 hectares of private forests by 2008, and about 100,000 hectares were exploited irrationally. A significant portion of these lands became degraded, suffering from various forms of erosion (Ministry of Agriculture and Rural Development, MADR, 2008).

Approximately 2.292 million hectares benefited from these works between 2016 and 2022, although the area decreased slightly to 2.280 million hectares in recent years. The annual increase is insignificant, with relative progress recorded between 2007 and 2011. According to the cited source, under the United Nations Convention to Combat Desertification, Romania is obligated to establish strategies and priorities for sustainable development policies. These aim to combat desertification, reduce the impact of drought, address the underlying causes of desertification, and give special attention to the economic factors contributing to this phenomenon.

A comparative analysis of the targets proposed in the "National Strategy for Reducing the Effects of Drought, Preventing and Combating Land Degradation and Desertification in the Short, Medium, and Long Term" (MADR, 2008) indicates that limited progress has been made.

4.2 National-Level Actions for Developing Irrigation Infrastructure

Irrigation infrastructure plays a crucial role in ensuring a consistent water supply for crops, especially during prolonged droughts. The network contributes to the stability of agricultural production and increases the efficiency of water resource use. Romania currently faces challenges related to its irrigation infrastructure. Many irrigation systems are outdated and require modernization to improve efficiency and performance. Some irrigation networks are deteriorated due to a lack of maintenance and investment, leading to significant water losses. Climate change, including more frequent and extreme droughts, underscores the need for efficient irrigation solutions. The total area equipped for irrigation in Romania is approximately 318,000 hectares (figure 2).

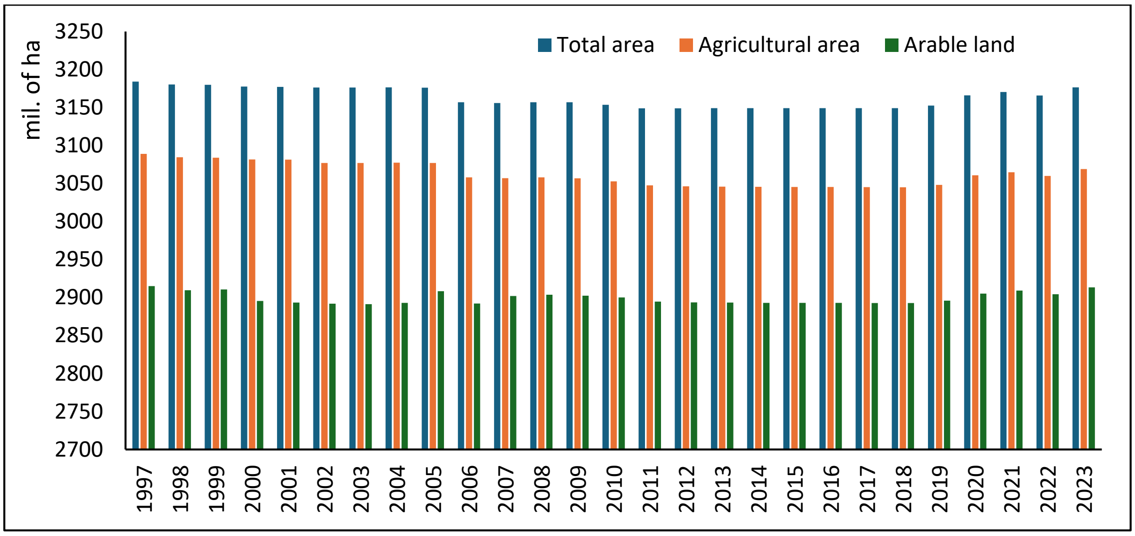

Figure 2. Irrigation improvements in Romania (total)

Source: Author, by using NIS (2024)

Approximately 97% of the total land equipped for irrigation consists of agricultural land, with around 91% of this being arable land. During the analysed period, there was no significant change around land equipped for irrigation, with an absolute decrease of 7,480 hectares recorded in 2023 compared to 1997. The trend in the areas subjected to at least one irrigation operation per year is shown in figure 3.

