CURRENT MANAGEMENT ISSUES IN EXPLOITATION AND MAINTENANCE OF IRRIGATION SYSTEMS IN WESTERN PART OF ROMANIA

PhD Thesis – Abstract

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CONTENT

PART I

Chapter 1. Introduction and general problems

The objective of the thesis is to perform a detailed analysis of the management of exploitation and maintenance of irrigation systems in western Romania, with a case study applied in the field, in the context of the evolution of this activity globally.

Irrigation systems arose from the need to provide water, in conditions of a deficit of moisture in the soil profile. Regardless of the size of the territories in which they are applied, irrigation is the sustainable solution for obtaining normal crops, if the water in the soil is not enough.

The area for irrigation is owned mainly by developing countries 78%, developed countries 15.8% and poorly developed countries 6.2%, while of the total area developed Asia and Oceania holds 71.7%, North and South America 15.6%, Europe 7.8% and Africa 4.9% [115, 116].

Currently only approx. 20% of the cultivated areas are irrigated, but they supply 40% of the world's agricultural production, respectively 60% of the total cereal production, the water sources used for irrigation being surface courses, groundwater and wastewater sources [115].

The situation of the irrigation sector in Romania shows a dramatic evolution, from the establishment of large facilities during the years 1970-1975 to 1989, with an area of approximately 3.1 million ha, comprising 375 large irrigation systems [3]. After 1989, due to the fragmentation of the land fund, the poor management of the infrastructure, the lack of investments in the field, it was reached that at the level of 2004 the functional irrigation arrangements from the total irrigated area to represent a percentage of 50%, and in 2013 of 45 %, with a total area actually irrigated (watering 1) of only 11% in 2004 and 5% in 2013, out of the total area covered with irrigation [114]. These statistics show the need to implement an efficient management of maintenance and exploitation, supported by a rehabilitation and modernization of the existing infrastructure, as well as the diversification of the arranged areas and the irrigation methods used.

Summarizing we can appreciate that if between 1950 and 1990, in Romania were implemented national irrigation systems that served 3.1 million hectares, a system that placed

Romania in the first countries in Europe, in terms of irrigation systems. At that time, Spain owned 3.39 million hectares arranged for irrigation and Italy 3.14 million hectares, among the European Union countries, ahead of Romania. After 1990, irrigation arrangements stagnated mainly for financial and legislative reasons.

It is found from the significant reduction of irrigation norms and areas, compared to 1989, that an incomplete irrigation of crops was applied, even in particularly dry years, such as the years: 1993, 2003, 2007.

The lack of a watering warning system for many facilities often leads to chaotic irrigation, without giving importance to the principles of sustainable development. The option for implementing a certain irrigation system must appear after the analysis of the proposed territory for development, the availability of water resources, the quality of water at source, but also the climatic and pedological environmental factors involved in establishing the technical solution. Land irrigation can increase production by up to 30%, but more importantly it increases the security of obtaining a stable production.

Romania's agricultural area registered minor decreases from one year to another, the main factors being the transfer of land areas to the construction and forestry sectors.

Repeated and discontinuous changes in the legislation related to land improvement have not progressed, on the contrary have led to deepening dysfunctions in the system, thus necessitating a revision of legislation aimed at new institutional reorganization measures regarding administration, research, design, execution and exploitation efficiency.

Worldwide, advanced research has been conducted on irrigation arrangements. In particular, research has been conducted on water sources, water and soil quality, irrigation equipment and the components of an irrigation system [124].

The appearance on the world market and in Romania of many constructive types of mobile irrigation equipment and the relatively low experience in their use requires in situ studies and research on their technical - functional characteristics, applied to different cultures, in the pedo - climatic conditions of Romania, and also in some local arrangements, as well as the correlation in operation of their parameters with the climatic conditions specific to the area.

Problems related to the management of existing irrigation systems have become a priority in recent years, due to changes in the approach to the role of the irrigation system in farming and due to the slowdown in the expansion of irrigation.

In Romania, after 1990, in the context of political change and the reorganization of state institutions, the field of land improvements was severely affected, both as an organization (administration, design, execution and operation) and as a research.

Until 1990, the land improvement sector had a complex organization, with over 120 thousand employees, having specialized structures for design, research, execution and maintenance of works.

Currently, in Romania in the field of land improvements there are about 2000 employees, employees of the National Agency for Land Improvement, the National Society for Land Improvement and the National Institute for Research and Development for Land Improvement - "ISPIF" Bucharest. [111, 117, 119, 122]

Romania must comply, after accession to the European Union, with Community policies and directives on agriculture and rural development, by adapting national legislation. Liberalization of the market, strengthening the status of farmers, decentralizing the decision-making process, streamlining the implementation of support programs, the environment, are the main directions of EU policies and directives in the field of agriculture and rural development.

The reality regarding the agricultural exploitation of the lands makes the design in the field of irrigations to aim at the establishment of smaller irrigation arrangements or the fragmentation of the big systems, with the finding of new water sources. Regarding the exploitation of the existing ones, there is a need for a rational analysis of each system, leading to finding the most appropriate means and measures to make them more efficient. One of the solutions for increasing the economic efficiency of irrigation facilities is modernization, which also involves new irrigation equipment,

some with a high degree of mechanization and automation and adaptation of irrigation schemes to field conditions.

The main objectives of the thesis are the following:

- Bibliographic synthesis on the situation of irrigation in the world and in Romania, in the context of climate change and increasing demand for increased agricultural productivity;
- Study of irrigation methods, with the presentation of the main characteristics, the implementation and maintenance in operation;
- Study of modern equipment for irrigation works, with the presentation of the latest technologies for sprinkler and drip irrigation;
- Analysis of the management of operation and maintenance of irrigation facilities in the West Region - Arad, Caraș-Severin, Hunedoara and Timiș counties, by presenting the structure of the National Agency for Land Improvement ANIF at local level, presenting the main existing irrigation facilities from the state patrimony and their functionality , as well as the financing perspective for the rehabilitation and modernization of irrigation facilities in the West Region;
- Study on the current state of local irrigation arrangements in the Western Region of Romania in various stages of implementation from private funds;
- The case study presenting the in situ researches within a local irrigation arrangement by presenting the arrangement scheme, the calculation of the water demand, the analysis of the technical-functional characteristics of the irrigation equipment, the study of the application of watering uniformity for each type of irrigation installations, and study of water quality for irrigation.

