ANALYTICAL STUDY ON THE TECHNICAL-ECONOMIC IMPACT OF IRRIGATION SYSTEMS: REVIEW ON RECENT DEVELOPMENT AND FUTURE PERSPECTIVES

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Abstract. *A large increase in average annual temperatures, a decrease in precipitation, and an increased frequency of extreme climatic events are the key hazards that Romanian agriculture faces in the near and medium term. Floods, droughts, and other extreme weather events would have the greatest impact on agriculture. From one year to the next, the earth's requirement for water grows. The increasing degradation of irrigation systems in Romania in recent decades, amid lack or insufficient maintenance and due to inadequate operation, coupled with low rainfall and unevenly distributed in the growing season, significantly affects agricultural production and living standards of the population from the irrigable territory of Romania. Due to this state of affairs, it was considered appropriate to conduct an analytical study to identify solutions to solve the objective problems faced by agricultural producers in Prut meadow amid drastic climate change in recent years, by rehabilitating and modernizing the irrigation infrastructure in the area. The increase of the technical-economic efficiency was taken into account, through a sustainable land-use. and by reducing irrigation water amount, aiming to obtain large, safe and quality agricultural production, while maintaining soil fertility. For this purpose, the scientifically substantiated results presented in scientific papers, technical and economic expertise as well as in projects and rehabilitation works performed on the components of irrigation facilities were analyzed. Both the works and the modern solutions adopted within the hydro-amelioration systems from the Prut meadow, from other areas of the country, as well as from abroad were analyzed. The investigations carried out highlighted possible appropriate research directions for the arrangements in the reference area, in order to streamline the crops irrigation activity.*

Keywords*: analytical study, crops irrigation, irrigation infrastructure restoration, technical-economic impact*

INTRODUCTION

Romania is one of the European countries with the most advantageous soil and climate conditions to achieve a quality agricultural production volume, which can cover an important segment of domestic demand for agri-food products. Romania managed to destroy practically all of its irrigation infrastructure a decade after 1990, but in the following ten years, the government has attempted to reconstruct it with the support of European Union subsidies.

The trouble is that the damage has already been done, and repairing it will cost millions of euros only to restore the irrigation system, not to mention tens of millions to keep it running. However, the European funding for this year have been depleted, with only about EUR 5 million remaining out of a total of EUR 200 million. Floods, droughts, and other extreme weather events would have the greatest impact on agriculture. From one year to the next, the earth's requirement for water grows.

Drought, insufficient water supplies, and poorly functioning irrigation facilities are wreaking havoc on a large portion of Romania's agricultural land. Because of the lack of or severe depletion of irrigation infrastructure, these phenomena devastated nearly 48 percent of the total agricultural area (7.1 million) in the worst-hit sections of the country. The creation of diverse efforts and synergies among stakeholders, notably farmers, water users associations, and researchers, justifies the growth of technical innovation as part of the modernisation of

irrigation districts (GONÇALVES ET AL., 2020). Irrigation water users' groups play a critical role in Romanian agriculture, and they must adapt to the new water management paradigm through technological and behavioral changes that are compatible with farmers' technical know-how and economic sustainability. As a result, improving water management, with an emphasis on water conservation and enhancing farmer revenue, is a top goal.

Despite the considerable capacity, the profitability in Romanian agriculture is still moderate, indicating a use of production factors below the level of optimal values. Through this study, on the evolution of agricultural production in Moldova area, comparing with the entire territory of the country, for the processing and interpretation of data, was used the method of comparative analysis of researched phenomena.

Depending on the available data, the comparison method was used in the analysis of the data series that covered certain time periods. It is clear that for the next period it is important to increase some measures to protect subsidies. To make extensive use of the need for irrigation, fertilization and other activities that provide a perspective on the evolution in this sphere of activity and lead to the agri-food protection and autonomy of Romania.