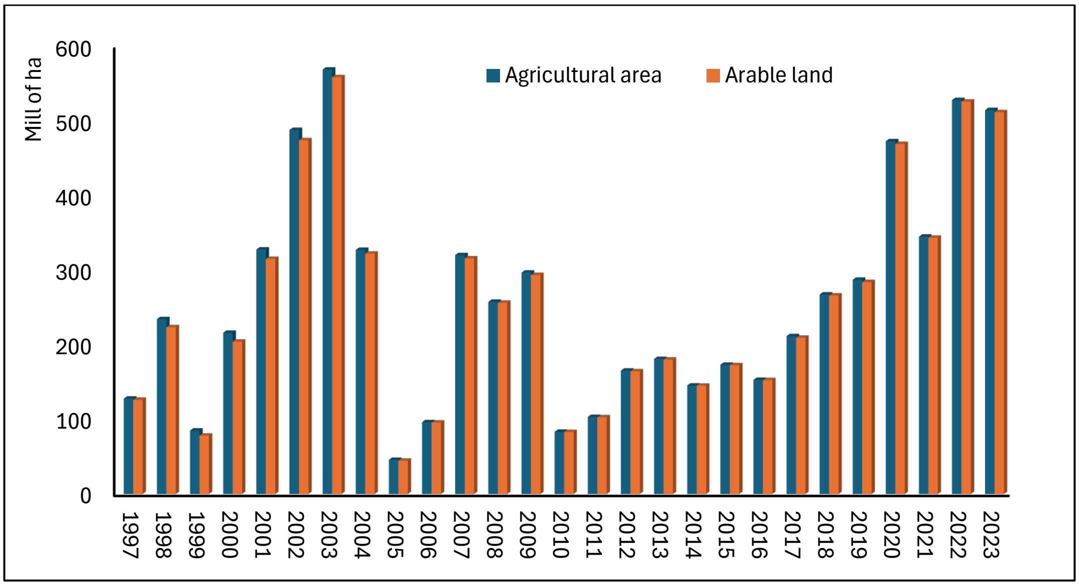

Figure 3. Area of agricultural land effectively irrigated with at least one watering

Source: Author, by using NIS (2024)

The evolution of irrigated land has experienced fluctuations, with peaks recorded during the years 2003 and 2022-2023, and historical lows in 2005 and 2010. Approximately 560 million hectares were irrigated in 2002, with values exceeding the 500-million-hectare mark in the last two years.

In 2022, over 8 million hectares were cultivated nationally, of which a little over 3 million hectares were irrigated, representing almost 40% of the total (table 1).

Table 1. Area irrigated vs. Total cultivated land, by region

Region	Area cultivated	Irrigated land	%
Total	8,211,163	3,176,567	38.69
North-West	805,007	18,178	2.26
Center	569,865	15,400	2.70
North-East	1,268,603	137,184	10.81
South-East	1,692,070	1,215,127	71.81
South-Muntenia	1,926,977	1,090,254	56.58
Bucuresti - Ilfov	62,264	49,560	79.60
South-West Oltenia	1,112,304	601,119	54.04
West	77,407	49,745	64.26

Source: Author, by using NIS (2024)

The percentage of irrigated land, relative to the total cultivated area, ranges from 2.26% in the North-West Region to 79.60% in Bucharest-Ilfov. Over 50% of irrigated land, correlated to the total cultivated area, is also recorded in the South-East, South-Muntenia, South-West Oltenia, and West Regions. Several factors must be considered to explain the significant differences in irrigated areas across Romania's regions. Regions with lower precipitation levels and higher temperature regimes, such as the southern and southeastern parts of Romania (Dobrogea and areas of Muntenia), experience a drier climate compared to other regions and, thus, have a greater need for irrigation. Soil composition varies between regions, affecting the soil's water retention capacity. Sandy soils drain water more quickly and require more irrigation compared to clay soils, which retain water better.

The percentage distribution of irrigated agricultural areas by region is presented in Figure 4. The South-East and South-Muntenia regions collectively account for over 72% of the total irrigated area at the national level.

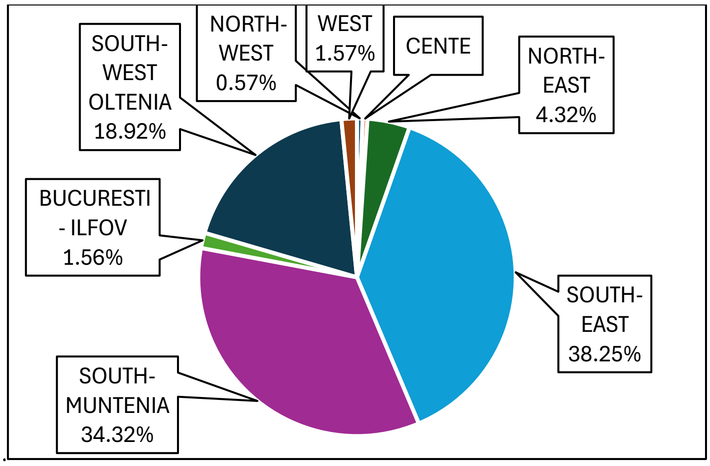

Figure 4. Agricultural lands irrigated, by development region of Romania

Source: Author, by using NIS (2024)

The proximity of agricultural land to rivers, lakes, or other easily accessible water sources significantly influences irrigation capacity. Regions with abundant natural water sources can more easily support irrigation infrastructure. The types of crops grown also have different irrigation needs. Regions specializing in water-intensive crops will have more irrigated areas compared to those with crops that require less water. In some regions, investments in irrigation systems, including those made before 1989, have provided a foundation for the current infrastructure. Additionally, wealthier regions or those with more agricultural investments may have better access to modern irrigation technologies and efficient systems.