Chapter 2. Synthetic presentation of the main irrigation methods

Irrigation has the main purpose of supplementing the moisture deficit, of the soils affected by this phenomenon, as well as of the soils in less arid areas with an unfavorable distribution of precipitations during the various periods of plant development.

Irrigation methods establish engineering techniques necessary for the design of hydro-amelioration works and constructions for the rehabilitation of soils affected by moisture deficit, by studying the conditions that influence the abnormal variations of soil moisture in the active profile.

In addition to presenting the various irrigation methods used, this chapter complements the information synthesized with implementation techniques and technologies, exploitation problems and maintenance methods.

All the technical aspects addressed in this chapter, as irrigation works, have as object of study the design, execution, exploitation and maintenance of hydro-amelioration works related to the rehabilitation, conservation and protection of soil quality.

Completing the moisture deficit is achieved by ensuring on the depth of the active layer the quantities of water necessary for raising the soil moisture, during the vegetation season or outside it. These measures are taken to ensure stable and secure agricultural production, and to maintain or even improve soil characteristics by supplementing it with other appropriate agrotechnical methods.

The choice of the optimal irrigation method between surface irrigation by submersion, furrows or strips, sprinkler irrigation, drip irrigation or subirrigation, is made taking into account soil conditions, land topography and type of crop, each of which has a set of advantages and disadvantages.

Submersion irrigation is a method of gravitational watering, which consists of total or partial coverage of crops according to the vegetation phase [43].

This method of irrigation is suitable for many field crops, rice grows best when its roots are submerged in water, and therefore submerged irrigation is the best method used for this crop. Other crops suitable for this method of irrigation are: alfalfa, clover, trees, cereals and tobacco.

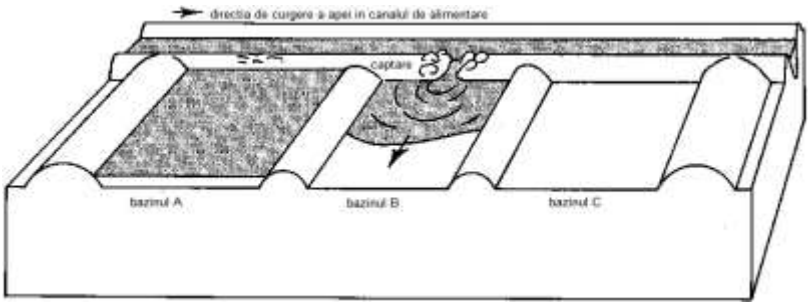

Figure 10 Direct irrigation method [7]

Submersible irrigation is generally not suitable for crops that cannot stand in wet or humid conditions for periods longer than 24 hours. These are usually root crops and tubers such as potatoes, cassava, beets and carrots that require well-drained soils.

Furrow irrigation is also a gravitational method, with water reaching the plants by draining along the natural slope or obtained as a result of leveling works. The furrows are small canals that carry water on the slope of the land between the rows of crops. Water seeps into the soil as it moves along the slope. [7].

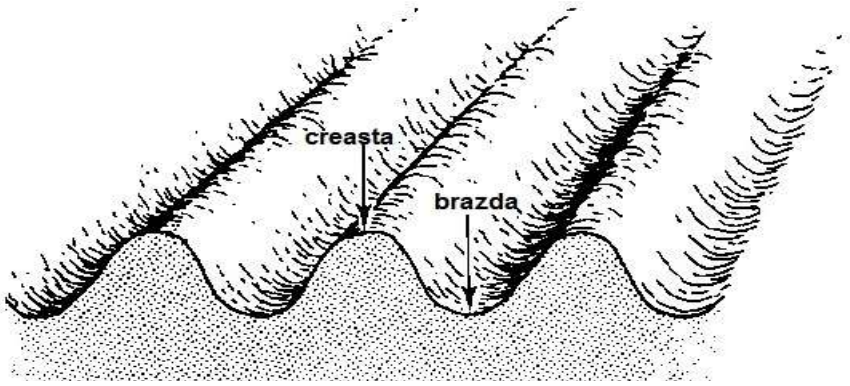

Figure 16 Furrow irrigation [7]

The crop is usually grown on the ridges between the furrows. This method is suitable for all crops in a row and for crops that cannot stay in the water for a long time. [7].

Strip irrigation is applied to small plots of land, cultivated with perennial legumes or straw cereals. This method is suitable for medium soils that are difficult to permeate [7].

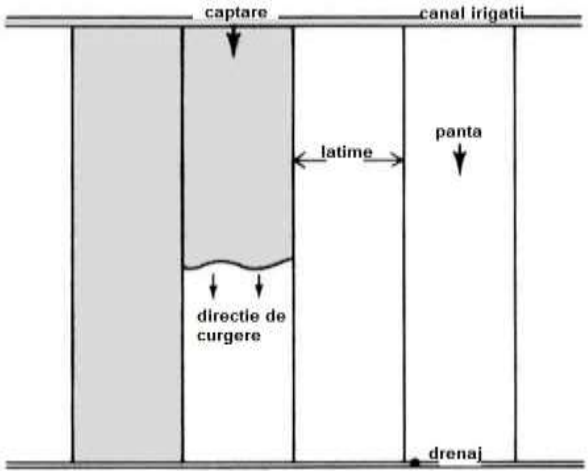

Figure 29 Strip irrigation [7]

Sprinkler irrigation is the method that imitates natural rain with a device called a sprinkler, the spray of the released water jet is dependent on the type of sprinkler, the diameter of the nozzle and its working pressure [7].

Sprinkler irrigation is suitable for most crops, field and tree, and water can be sprayed over or under the crop. However, large sprinklers are not recommended for irrigating delicate crops, such as lettuce, because large drops of water produced by sprinklers can damage the crop.

Sprinkler irrigation is adaptable to any slope, uniform or undulating. Side pipes supplying water to sprinklers should always be placed along the contour of the ground whenever possible. This will minimize pressure changes to the sprinklers and ensure uniform irrigation [7].

The most common type of sprinkler system layout is shown in the figure below.

