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BUILDING RESILIENT WATER SYSTEMS. IRRIGATION FOR THE PREVENTION OF NATURAL HAZARDS, COMBATING DESERTIFICATION AND LAND DEGRADATION

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Abstract: *Many natural systems are now affected by climate change. To reduce the negative impact, the international community has adopted several measures to deal with climate change. Adaptation measures can mitigate the negative impact of climate change, but with its intensification. Therefore, to deal with climate change, it is necessary to adopt mitigation and adaptation measures at the same time. Climate change has increased the likelihood and intensity of drought. Thus, proper water management in irrigation systems could increase the resilience of agricultural production to climate change. Due to water resource constraints, water supply for agricultural irrigation cannot be ensured without sustainable management. Studies have shown that increased efficiency in efficient water use holds the key to addressing water scarcity and food security issues. Studies have shown that water consumption can be reduced and grain production can be increased. Saving water in agriculture is a necessary prerequisite for remedying water scarcity problems. Irrigation with treated water is a major contribution to the significant increase in yield and efficiency of water use, treated wastewater can represent an effective alternative to cover the water demand of the agricultural sector. Crop production systems that use treated water and save water on a large scale need to be established in the near future to feed the growing population. Also, to mitigate climate warming, it is necessary to minimize greenhouse gas emissions resulting from the production of energy used in irrigation water pumping stations, by using green energy (solar, wind, geothermal). The measures help combat climate change by providing technical support for appropriate actions, reducing their negative impact on agricultural production and ensuring food security. The use of treated water and sewage sludge can reduce soil salinization and conserve soil to support land productivity and environmental benefits.*

Key words: *climate change, water resource management, infrastructure resilience, integrated planning*

INTRODUCTION

Building resilient water systems is crucial in the face of climate change. Here are some key functions that resilient water systems should have:

- ✓ **Water resource management:** Resilient water systems should prioritize efficient and sustainable water resource management. This includes implementing strategies to conserve and protect water sources, such as reducing leakage in distribution networks, promoting rainwater harvesting, and implementing wastewater treatment and reuse systems.
- ✓ **Infrastructure resilience:** The infrastructure of the water system should be designed to withstand the impacts of climate change, such as increased flooding or droughts. This may include improving infrastructure design, retrofitting existing structures for resilience, and diversifying water supply sources to reduce dependency on a single source.
- ✓ **Integrated planning:** Resilient water systems require integrated planning that considers multiple aspects such as land use, urban development, agriculture, and ecosystems. This approach ensures that decisions regarding water allocation and management take into account potential climate change impacts across sectors.
- ✓ **Early warning systems:** Implementing effective early warning systems is essential for resilient water systems. These systems can help monitor weather patterns, predict extreme events like floods or storms, and provide timely alerts to communities at risk.
- ✓ **Community engagement:** Building resilience in a water system requires active community engagement and participation. Local communities should be involved in decision-making processes related to their access to clean drinking water, sanitation services, and overall resilience planning.
- ✓ **Capacity building:** Developing the capacity of relevant stakeholders involved in managing the water system is crucial for its resilience. It includes training programs on sustainable practices in agriculture or industry that minimize impacts on freshwater resources while adapting to changing climatic conditions.
- ✓ **Monitoring and evaluation:** Regular monitoring of key indicators helps assess the effectiveness of interventions implemented within a resilient watery system. Evaluation of the performance of interventions allows decision-makers to take measures to adjust strategies and improve their efficacy over time.

Overall, resilient water systems should strive for adaptation to changing climate conditions while ensuring long-term sustainability in meeting the challenges posed by climate change impact son water supply and quality.

1.1. Land fund and irrigation potential

With a total area of only 238,397 km^2, representing 4.8% of the territory of Europe, Romania is an important exporter of agricultural products from Europe.

Data centralized by the National Institute of Statistics (INS) show that the cultivated area at the national level has increased in recent years by approximately one thousand hectares, reaching 8.263 million hectares (ha).

Until now, the agricultural commercial year 2022/2023 (1 July 2022- 30.06.2023), places Romania's cereal exports (wheat, common wheat flour - grain equivalent, durum wheat, durum wheat flour - grain equivalent, barley, malt -equivalent in grains, corn, rye, oats, sorghum) in the second position among European grain exporters, reaching 7.4 million tons, according to European Commission data.

As last year, France remains the market leader, with exports of 14.4 million tons, while the third position was awarded to Germany, with 6 million tons, followed by Poland with 3.8 million tons.

At the level of the European Union, the most important crops on arable land are cereals, with the largest shares having: wheat (45.6% of the total area cultivated with cereals), barley (19.7%) and corn (17.5%) (Graphic no. 1: Share of cereals in the cultivated area at EU level).