Topography can facilitate or hinder the implementation of irrigation systems. Plains are generally easier to irrigate, requiring lower operational costs for networks compared to hilly or mountainous areas. Regional policies and subsidies can also influence irrigation practices. Regions receiving more government support for irrigation development are likely to have more irrigated areas. Developing irrigation infrastructure requires focusing on adopting modern technologies, attracting financing, and implementing integrated water resource management. Investments in this area can enhance water use efficiency, improve agricultural production, and increase stability.

4.3 Shelterbelts and Anti-Erosion Afforestation

Shelterbelts and anti-erosion afforestation are crucial measures in Romania for soil protection and environmental improvement. These forestry practices are used to combat soil erosion, protect agricultural crops, and stabilize degraded lands. The total areas subjected to forestry regeneration, both on forest lands and outside of them, are presented in Figure 5. The total annual regenerated area varies between 22,853 ha (2009) and 29,905 ha (2014). There were no significant fluctuations during the analyzed period.

Journal of Agriculture and Rural Development Studies
Volume 1 – Issue 1
ISSN – Online 3061-2756
www.imadr.jards.ugal.ro

Anti-erosion afforestation involves planting trees and vegetation on degraded lands or in areas prone to erosion to stabilize the soil and prevent landslides.

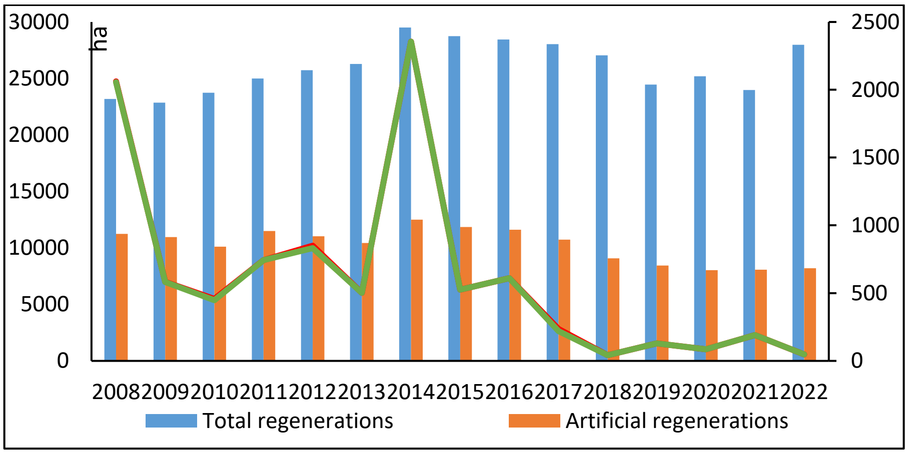

Figure 5. Forest regenerations (Total and lands outside the forest fund)

Source: Author, by using NIS (2024)

The proportion of artificial regeneration, through tree planting by forestry authorities on forest lands, ranged between 29.3% in 2022 and 49.5% in 2008. Most afforestation on non-forest lands has been carried out artificially. Over 2,000 ha of afforestation were achieved in 2008 (2,062 ha) and 2014 (2,355 ha), while in other years, the area did not exceed 500-600 ha. Historical minimum values were recorded in 2008 (42 ha) and 2022 (48 ha). Between 2008 and 2022, Romania planted 5,670 ha of shelterbelts, with artificial regeneration through planting seedlings being the predominant method (see Figure 6).