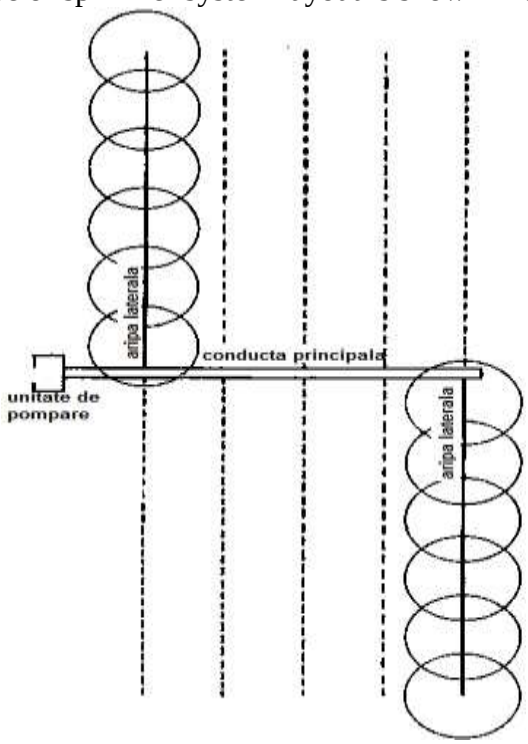

Figure 33 Sprinkler irrigation system using side watering wings with manual move [7]

Drip irrigation is the method by which the individual watering of the plants is carried out, with the help of a network of pipes located along the cultivated rows and on which is next to each plant a device called a dripper [7].

Drip irrigation is best suited for vegetable crops, orchards and vines, where one or more drippers can be provided for each plant. In general, drip irrigation systems are used for crops considered of high value due to the high costs of installing a drip system.

Drip irrigation is adaptable to any slope of the land. Normally, the crop can be planted along the contour lines, and the water supply pipes (drip lines) would also be placed along the contour. This is done to minimize changes in drip discharge due to changes in terrain height [7].

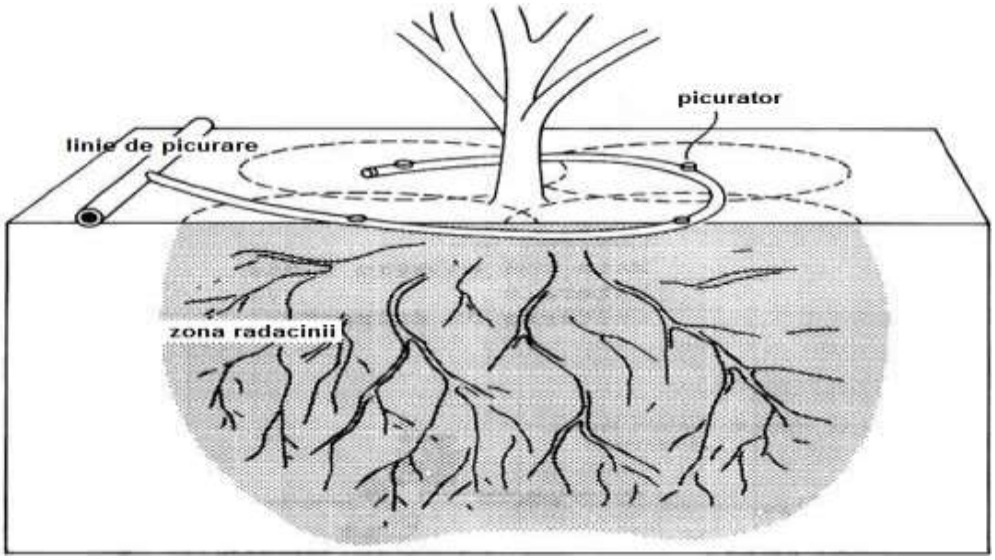

Figure 36 Drip irrigation system (localized) for trees [7]

Drip irrigation is suitable for most soil types. On clay soils, water should be applied slowly to avoid puddles or surface runoff. Higher hourly flow rates of the drip will be required on sandy soils to ensure adequate soil moisture.

Subsurface irrigation or underground irrigation is the method, specific to areas drained in dry periods, in which raising the soil moisture to the thickness of the active profile to the value of field capacity can be achieved by raising the groundwater level. Raising the groundwater level can be achieved by pressurizing the drainage network [7].

This method of irrigation has been known since the beginning of the 19th century, being applicable in soils with good capillary properties, having a not very deep impermeable layer. The method is not indicated in soils with a high salt content, due to the secondary salting produced by the capillary ascent.

Chapter 3. Modern equipment for irrigation works

Irrigation systems are in a continuous process of improving performance, with reflection on the quality of watering, labor productivity, easy adaptation to natural conditions, in order to achieve a high degree of automation and increased agricultural production. Rehabilitation, modernization of irrigation system infrastructure and functional automation will bring benefits, but will also increase the risks posed by intensive operation [22].

Among the irrigation installations to be mentioned are those that have a high degree of use and that stand out both by the reduced and controlled consumption of water in the conditions of climate change and the reduction of clean water sources, and by the degree of automation and control in the conditions of force. limited and expensive labor [109, 110]. Thus, the irrigation installations are used using the method of sprinkler and drip irrigation, which also covers the needs for both large field crops and for vegetable, fruit or vine plantations.

This chapter presents the latest generation technologies and equipment for sprinkler and drip irrigation.

The main method of irrigation used until the middle of the twentieth century was that of surface runoff, after which at the end of World War II irrigation was expanded by sprinkling, and lately drip irrigation it is beginning to be used more frequently.

In Romania, approximately 80% of the area arranged for irrigation is irrigated using sprinkler irrigation technologies and equipment, thus being very important a good knowledge and

choice of them in order to modernize and refurbish existing facilities, and given that in the financial cycle 2021- 2027 relies on the allocation of European funds for the purchase of irrigation equipment.

Drum and hose sprinkler systems can be used for irrigation of all crops, being characterized by high maneuverability, high reliability, lower initial investment and automated operation.

Figure 42 Drum and hose sprinkler systems [123]

Central pivot sprinkler irrigation systems are characterized by circular movement around the supply point, hence the name pivot. This type of installation is self-propelled and consists of a suspended watering pipe, supported by movable brackets that rotate around the central pivot. [127]

Figure 55 Central pivot sprinkler irrigation systems

Linear sprinkler irrigation systems have similarities with central pivot systems in terms of the structure on which the watering pipe is located, the displacement system, the device for maintaining the linearity of the installation, etc. The difference between the installations consists in the fact that in the installations with linear displacement, all the actuation towers move with the same speed, in a direction parallel to the channel or the supply pipe [127].