In Romania, the share of the total area cultivated with wheat in the European Union decreased compared to the previous year by 0.3 percentage points.

"Romania, the largest grower of grain corn in the European Union (more than a fourth), had a smaller share within the European Union, compared to 2020, namely 27.8%", INS statistics show.

The total area cultivated with grain corn exceeded 2.549 million ha last year.

Through the National Strategy for the Rehabilitation and Expansion of the Romanian Irrigation Infrastructure[1], the Ministry of Agriculture and Rural Development (MADR) provides for the staged rehabilitation of the main irrigation infrastructure in the public domain of the state from irrigation facilities with an area of 2,004,639 ha, of public utility (Table no. 2).

1.2. Irrigation infrastructure

The theoretical irrigable potential of Romania is estimated at around 7.4 million hectares (Source: Land Registry, 2022) under the conditions in which the lands for which the moisture deficit is greater than 100 millimeters (1000 cubic meters of water) were considered per hectare) and the slope of the land is uniform.

The limiting criteria that compete with the application of irrigation were not taken into account: soil, hydrogeological conditions, water source (both qualitatively and quantitatively), energy consumption, socio-economic conditions, demand and supply of irrigation water. All these conditions influence the economic and financial efficiency of the works to be carried out.

[1] Developed based on the provisions of art. 6 of the Emergency Ordinance no. 4 of February 15, 2019 regarding the transfer of the "Siret-Bărăgan Main Canal" investment objective from the administration of the Ministry of Water and Forests, through the National Administration "Romanian Waters", to the administration of the Ministry of Agriculture and Rural Development, through the National Agency for Land Improvements

1.2.1. Current status of centralized irrigation systems

The irrigation systems in Romania were built until 1990, being located mainly in the south, south-east and east of the country, the areas most affected by drought, the area arranged for irrigation occupying about 22% of the country's agricultural area and about 34% of the arable surface.

Currently, Romania has an irrigated area of approx. 3.1 million ha, but which is not entirely viable from an economic point of view, the actual irrigated area varies a lot from year to year depending on precipitation and the technical condition of the facilities of irrigation.

The current situation regarding the irrigation system is as follows:

TOTAL IRRIGATIONS ANIF ON 19.06.2023

➢ Surface prepared for irrigation:	1.401.419,11	he
➢ Contracted surface:	856.451,83	he
➢ Filled irrigation canals:	2.432,04	km
➢ The surface that can be served as a result of filling the respective channels:	779.461,77	he
➢ Cumulative irrigated area:	286.064,51	he
➢ Irrigated surface:	195.963,87	he
➢ Irrigated crops: barley, canola, wheat, fodder, vegetables, sorghum, potatoes, soybeans, pasture, corn, peas, rice, hazelnut, tobacco, orchard, medicinal plants, vines, sugar beets, sorghum, others crops		
➢ Base and re-pumping stations on:	139	pieces
➢ Commissioning stations under pressure:	319	pieces
➢ Motor pumps on canals:	786	pieces
➢ OUAI served by these filled canals:	308	pieces
➢ OUAI that requested water for irrigation:	192	pieces
➢ Other beneficiaries who have requested water for irrigation	127	pieces

1.2.2. Main drinking water channels and irrigation infrastructure

The works in the irrigation facilities managed by the National Land Improvement Agency include pumping stations, adductions, exploitation constructions, pressurization stations and distribution networks mostly taken over by OUAI, this is how they are managed:

- ✓ 7,507.6 km of irrigation canals,
- ✓ 16,999.6 km of buried pipelines,
- ✓ 2,710.0 pcs of pumping stations,
- ✓ 869 pieces of exploitation constructions.

a) Siret-Baragan main canal - Stage I includes the canal on the Calimanesti-Ramna catchment area, 51.5 km long.

By achieving the investment objective, water for irrigation can be provided for about 100,000 ha, with an impact in obtaining safe and stable productions, with increased yields, on lands with high fertility classes, but subject to unfavorable climatic factors.

b) The Siret-Baragan main canal - Stage II includes the canal on the Ramna-Acumulare Dridu area, over a length of 139.5 km.

According to the data of the National Land Improvement Agency, as of March 22, 2022, the potentially irrigable surface is 1,289,381 ha, being served by the functional land improvement infrastructure, of which 3,009 km of canals.

1.2.3. Centralized drying systems

The irrigation activity cannot be taken out of the context of the complex activities of desiccation, drainage and combating soil erosion, as they are works that successively transmit their effects.