The objective of the paper is the research and technical-economic substantiation of technological systems for irrigation of open field crops or in protected environments (greenhouses, solariums), in the context of the evolution of the energy crisis and the increasing danger of desertification in Romania and the central area. European Union. The totality of the properties of the hydrotechnical works consists in achieving the safety of the water source, necessary for irrigations. The unclear performance of computer irrigation model technologies is not necessary for public authorities to design appropriate interventions to convey their development. The present study could help to fill the gaps in the dedicated literature, which, according to some authors, does not provide an accurate understanding of the real benefit of introducing computerized irrigation models in agriculture.

The paper is organized as follows: a review of the literature discussing how uncertainty is addressed in the agricultural economic literature, motivating the criteria used to assess the viability of new sources of information. It describes the approach of the evaluation that was adopted, through which we compare different sources of information to schedule irrigation interventions at the experimental level. Debate the main implications of the results obtained. And in conclusions on the current situation of irrigation systems.

Subsequently, the collected informations were used to develop three comparative approaches to evaluate the performance of new technology in irrigation systems rehabilitation and arrangement.

RESULTS AND DISCUSSIONS

The systemic analysis applied to the research carried out in the scientific papers specified in the bibliography, highlighted the following interpretations of the retained results, presented in summary: Large-power PV irrigation systems (PVIS) ranging from 40 kWp to 1 MWp are increasingly being introduced onto the market, according to Narvarte et al (2019), because the main technical barriers have been removed, and some real-scale demonstrators have shown cost savings of up to 80% when compared to grid electricity or diesel generators.

Figure 1 depicts the frequency of an Open-circuit voltage at Standard Test Conditions (V_{oc}) bigger than this amount occurring per hour of the day in the tracker during the daylight. The majority of the incidents, as expected, occur in the morning due to the lowest cell temperature during these times. It's worth noting that for 22 modules in the coldest location (Villena), there are some days when the overvoltages persist.

Increased irrigation water efficiency is one technical solution frequently offered for reducing water constraint. Since 2000, many programs have been implemented in Romania to modernize irrigation infrastructure and generate water savings of 2,500 hm^3/year while also promoting rural development. The current study employs a footprint approach to assess the implications of irrigation modernization programs in agriculture in Romania between 2005 and 2011 on land, water, energy, and carbon emissions.

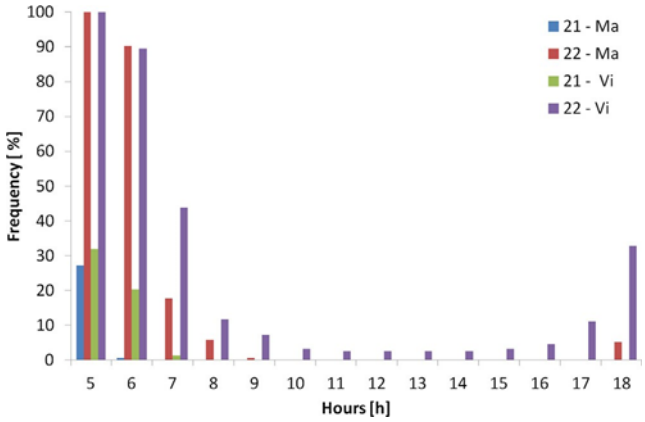

Figure 1. Frequency of occurrences of hourly *V*oc > 800 V in the N-S structure

The findings reveal that the irrigated area remained steady (+0.3 percent) across the study period, despite a shift in crop patterns, with low-value non-permanent crops being replaced by high-value permanent crops. The water demand for irrigation fell by 21%, with half of this due to changes in crop patterns and a drop in the consumptive proportion (i.e., blue water footprint), and the other half due to reduced return flows associated with improved irrigation infrastructure efficiency. Changes in water demand have resulted in a gradual shift away from surface water and toward groundwater. Reduced irrigation water demand has resulted in a 13 percent reduction in water's energy footprint and a 21 percent reduction in water's carbon footprint.