Figure 67 Linear sprinkler irrigation systems

Irrigation devices can be mounted on the watering pipe (nozzles) or suspended from the watering pipe (sprinkler hoses), and distribute the water under pressure as the system moves controlled according to the set speed and the set irrigation norm. Installations may have high-tech components incorporated, including GPS technology for automated movement, maintaining linearity during operation, uniform water distribution, as well as remote control and radio or internet programming using GSM terminals or electronic tools.

In recent years, in view of the possibility of accessing European funds through sub-measure 4.1a - Investments in fruit farms, *drip irrigation* technologies and equipment have had a significant demand, being suitable for such investments.

Irrigation equipment and irrigation installations have diversified after 1990 on the Romanian market, but in order for them to be operated efficiently, it is necessary to apply modern technologies that respect the soil-water-plant interrelation..

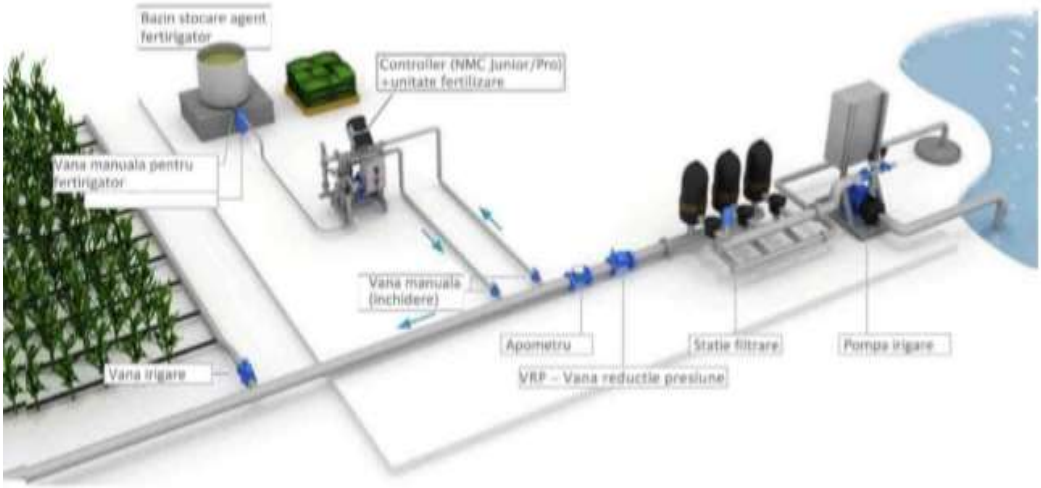

Figure 72 General scheme of a drip irrigation system [126]

The quantities of water needed for agricultural crops, in the process of growth and fruiting, so as to ensure stable and safe production, must be provided in cases where plants cannot grow because water from natural rainfall or groundwater does not exist or it is not enough. Thus, by using

local water sources and by using modern technologies, it is possible to complete the necessary water at the plant, contributing to increasing the efficiency of irrigation, to achieving a sustainable and environmentally friendly agriculture.

The choice of irrigation technique is a complex problem, which must be solved by specialists in the field by studying the diversity of irrigation installations / methods and the multiple application technologies for various crops.

Recent studies show that over 50% of agricultural production increases are mainly due to the application of irrigation. Choosing the right irrigation method is important for the type of crop, soil type, irrigated area, but is also important the choice of irrigation equipment, thus become essential. Maintaining the irrigation system at maximum efficiency can be achieved through good management of the system, through proper maintenance and operation, but also through careful monitoring of its functionality.

PART II

Chapter 4. Management of exploitation and maintenance of irrigation facilities in the West Region

Chapter 4 presents in the beginning the general problems of the management of an irrigation arrangement and the side effects that are manifested in the arrangement and operation of an irrigation system.

A well-designed and managed irrigation system reduces water loss through evapotranspiration, deep percolation and runoff, and minimizes erosion through applied water [4]. The application of these management measures reduces water waste, improves water use efficiency and reduces the total amount of pollutants from the application of irrigation. It also focuses on components to manage the timing, quantity and location of water applied to meet the water needs of the crop.

The following conditions and limitations have been identified regarding water management in an irrigation system:

- The flow of water in the irrigation system can be conditioned by other water consumption;
- by increasing the efficiency of water use in an irrigation system, the volume of water introduced into the arrangement will usually be reduced, the probability of introducing a polluting source into the arrangement will be reduced, but there is a risk of increasing the concentration of pollutants in the arrangement;
- the time between ordering and delivering irrigation water to the consumer may limit the ability to achieve maximum efficiency of use in operation;
- monitoring for soil control in soil profile;
- sprinkler irrigation to protect against frost or for cooling crops.

Irrigation systems consist of two basic elements: the transport of water from the source to the field and the distribution of water transported to the plant. A number of soil properties and qualities are important for the design, operation and management of irrigation systems, including water storage capacity, soil intake characteristics, permeability, soil condition, organic matter, slope, groundwater, soil erosion, properties chemical, salinity, sodium and pH.

The side effects that may occur in the arrangement and operation of an irrigation system are the following [18]:

- Anthropic salinization of the soil;
- Water loss;
- Soil and groundwater pollution;
- Destruction of soil structure.

In the second part of the chapter was briefly presented the Western Development Region comprising the counties of Arad, Caraş-Severin, Hunedoara and Timiş, highlighting the

characteristics of relief, climate, hydrography and water resources, biodiversity, soil and natural resources, and characteristics socio-economic, all of which interact directly or indirectly with irrigation activity.

The last part of Chapter 4 is dedicated to the presentation of the organizational structure of the National Agency for Land Improvement (ANIF) with the arranged surfaces. The presentation and analysis of the main irrigation facilities in the patrimony of the Romanian State in the Western Region revealed that most large systems are non-functional and only some of them are included in the National Rehabilitation Program of the Main Irrigation Infrastructure in Romania.

Research on the current situation of the land improvement sector deals with the problems of the factors involved in the operation, maintenance and repair of land improvement works. The steady decline in specialized personnel in all branches of the sector, recorded after 1990, raises particular management problems in exploitation and maintenance.