It can be stated that the vast majority of irrigation schemes in Romania were carried out mainly on the Danube terraces, this being the main source of water (Mutres, Olt, Siret, Prut)

1.2.4. Flood protection dykes

Flood dikes protect adjacent towns and agricultural land from flooding.

Most of the dykes during the exploitation period were damaged by the waters of floods and floods, thus, the necessity of carrying out repair works up to the level quotas has now arisen. From the existing data we could not determine the current condition of the flood protection dikes.

1.3. Predisposition of areas in Romania to land degradation and desertification processes

Romania ranks first in the European Union in the area cultivated with sunflowers (about a quarter of the total area cultivated with sunflowers), totaling 1.124 million ha, also the area cultivated with rape places us in fourth place among the States Members, with 445,900 ha, and its share in the total area cultivated with rapeseed in the European Union increased by 1.7 percentage points, compared to the previous year.

However, the effects of climate change and the grain crisis from Ukraine have now endangered the production of local crops, especially in the areas of the counties that held the most important shares in the total cultivated area, such as: Dolj (5.9% , respectively 484,101 ha), Constanta (5.4% - 445,674 ha), Galati (5.1% - 419,770 ha), Călăraşi (4.9% - 403,411 ha) and Teleorman (4.7% - 385,822 ha).

The impact of the phenomena of drought, land degradation and desertification is particularly complex, the effects on the state of vegetation and the productivity of agricultural crops being direct and/or cumulative, momentary and/or prolonged, local and/or extensive

1.4. The factors that contribute to the occurrence of land degradation and desertification processes

Land degradation and desertification processes are the result of a complex and long-term interaction between natural (climate, soil, vegetation, relief) and anthropogenic (socio-economic) factors. Within this interaction, climatic factors can play a double role, either as a shutter for the desertification process (e.g. aridity, drought, heat value), or as a trigger for land degradation processes through erosion (e.g., wind speed).

Among the most relevant climatic factors for the production of land degradation processes and desertification are: air temperature - positive thermal extremes (e.g. heat waves), precipitation - aridity, drought, heavy precipitation (torrential), long-lasting precipitation . (wet intervals), wind – wind intensifications, atmospheric humidity – the reduced partial pressure of water vapor in the atmospheric air causes the loss of water by evaporation at the soil surface.

Directions and goals. Evaluation of alternatives and analysis framework

Water resources for irrigation: Water resources available for use in water management are the difference between potential and ecological resources, and are used for water consumption (land irrigation, population and industrial water supply), as well as water use (fish farming, recreation, etc.).

Romania's water resources are made up of surface waters: rivers, lakes, the Danube River (~90%) and underground waters (~10%).

The amount of theoretical water resources reaches high values compared to the requirements of this resource. Thus, the total theoretical resource is 136,600,000 thousand m3, the existing resource according to the degree of development of the hydrographic basins is 40,482,841 thousand m.c. and the requirements are 12,265,698 thousand m3.

Surface waters: The total coded water courses of our country is 78,905 km. The water quality monitoring activity was organized in 2006 mainly on the middle and lower watercourses (over a length of 27,056 km), where the impact of human actions on the environment, respectively on the water quality, is manifested.

Groundwater: Over time, the natural regime of underground water has undergone a series of quantitative and qualitative changes. These changes are due both to their use as a source of water supply for the population (drinking and industrial), to the execution of some hydro technical and water improvement works, as well as to polluting factors (natural and anthropogenic).

From the quantitative point of view, of water reserves, the years rich in precipitation lead to the increase of piezo metric levels. Thus, in the area of the Bailesti, Romanati and Baragan plains, increases in piezo metric levels of 2-15 m can occur, and in southern Dobrogea the increase can be 2-10 m. In dry periods, strong natural decreases in piezo metric levels (of over 3 m).

Waste water: The statistical analysis of the situation of the main sources of wastewater, according to the results of the supervision carried out by the National Agency for Environmental Protection, revealed the following global aspects:

- ✓ compared to a total discharged volume of over 5 million m3/year, approximately 52.7% constitutes waste water that must be purified,
- ✓ of the total volume of wastewater requiring purification, about 20.2% were sufficiently (properly) purified.

In the rest, approximately 34.9% represents untreated wastewater and approximately 44.9%, insufficiently purified wastewater. Therefore, approx. 79.8% of wastewater, from the main sources of pollution, ended up in natural receivers, especially rivers, untreated or insufficiently treated.

CONCLUSIONS

Romania is a country where the agricultural sector remains important for the economy, the potential of agriculture can ensure food security and fully cover the demand on the domestic market through coherent sectoral policies, increasing the productivity and competitiveness of the sector through the development of a sustainable agri-food system.