Its environmental impact Water efficiency (m^3 consumed/m^3 irrigated) has increased by a factor of two. Although this has increased the energy intensity (kWh/m3) by 8%, it has also increased the energy intensity (kWh/m^3) by 9%. As a result of the lowering in the emission factor of power production, the emission rate ($KgCO_2$ equivalent/m^3 irrigated) has fallen by 12%. Overall, irrigation modernization programs in Romania-Moldavan aria have aided the shift from a less technologically advanced and primarily reliant on surface water irrigation system to a more productive and groundwater-based one. From a resource-use standpoint, the transformation has helped to stabilize or even decrease irrigated land, as well as exceed the yearly water savings objective of 2,500 hm^3, while simultaneously increasing the sector's energy dependence. Despite the overall excellent results, other synergistic factors obscured the reported water savings, including favorable climatological circumstances at the end of the study period, which helped significantly to reducing overall irrigation water consumption. Given the increased frequency of droughts in Romania, current investments can not guarantee that the targeted water-saving targets will be met unless they are supplemented

with additional measures such as limiting irrigated land and/or imposing limitations on water-intensive crops. (WILLAARTS ET AL, 2019).

Irrigated agriculture has a significant environmental impact. It is vital to provide extensive analyses beyond the strictly technical domain in order to reduce negative consequences and increase good outcomes. In this study, was used multi-criteria analysis methodologies to apply a methodology for identifying priorities in implementing irrigation plans on a specific case study area in the Orljava River sub-catchment area in Poega - Slavonia County, Croatia. Orljava - Londa, Pleternica, Ovcare, and Tretanovci are five possible irrigation areas, and Venje - Hrnjevac) were examined using five separate criteria: environmental protection, water-related (four sub-criteria), social, economic, and temporal criteria, all of which were given various weights (weight) (figure 1).

The goal of this study was to confirm the efficacy of using six multi-criteria analysis (MCA) methods (the most commonly used: PROMETHEE, AHP, ELECTRE TRI, and the less commonly used: DEXi, PRIME, and PCA) in determining irrigation priorities, present models for input data preparation, apply certain methods, and compare the results on the chosen case study area. During the research, the adequacy of the methodologies was established.

The Ovcare area was identified as the most appropriate for irrigation development by five of the six MCA approaches (i.e., it has priority in implementing the irrigation plan). Orljava - London has more advantages than other regions, according to one of the six methodologies (AHP). Except for PCA, all MCA approaches identified Venje - Hrnjevac as the least advisable (last to be implemented) option. The findings of this study corroborate those of a recently published study on the use of MCA to solve water management issues. (KARLEUŠA et. al, 2019).

Figure 2. Presentation of results of DEXi application for Scenario 1: result based on evaluation of all criteria, and result for two criteria (KARLEUŠA ET. AL, 2019)

Freshwater supplies have been severely strained as a result of climate change, drought and water resource competition, and urbanization. As a result, alternative water sources are being promoted as a strategic option for increasing water supplies and protecting river systems more frequently.

Ricart et al., conducted a screening on publications that study the possibilities of reusing wastewater in agriculture. The results of this study are presented in Figure 3.

Water shortages and stress, food security challenges for growing populations, and environmental contamination from poor wastewater disposal have all been identified by the World Health Organization as driving forces for worldwide wastewater reuse. (RICART ET AL, 2019).