One of the causes of the significant decrease of irrigated areas in existing facilities is in addition to the degradation of the main and secondary infrastructure for irrigation, the lack of irrigation equipment, as shown by data analyzed from the database of the National Institute of Statistics and centralized data of ANIF for 2019. The irrigated area can be increased by equipping with modern irrigation installations and equipment, with a high degree of automation and control, and at the same time by identifying areas where arrangements can be made with minimal investment costs in arrangements local irrigation.

The detailed analysis of the degree of maintenance and operation of land improvement works and their ability to cope with interventions in case of natural disasters due to moisture deficiency was performed taking into account the nomenclature of works required and periodicity of execution.

Although until 1989 the land improvement sector benefited from dedicated financing and specialized personnel, irrigation facilities being an investment priority in agriculture, reaching a developed and functional area comparable to that of western states, the equipment and technologies were not the ones. more economically or efficiently suitable. The lack of a strategy to continue working in the land improvement sector after 1990, the legislation applied and the inefficient management of these facilities have further aggravated the problem of operation and maintenance of irrigation facilities. Thus, it is becoming important at the moment to find legislative solutions that allow the operation of land improvement systems in good conditions, and to allow major investments in infrastructure and equipment, both from private financing and with state support.

For the future European financial year scheduled for the years 2021 - 2027, a budgeted amount of approximately 2.5 billion euros from European funds is foreseen for the continuation in the National Program for Rehabilitation of the Main Irrigation Infrastructure in Romania, but funding sources are also sought. Alternatives for areas outside the areas arranged for irrigation in order to complete the area with local irrigation facilities.

Chapter 5. Current status of self-financed local irrigation facilities in the West Region

In recent years, in the West Region, mainly in the Western Plain, several investments have been developed in irrigation works consisting of local irrigation arrangements superimposed over drainage works with character of drainage or in undeveloped perimeter, with supply through existing infrastructure or by feeding directly from the water source.

This chapter presents the main local irrigation arrangements in different phases from the feasibility study, to the technical project, in implementation or in operation, in western Romania. The study presents 8 local irrigation arrangements that partially or totally overlap with areas that are part of drainage facilities. The local irrigation arrangements presented use modern sprinkler irrigation systems, such as those analyzed in Chapter 3.

The local irrigation arrangements presented are:

- Local irrigation arrangement in Sânnicolau Mare, Timiş County;
- Local irrigation arrangement in Birda, Timiş County;

- Local irrigation arrangement in Cenei, Timiş County;
- Local irrigation arrangement in Otelec, Timiş County;
- Local irrigation arrangement in Foeni and Giulvăz, Timiş County;
- Local irrigation arrangement in Otelec and Giulvăz, Timiş County;
- Local irrigation arrangement in Uivar, Timiş County;
- Local irrigation arrangement in Voiteg, Timiş County.

For example, "Local irrigation development in Uivar locality, Timiş County" is presented.

The investment objective is located in the territorial administrative area of Uivar commune, Timiş County. From the hydro-amelioration point of view, the lands overlap with the drainage arrangement Răuţi - Sânmihaiul German.

Irrigation planning consists of an irrigation system, using modern sprinkler irrigation systems, fed directly from the channels. The irrigation water is taken from the river Bega through the Proletaru Amonte water intake and transported to the irrigation system on the distribution channels. The investment is in the implementation phase. [88]

The total surface of the lands in the analyzed perimeter is of 991 ha with an effectively irrigated surface of 871.21 ha.

Table 47

The areas served in the local irrigation arrangement in Uivar locality,Timis County [88]

Crt. Nr.	Surface type	use	Total surface (ha)	percentage %
		arable (ha)		
1	Land area in the analyzed perimeter	991	991	100
2	Land area landscaping with irrigation works	871,21	871,21	87,91

The water source is the river Bega, the water being captured through the Proletarian Upstream water intake and additionally through the pumping station with mobile thermal aggregates.

The water is transported through the internal network of canals to the sprinkler irrigation systems. For the water supply of the installations, parts of the existing canals are used by resizing them and using irrigation canals with a double role. The canal network is completed with new canals or sections of canals, in order to be able to implement the irrigation project, without affecting the drainage capacity of the existing arrangement. The total length of the distribution channels is 11.83 km.

The network of existing exploitation roads on the site is not affected by the new spatial planning scheme, at the intersection with the newly designed canals bridges are placed to ensure free movement. The network of operating roads is completed with a length of 7.85 km. On the internal network of canals with double role of drainage - irrigation there are a number of 64 hydrotechnical works for water management and for ensuring safety in operation, consisting of bridges, damper bridges, dam bridges, dams, underpasses, concrete falls.

The sprinkler irrigation installations are of the fixed central pivot type - 2 pieces with lengths of 530 and 630 m, installation with linear displacement - 3 pieces with lengths of 420 and 750, installation with universal displacement - 1 piece with length of 366 m and installations with drum and hose with water cannon - 3 pieces with lengths of 420 m.

Figure 123 Local irrigation developments in Uivar locality, Timiş County [88]

Table 47 Areas served in the local irrigation arrangement in Uivar locality, Timiş County [88]

Crt. No.	Crop	Surface		Irrigation norm, m^3/ha		
		ha	%	Total		
1	wheat	800	81	1500		
2	corn	191	19	2800		
Total		991	100	-		
Indicator name				notation	U.M.	result
Average irrigation rate in July				m	mc/ha	1126
Hydromodule per hectare irrigated				qi	l/sxha	0.521
Watering efficiency				η	%	84
Hydromodule at the installation				q	l/sxha	0.620
Hydromodule at the motor pump				q	l/sxha	0.689
Losses				ηv	%	58
Hydromodule at the outlet				q	l/sxha	1.188
Required flow				Q	l/s	950
Total volume				V	mc	2052000

The main proposals for approaching the management of the irrigation sector in Romania follow the following aspects:

- implementation of a territorial computerized-digitized system of the irrigation facilities infrastructure, synthetically structured on designed, executed and existing hydrotechnical systems;
- completion of economic viability systems;
- keeping records of operating systems without investments;
- granting the status of "public utility" to gravity supply irrigation systems;
- establishing the list of priorities for investment systems in rehabilitation and modernization - modern irrigation infrastructure and installations;

For the drainage sector, several proposals are highlighted:

- the need to create a territorial digitized computer system;
- the importance of carrying out a specialized land improvement service to be equipped with emergency response machinery and equipment.