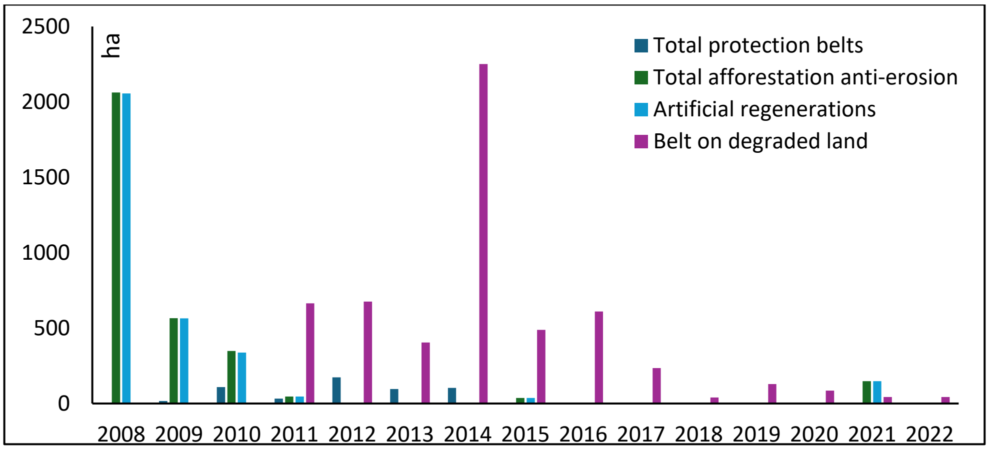

Figure 6. Field protection belts and anti-erosion afforestation

Source: Author, by using NIS (2024)

More than 50% of the total 9,418 hectares of afforested land outside the forest fund consists of shelterbelts. According to Bucur (2016), Romania would need between 865,500 and 1,298,248 hectares of shelterbelts. Currently, the afforested area represents less than 1% of the minimum indicated by specialized literature. In Romania, the primary purpose of developing and expanding shelterbelts is to protect localities from adverse natural phenomena such as soil erosion, blizzards, and floods.

From an agricultural perspective, shelterbelts mainly influence the microclimate in the protected area, improving the relationship between plants and water regime. Microclimate changes occur through the reduction of wind speed and intensity, significantly affecting snow accumulation during winter and reducing soil water evaporation during the growing season. Additionally, shelterbelts create suitable habitats for many bird and wildlife species, contributing to environmental health. By enhancing biodiversity, shelterbelts can play a crucial role in maintaining the ecological and biological balance of the protected area. Planting initiatives for shelterbelts are more commonly used in the southern and eastern regions of Romania, where agriculture is intensive, soils are more prone to erosion, and there is a tradition of using these methods for soil protection. According to a study published by the Journal of Forestry and Game Management (2021), the first shelterbelts were planted in Romania in 1880, making the country a pioneer in this field. The most extensive national planting campaign during the interwar period began in 1902, and by 1907, approximately 500 kilometres of shelterbelts had been planted around farms, fields, and along roads in Southern Oltenia, near Sadova. This action continued until 1947, with over 1,000 hectares planted. During the communist regime, the area allocated to shelterbelts increased to 5,000 hectares by 1960, of which 3,350 hectares were used to protect agricultural lands adjacent to the Danube-Black Sea Canal. Nearly 1 million hectares of agricultural land were thus protected.

5. Conclusions

The reduction in agricultural activity due to climate change could jeopardize national food security, leading to an artificial increase in food prices, economic difficulties, and reduced well-being for vulnerable populations. Climate change can impact the economic stability of farming communities, resulting in increased rural-to-urban migration and exacerbating poverty in rural areas.

The development of technical and economic studies for measures needed to protect agricultural areas from climate change should be consistently aligned with the necessary funding, whether accessed from the national or European budgets. From the perspective of irrigation infrastructure, land improvement actions to prevent soil degradation or erosion, and especially the development of afforestation, particularly shelterbelts, Romania is not yet prepared to cope with global warming.

References

1. Andre, P., Boneva, T., Chopra, F. et al. (2024). Globally representative evidence on the actual and perceived support for climate action. Nat. Clim. Chang. 14, 253–259, https://doi.org/10.1038/s41558-024-01925-3.
2. Boboc, M. (2022). Cercetări privind influența variabilității climatice asupra condițiilor de producție agricolă din România, Teză de doctorat, Rezumat, Universitatea ”Dunărea de Jos” din Galați, https://ugal.ro/files/doctorat/sustineri/2022/BoMG-REZUMAT-TEZA-220930.pdf.
3. Bojariu et al. (2015). Schimbările climatice– de la bazele fizice la riscuri și adaptare, Administrația Națională de Meteorologie, Editura Printech, București, https://www.meteoromania.ro/anm/images/clima/Schimbariclimatice2014.pdf,
4. DIGI24. (2022). Peste 90% dintre ţările lumii se vor confrunta cu temperaturi extreme din cauza emisiilor de gaze cu efect de seră (studiu), https://www.digi24.ro/stiri/sci-tech/natura-si-mediu/peste-90-dintre-tarile-lumii-se-vor-confrunta-cu-temperaturi-extreme-din-cauza-emisiilor-de-gaze-cu-efect-de-sera-studiu-1794365,
5. Dincă, C., Băcanu (Serban), C., Ion (Dumitru), I.M., Stanciu, S. (2019). Aspects Regarding the Certified Seed Production in Romania, Research in Agriculture and Agronomy, Vol. 2019, Article ID 797526, DOI: 10.5171/2019.797526.