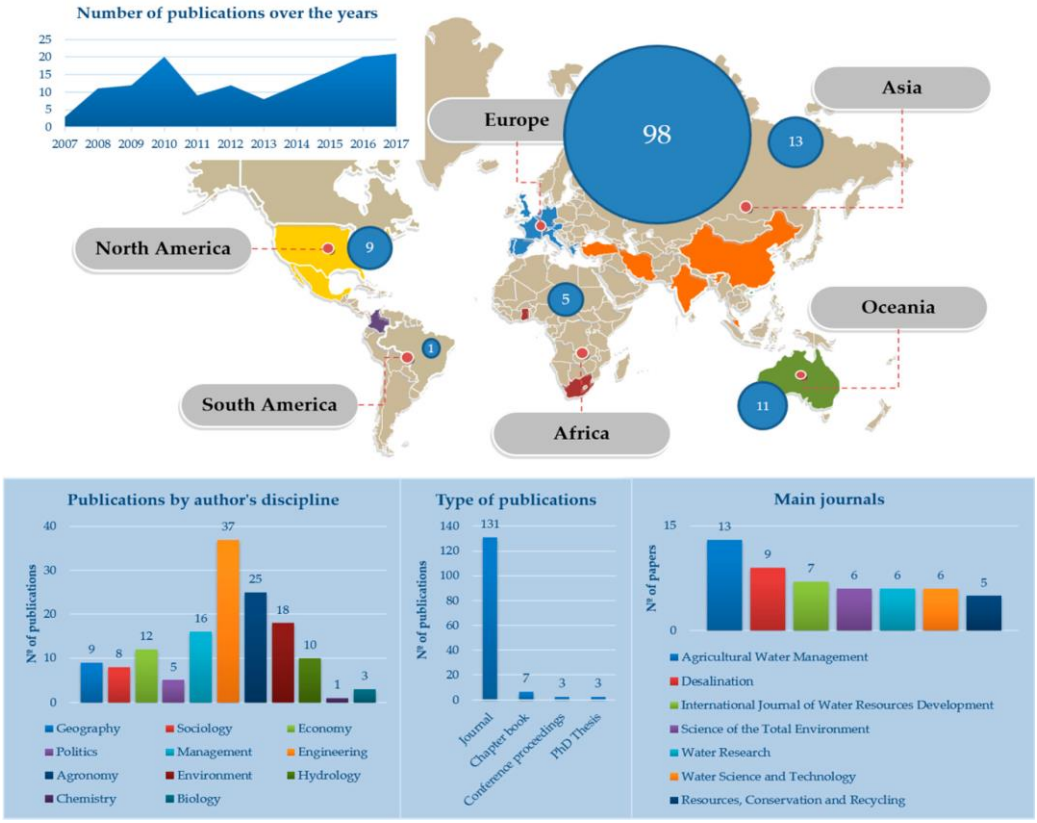

Figure 3. Geographic analysis of selected publications by typology, year of publication, source and author's discipline. Adapted from Sattler et al. (RICART ET AL, 2019).

WIDL stands for water-saving irrigation development level, and it refers to appraising a water-saving region fairly and accurately based on an examination of all aspects impacting water-saving irrigation development. The scientific planning direction to irrigation work is based on the evaluation of regional WIDL. (ZHAO ET AL, 2019).

Natural circumstances such as hydrogeology, channel soil, irrigation soil, crop species, irrigation district management and maintenance, farmer water use habits, and water price policy vary by region, resulting in varied engineering innovations, economic benefits, and water price policies, environmental benefits, as well as the level of development of water-saving irrigation in different regions. Although many studies have focused on evaluating water-saving irrigation technology or overall advantages, there has been little study on evaluating the regional level of water-saving irrigation development (WIDL). WIDL refers to determining a water-saving or high-efficiency water-saving region based on an examination of all elements impacting water-saving irrigation development in a reasonable and correct manner.

Due to climate change, economic growth, and a growing population, water is becoming increasingly scarce in northeastern Romania. Improving the efficiency of water use in agriculture is critical for inland river basins in dry and semi-arid climates to increase their socio-economic productivity. The efficiency of maize irrigation water use (IWUE) is assessed using household data gathered in Moldova, which is located in the north-central section of the Prut meadow, using a stochastic border analysis. The impact of influencing factors was investigated further, particularly participatory irrigation management (MIP) through water user associations (WUAs). The estimated average technical efficiency (TE) and IWUE of maize production are 0.74 and 0.24, respectively, according to the findings. Irrigation management has a very low level of engagement. The amount of the MIP's impact on the IWUE is quite tiny, according to empirical studies, despite the fact that it is significantly positive. Households that attended WUA meetings had an IWUE that was only 0.002 percent greater than those who did not. WUAs do not achieve the desired results. WUAs do not achieve the desired results. As a result, it is critical to alter the existing approach of operating WUAs in order to make them more open, fair, and inclusive of farmers. Furthermore, we discover that the price of water, the source of irrigation water, irrigation technology adoption, farmer education, and agricultural experience all have a considerable positive impact on IWUE. (ZHOU ET AL, 2017)