For the entire field of land improvement works, it is necessary to make sustainable use of natural resources essential to sustaining life for future generations, taking into account the impact of climate change characteristic of the current context: water, land, forest, climate, unconventional energy.

Chapter 6. Case study: The study of the uniformity of the irrigation application and of the water quality for irrigations within the local irrigation arrangement SC EMILIANA WEST ROM SRL Aranca.

In the first part of Chapter 6 was presented a local irrigation arrangement located in the Western Region, Romanian Plain - Aranca Plain, with the main general characteristic data on location, climate, relief, soil, and projected parameters.

The local irrigation arrangement is part of the Western Plain of Romania, a relatively flat plain with certain non-uniformity, given the presence of numerous valleys, hollowed areas, ridges and dunoid formations. [82]

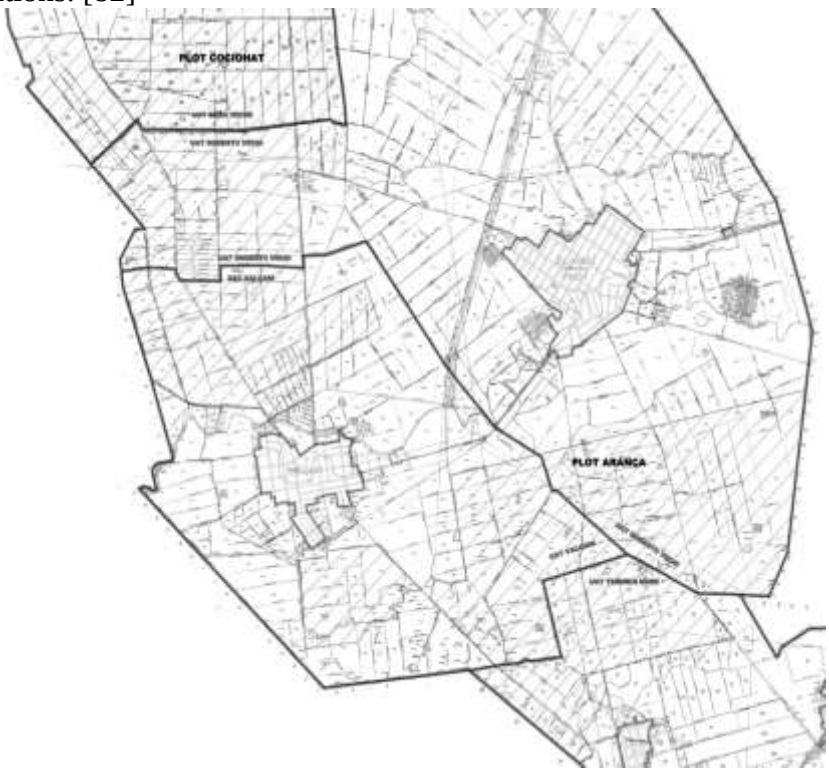

Figure 125 Overview of the location of the local irrigation system [82]

The local irrigation development implemented in the period 2012-2020 includes 4 plots: Aranca, Pivot 1, Pivot 2 and Cociohat, and overlaps over part of the Aranca drainage development. By repositioning and readjustment the main arrangement scheme on the perimeter interested in the works, the double functionality of the arrangement was ensured, being ensured both the main drainage role and the secondary irrigation role. In view of the increasingly pronounced climate changes in recent years in the analyzed perimeter, it is necessary to ensure the secondary role for irrigation, taking into account that the area was arranged between 1965 and 1974-1977 to ensure the evacuation of excess moisture from the soil by drainage.

The studied area within the local arrangement arranged for drainage and irrigation works is of 7,849 ha of which 6,711 ha represents the gross surface arranged for irrigations. The surface arranged with irrigation works executed so far is 4,752 ha.

Case study 1 regarding the uniformity of irrigation application for the 2 types of installations within the local irrigation arrangement was performed using 3 calculation methods, respectively the Cristiansen uniformity coefficient method, the Pearson coefficient of variation method and the field uniformity determination method.

The measurements for each irrigation system were performed using circular rain gauges with a diameter of 11 cm, the amount of water accumulated in each rain gauge was measured with a graduated cylinder and counted in a summary table.

Figure 134 View along the linear sprinkler irrigation system

Figure 135 Three-row arrangement of circular containers for sample collection

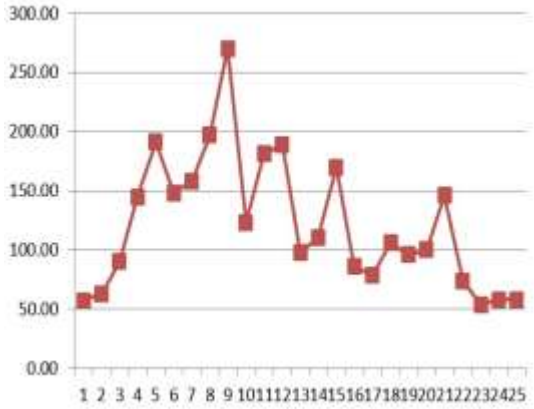

Figure 133 Graphical representation of the measurements on the central pivot Sprinkler irrigation system [62]

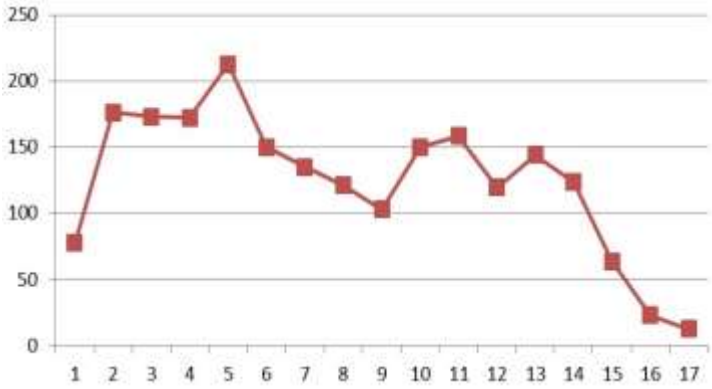

Figure 137 Graphical representation of measurements on linear sprinkler irrigation system [62]

For the fixed central pivot sprinkler irrigation system, the measurements were made by placing the circular collection containers on two rows at distances of 1 meter near the middle area of each beam along the installation. To correct the samples taken in certain sections, the circular collection containers were doubled. The results were centrally tabulated and represented graphically. Similarly, measurements were made for the linear displacement sprinkler irrigation system by placing circular collection containers in three rows at distances of 1 meter in the middle of the middle area of each span along the installation.