6. European Union. (2020). What is climate change?, https://youth.europa.eu/ get-involved/sustainable-development/what-climate-change_en,
7. European Union. (2024). Utilizarea culturilor și soiurilor adaptate, Climate-Aadapt, https://climate-adapt.eea.europa.eu/ro/metadata/adaptation-options/use-of-adapted-crops-and-varieties.
8. European Parliament. (2024). Combating climate change https://www.europarl.europa.eu/factsheets/en/sheet/72/lupta-impotriva-schimbarilor-climatice.
9. Grupul de lucru pe tema „Combaterea schimbărilor climatice: o abordare integrată". (2023). Limitarea schimbărilor climatice și a impactului lor: o abordare integrată pentru România. Administrația Prezidențială, Departamentul Climă și Sustenabilitate, București, România, https://www.presidency.ro/files/userfiles/Raport%20Limitarea%20Schimb%C4%83rilor%20Climatice%20-%20iunie%202023.pdf,
10. Institutul Național de Cercetare - Dezvoltare în Silvicultură "MARIN DRACEA" INCDS, et al. (2023). Studiu pentru elaborarea strategiei naționale privind prevenirea și combaterea deșertificării și degradării terenurilor 2019-2030, https://www.mmediu.ro/app/webroot/ uploads/files/ Strategia%20Na%C8%9Bional%C4%83%20privind%20Prevenirea%20%C8%99i%20Combaterea%20De%C8%99ertific%C4%83rii%20%C8%99i%20Degrad%C4%83rii%20Terenurilor%202019-2030.pdf,
11. Ionescu, R.V., Zlati, M.L., Antohi, V.M., Stanciu, S. (2021). Modelling EU agriculture's regional disparities under the national accounting system's approach. The impact of the new economic and environmental challenges, Economic Research - Ekonomska Istrazivanja, 34(1), 902-928, DOI: 10.1080/1331677X.2020.1805347.
12. IPSOS. (2024). Studiu Ipsos de Ziua Pământului 2024: în timp ce criza climatică se agravează, interesul public față de problema încălzirii globale scade, https://www.ipsos.com/ro-ro/studiu-ipsos-de-ziua-pamantului-2024.
13. Ministerul Agriculturii și Dezvoltării Rurale. (2008). Strategia națională privind reducerea efectelor secetei, prevenirea şi combaterea degradării terenurilor și deșertificării, pe termen scurt, mediu și lung, http://old.madr.ro/pages/strategie/strategie_antiseceta__update_09.05.2008.pdf.
14. Ministerului Mediului, Apelor și Pădurilor MMAP. (2023). Schimbări climatice, https://www.mmediu.ro/categorie/schimbari-climatice/1.
15. Ministerului Mediului, Apelor și Pădurilor MMAP. (2024). 2023 - cel mai cald an din 1900 şi până în prezent, https://www.mmediu.ro/articol/2023-cel-mai-cald-an-din-1900-si-pana-in-prezent/6696.
16. Patriche C.V., Rosca, B., Pîrnău R.G., Irimia, L.M., Vasiliniuc, I. (2023). Impactul potențial al schimbărilor climatice asupra proceselor de eroziune în suprafață a solului în România, Simpozionul "Sisteme Informaționale Geografice" 29, (Iași, Romania, 30 martie 2023), https://ibn.idsi.md/vizualizare_articol/177922.
17. Revista Fermierului. (2024, March 22). Gestionarea eficientă a resurselor de apă, https://www. Revistafermierului.ro/din-revista/opinii/item/6088-gestionarea-eficienta-a-resurselor-de-apa.html.
18. Revista de Silvicultură și Cinegetică. (2021, October 19). Perdelele forestiere: scurt istoric, efecte, avantaje, https://forestmania.ro/perdelele-forestiere-scurt-istoric-efecte-avantaje,
19. Walsh, M. K., Backlund, P., Buja, L., DeGaetano, A., Melnick, R., Prokopy, L., Takle, E., Todey, D., Ziska, L. (2020). Climate Indicators for Agriculture. USDA Technical Bulletin 1953. Washington, DC. 70 pp, https://doi.org/10.25675/10217/210930.