Drought, rising floods, and sediment movement intensify landscape-scale water concerns across northeastern Romania and many other land-based regions around the world. Less winter precipitation and warmer temperatures reduce snowpack storage, resulting in decreased spring runoff and shorter flow times for downstream water users. The historical overlap and suppression of fires corresponding to climate conditions that began at the end of the 19th century are responsible for the landscape losses of deep soils and plant cover in this region. Rain and melting snow can no longer be kept by the soil and released gradually over the year; instead, they flee instantly after floods, causing catastrophic flows and severe erosion. As the vegetation in the highlands declines, the hydrological energy in the valley bottoms rises, increasing the purification of plant and soil along the canal's bottoms and condensing the valley flows (figure 4). Flooding in many river networks was historically more linked to richer floodplains.

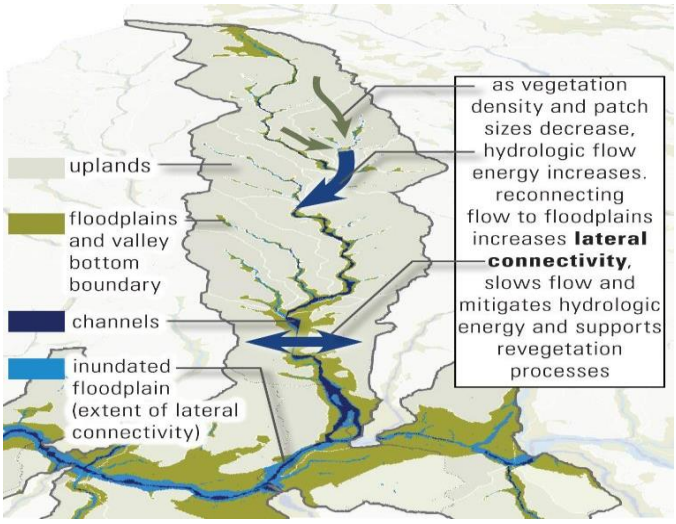

Figure 4. The dynamics of flood flow connections to the landscape are significant drivers of watershed conditions. (MAXWELL ET AL, 2019)

The number of persons employed in agriculture production as a primary source of income is substantially higher than in other industries. Agriculture accounts for around 67 percent of total global water usage, which is the largest when compared to industry (25 percent) and homes (8 percent). The primary goal of agricultural production is to ensure that humanity has enough food and raw materials.

Chernykh et al. (2021) created a map of the mainland that indicates regions that have irrigation systems, are irrigated, or have been set aside for groundwater irrigation (figure 5).

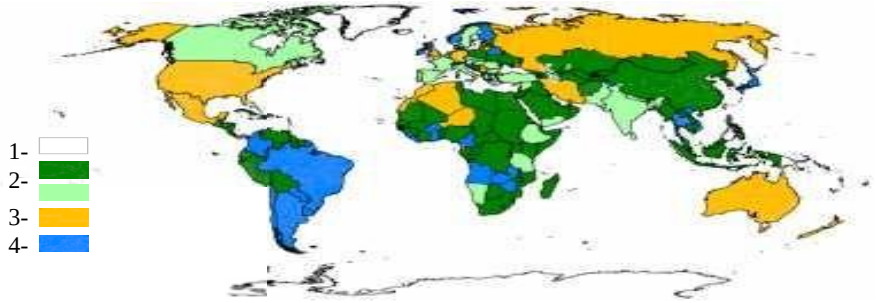

Figure 5. Irrigation fields on the mainland map: 1 – areas without irrigation; 2 – areas equipped with irrigation systems using ground water (AEI GW); 3 – areas actually irrigated with ground water (AAI GW); 4 – areas designated for irrigation with possible use of ground water (IWWD GW); 5 – areas equipped with irrigation systems using surface water. (CHERNYKH ET AL, 2021)