The analysis by the method based on the Cristiansen uniformity coefficient revealed that both the fixed central pivot type sprinkler irrigation system with a coefficient Cu = 67.68% and the linear displacement sprinkler system with a coefficient Cu = 66.71%, meet a stable uniformity.

The results obtained by the method based on the Pearson coefficient of variation showed an appreciation of non-uniform sprinkling, with a coefficient Cu = 40.87% for the fixed central pivot type sprinkler irrigation system, and also for the linear displacement sprinkler irrigation system with a coefficient Cu = 43.75%.

The determination of the uniformity of watering in the field resulted in an insufficiently watered area of 36%, a normally watered area of 32% and an excessively watered area of 32% for the fixed central pivot type sprinkler irrigation system. For the linear displacement sprinkler irrigation system, an insufficiently watered area of 23.53%, a normally watered area of 41.18% and an excessively watered area of 35.29% resulted.

By centralizing the results obtained by the 3 methods, in table no. 73 and table no. 74, it is found that the sprinkler irrigation installations type fixed central pivot and with linear displacement do not work at normal parameters and measures must be taken to remedy these deficiencies.

Table 73 Results control for the central pivot irrigation system [62]

Sum	-	9	8	8	67.68	40.87
Sn	-	1296	1152	1152		
P	-	36	32	32		
Appreciation	Non-irrigated surface	Insufficiently irrigated surface	Normally irrigated surface	Excess irrigated area	Stable uniformity	Uneven spraying

Table 74 Results control unit for linear displacement irrigation system [62]

Sum	-	4	7	6	66.71	43.75
Sn	-	576	1008	864		
P	-	23.53	41.18	35.29		
Appreciation	Non-irrigated surface	Insufficiently irrigated surface	Normally irrigated surface	Excess irrigated area	Stable uniformity	Uneven spraying

Case study 1 concludes that the 2 irrigation equipment's require a careful monitoring and adjustment of the operating parameters, the results showing an operation close to the optimal parameters, but with deficiencies in terms of uneven sprinkling.

Case study 2 analyzes and interprets the quality of irrigation water in the local irrigation system. Water sampling was performed by collecting water applied by sprinkler irrigation systems of the fixed central pivot type and with linear displacement, in normal operation. The water was collected in sterile containers and transported in suitable conditions so as not to affect the quality of the samples. The analysis of the water samples was performed in a certified laboratory, at a temperature of 25 ° C, using specialized software.

The interpretation of water quality for irrigation is based on the physic-chemical, biological and microbiological properties, taking into account the possible impact on soil, plants, environment

and consumers. Salinity is a common problem faced by farmers who irrigate in arid climates, due to the fact that all irrigation water contains soluble salts.

The results on the quality of water used for irrigation in the local arrangement of irrigations interpreted from the point of view of salinity classification show a slightly saline character with EC = 1,389 dS / m and TDS = 593 mg / liter, with no potassium and boron content. There is also no danger of salting, under proper management, based on the result ECw = 0.926 dS / m and SAR = 1.03 ions meq / liter units. In conclusion, water is of good quality depending on the value of CSR, suitable for most crops. A periodic qualitative analysis of the water used for irrigation inside the irrigation system, on the distribution channels, and permanent observation of the control sections on the different water sources, the Mureș River and the Aranca canal is recommended.

Water sampling was performed by collecting water applied by sprinkler irrigation systems of the fixed central pivot type and with linear displacement, in normal operation. The water was collected in sterile containers and transported in suitable conditions so as not to affect the quality of the samples. The analysis of water samples was performed in a certified laboratory, at a temperature of 25 ° C, using specialized software, the results being presented in figure no. 132.

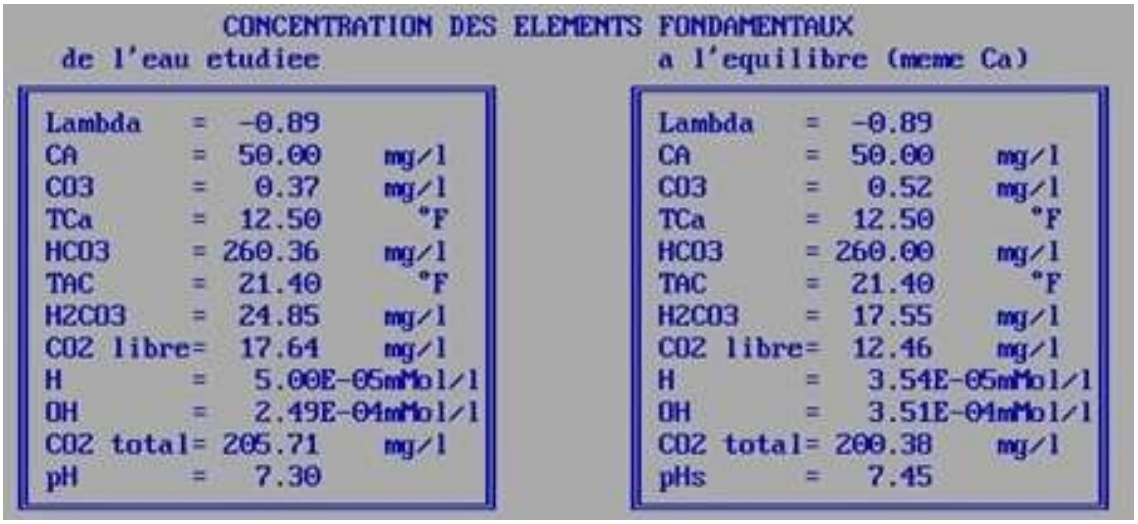

Figure 138 Data obtained after processing the samples in the laboratory [34]

Irrigation water quality is interpreted according to its physic-chemical, biological and microbiological properties, taking into account the possible impact on soil, plants, environment and consumers, humans or animals [63].

Table 75 Chemical, physical and biological parameters [63]

Chemical parameters	Physical and biological parameters
Salinity, ECw dS/m, TDS mg/l	Color
Acidity / Basicity, pH	
Hardness, CaCO3 mg/l	
Type and quantity of anions and cations, me/l	Smell
Sodium absorption rate, SAR	
Nitrogen, NO3–N mg/	Turbidity NTU
Phosphate, PO4–P mg/l	
Other, mg/l	BOD 5 mg/l (Biochemical Oxygen Demand)
Heavy metals, mg/l	

The results of the qualitative analysis of water for irrigation on the case study are presented in table no. 79.