Agricultural production also depends to a large extent on climatic conditions, drought has become a serious destructive factor over several years, directly affecting the country's food security/independence.

Building resilient water systems with major benefits for irrigation systems, preventing natural hazards, combating desertification and land degradation can help economic, social and environmental growth.

The instability of agricultural production is also a consequence of poorly developed tools for mitigating risks, dependent on climatic conditions, including insufficient access to irrigation, the low level of application of modern agricultural technologies (use of drought-resistant varieties, anti-hail protection tools, etc.) and the lack of innovative insurance systems in agriculture, such as index-based insurance programs for weather risks.

The centralized irrigation services managed by ANIF are partially functioning, not providing producers with the necessary quality water for irrigation at the right time.

Of course, correlating all the solutions and applying the best practices in the field remains a complicated solution. Implementation challenges may arise, such as administrative bottlenecks, funding issues, and other issues that we will present in future research.

It is certain that these challenges have already become a reality, and their approach has brought encouraging results, other, unexpected ones may still appear in different contexts.

The outcomes of different water resource management solutions required for irrigation systems ultimately depend on the unpredictable behavioral responses of different stakeholders, such as farmers and authorities, and the ability of the system to remain responsive to different aspects of implementation.

Therefore, learning through the power of example is essential, gathering data on the implementation and use of new solutions highlights some methods and approaches that Romania can use.

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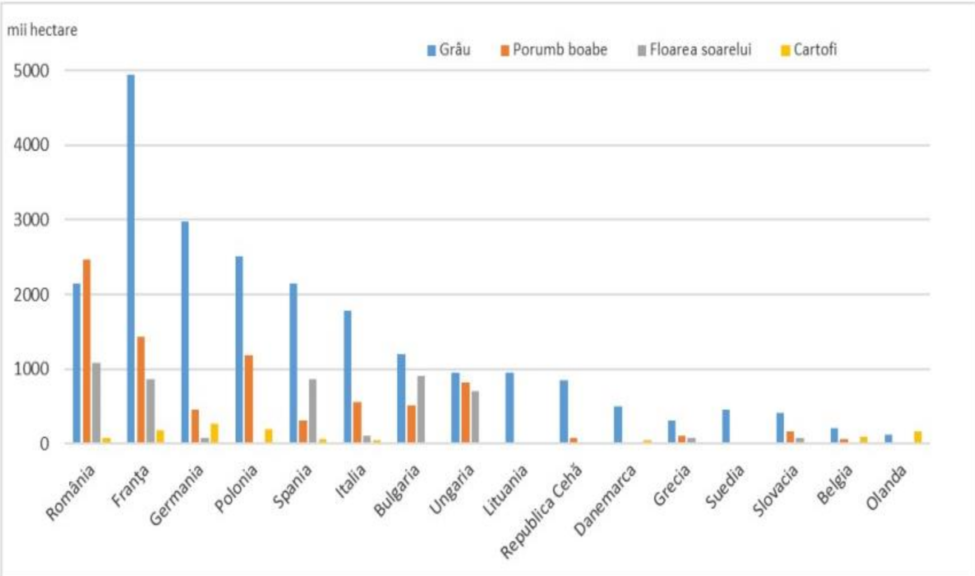

Fig. 1. The share of cereals in the cultivated area at EU level

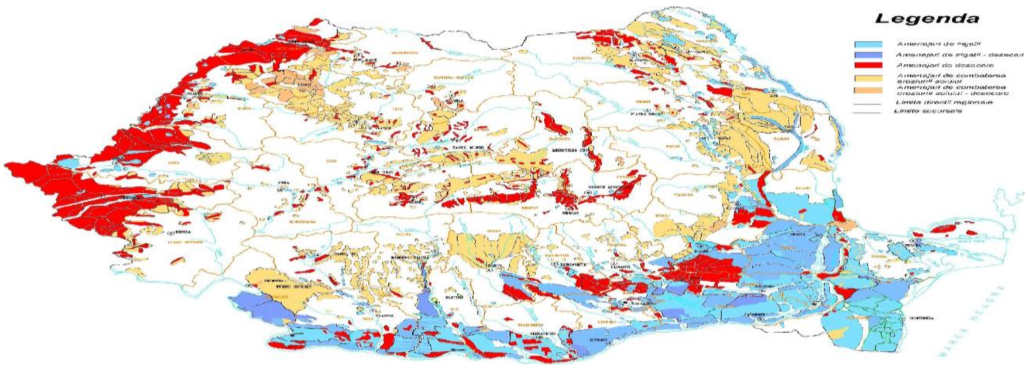

Fig.2. Land improvement arrangements