Large-scale irrigation projects, which are frequently built in floodplains, overestimate technological expertise and natural-hazard control, and are especially vulnerable to floods, yet there has been little research on the impact of floods on irrigation operations. Using a transdisciplinary approach developed in the Chokwe irrigation scheme during the post-flood recovery period 2013, the impact of floods on the scheme was analyzed, with a focus on maintenance. The flood catastrophe has allowed for a rethinking of maintenance methods by reconsidering the relationships and duties among the players in this large-scale irrigation project. However, the system's robustness can only be improved if the improvements increase the capacity for collective action.

The capacity of large-scale irrigation schemes to retain their performance over time is an important policy problem because to the significant expenditure necessary for their design, construction, and maintenance. It is critical for them to be able to adapt to a changing environment, regardless of technological advances, macropolitical economic transformations, or climate change. (DUCROT ET AL., 2019)

The crops used have a high value-added and maximize the value of irrigation water, according to the agro-economic analysis. Due to the new irrigation technology introduced, which limited water percolation to the aquifer, the environmental impact resulted in an average decrease of 2.59 m in the static level of groundwater. (MOURADI ET AL, 2018)

Water-management infrastructure, such as dams, diversions, and levees, provides vital societal benefits such as energy, flood management, and water supply, but it is also a major contributor to the deterioration of freshwater ecosystems and the services they provide. (OPPERMAN ET AL, 2019)

Water resources availability has a direct impact on a country's economy and the growth of key production processes, such as agriculture, irrigation, and food production, as well as energy generation and water supply. An adequate management of water resources has an impact on regional economic and social development because it stimulates the economy by expanding the ability to deliver water for numerous applications, directly affecting the generation of jobs and improving the population's quality of life. (MORENO-PIZANI, 2021)

Despite the availability of appropriate technologies, economic, political, legal, social, and environmental constraints frequently obstruct stakeholders, particularly decision makers, from realizing the potential of existing solutions. This research examines six topics: policy and institutions, the economy, society, water management, legislation, and the environment.

The process of purifying wastewater to turn it into water that can be used for beneficial purposes is known as water reclamation. (OERTLÉ ET.AL., 2020)

In certain agricultural regions, Water User Associations (WUAs) administer irrigation services and hydraulic networks, as well as supply and deliver irrigation water to connected farmers. These agencies may be funded by financial earnings from associated users, with possible assistance from national or local governments, to operate vast water networks and manage irrigation services. The role of WUAs in managing agriculture's irrigation resources through a "participatory irrigation management" approach has been growing for several decades because this approach appears to be suitable for dealing with historical irrigation management problems, such as water scarcity and the fact that agriculture is the largest consumer of water.

The collective irrigation service's performance is frequently poor, indicating a lack of technical and financial sustainability. In terms of technical management, the irrigation service demonstrates a lack of justice and consistency in water distribution, and the water delivered to farms is frequently insufficient to meet crop irrigation needs. (ZEMA ET. AL, 2020)

CONCLUSIONS

The analytical study aims to highlight, interpret and present synthetically – having as a priority criterion the value and ability of solutions – the theoretical and experimental results of studies and research conducted and supported in an appreciable diversity of scientific and technical papers developed by specialists in the country and abroad.

The opportunity and necessity of the work derive from the synthetic interpretation, by categories of objectives and problems, of the directions of applicability in the hydro-amelioration arrangements and especially to the irrigation systems, for their rehabilitation, refurbishment and modernization.

Sectors and sections of the hydrotechnical schemes remain uncovered, especially at the level of water distribution to agricultural crops and regarding the solutions for streamlining the irrigation-watering processes.

The final conclusions result from the partial analysis of the works. It is that most of the solutions and results have not yet been applied in hydro-amelioration systems, and those, very few, that have been applied did not have the appropriate operating conditions to prove their effectiveness. A representative sample of farmers was used to assess the performance of the localized irrigation system, reflecting the diversity of the research area.

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