Table 79 Chemical water analysis data sheet [63]

G.N. Pelea Locality: Sânnicolau Mare, Timiş, Romania				Date: 29.06.2015 Aquatim	
Remarks: water sample for irrigation					
LABORATORY RESULTS				Analyst: A.Cococeanu Date: 17.07.2015	
Electrical conductivity ECw dS/m: 0.926				pH 7.3	
anions	mg/liter	meq/liter	cations	mg/liter	meq/liter
Chloride (Cl^-)	90	2.54	Sodium (Na+)	40.2	1.75
Sulfate (SO4)	80	1.67	Potassium (K+)	none	none
Carbonate ($CO3^{--}$)	0.37	0.01	Calcium (Ca++)	50	2.50
Bicarbonate ($HCO3^-$)	260.36	4.27	Magnesium (Mg++)	40	3.28
Nitrate ($NO3^-$)	<1	<0.02	Boron (B)	none	none
Total	/	8.51		/	7.53
TDS	593				
Evaluation: SAR = 1.03 RSC = none					

Regarding the quality of water used for irrigation, although the case study shows that when taking and studying water samples it met the quality requirements, uncontrolled application of irrigation works can lead to accidental pollution or soil salinization, by accidental pollution of the source of water or by the slightly saline character of the water. A periodic qualitative analysis of the water used for irrigation within the irrigation system on the distribution channels and permanent observation of the control sections on the different water sources, the Mureş River and the Aranca canal is recommended [39]. Also, a close and permanent collaboration with the water management supervisory authorities, the Banat Water Basin Administration and the Arad Water Management System is recommended. In case of accidental pollution identified inside the irrigation system, it is recommended to close and locate the source of pollution or the polluted perimeter, alert the main network administrator represented by the National Agency for Land Improvements Timiş Branch and Timiş Environmental Guard, to take location measures and decontamination.

As a result of the reorganization of the centralized organizational structures for monitoring the operation and maintenance of land improvement facilities, it is necessary to implement the Regulation for operation and maintenance of land improvement works after receiving the works by the development administrator and the accidental pollution prevention and control plan. for monitoring the quality of water at the source, both regulations being indispensable in the authorization procedures for the operation of the works and in ensuring a sustainable management of the arrangement.

Chapter 7. Conclusions and personal contributions

Globally, the development of sustainable water and soil resource management policies within irrigation systems is based on several principles:

- the holistic approach of irrigation systems, in the form of a whole and therefore of a management that perceives the water and soil resource as part of a functional system in which the physical and biological components interrelate with each other;
- water and soil resource management must be part of a comprehensive long-term approach to the sustainable use of natural resources that includes ecological, economic and social aspects;
- the requirement for a balance between the trend of privatization and globalization of the economy and the role of society and the state in preventing the degradation of water and soil resources.

These issues of conservation and sustainable development of irrigation systems are not a priority issue in project planning and implementation. The current guidelines draw attention to the need to develop a sustainable management of water and soil resources that must be put into practice in the rehabilitation of primary irrigation infrastructure, otherwise these resources can be destroyed at an accelerated pace.

The paper addresses at a theoretical and practical level the current issues regarding the management of operation and maintenance of irrigation systems in Western Romania, in the context of climate change and the need to modernize, rehabilitate, refurbish and expand existing facilities.

The personal contributions in this paper are directed on several levels, among which I mention:

- bibliographic synthesis of the history of irrigation and the situation of irrigation works at global level, with the statistical presentation of irrigated areas and applied methods;
- bibliographic synthesis of the history of irrigation and the situation of irrigation works in Romania, with the statistical presentation of irrigated areas and the stage of functionality of irrigation facilities;
- study of irrigation methods, with implementation techniques and technologies, operation problems and maintenance methods;
- study of modern equipment for irrigation works, with state-of-the-art sprinkler and drip irrigation technologies and equipment;
- analysis of the management of the operation and maintenance of irrigation arrangements in the Western Region, identification of salinization-alkalization mechanisms and proposal of remedial solutions for heavily salinized and alkalized territories;
- monitoring the quality of water destined for irrigation and evaluating the causes of soil degradation with centralization of data for the forms of degradation manifested in the West Region;
- presentation of the structure of the National Agency for Land Improvement ANIF at local level, presentation of the main existing irrigation facilities in the state patrimony and statistical analysis of the state of their functionality, as well as identification of financing ways in the perspective of rehabilitation and modernization of irrigation facilities in the West Region;
- inventory of land improvement works in the Western Region;
- study on the current state of local irrigation facilities in the Western Region of Romania, presenting the main local irrigation facilities in various phases from feasibility study, to technical project, implementation or operation;
- presentation of the main characteristics of a local irrigation arrangement, calculation and analysis of the necessary water for irrigation, presentation and study of irrigation equipment;
- study of the uniformity of irrigation application for the fixed central pivot-type sprinkler irrigation system and for the linear displacement sprinkler irrigation system, by the methods of the Cristiansen uniformity coefficient, the Pearson variation coefficient and the field uniformity determination, within the arrangement local irrigation;
- establishing the correlations between the uniformity of watering application in irrigation systems and the forecast factors;
- the study of the water quality for irrigations, within the local irrigation arrangement, by the analysis from the point of view of the salinity of the water for irrigations;
- presentation of the sets of equations used to calculate the water requirement, its quality, but also the relationship between water and soil;

A number of issues presented in this paper have the potential for development in fundamental research topics in the field:

- detailing the influence of the climate regime on the availability for water of watercourses with the proposal of schemes for irrigation arrangements at basin level to supplement the flows in case of insufficient flows in dry years;

- studying the impact of pollution from diffuse sources on the quality of surface waters, in the conditions of the realization of some irrigation systems;
- sustainable use of land improvement works taking into account the impact of climate change characteristic of the current context;
- the possibilities of using unconventional energies in the operation of the Irrigation and / or drainage arrangements;
- deepening the processes that take place in the water-soil system within an irrigation arrangement with the identification of the influences on the soil type and the suitability on the type of land use.

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