REHABILITATION AND MODERNIZATION OF IRRIGATION PLOTS FOR CURRENT OPERATING CONDITIONS

Mihail LUCA[1], Andrei-Ștefan STICEA[2], Nicolae MARCOIE[1]

e-mail: mluca2015@yahoo.com

Abstract

The optimal exploitation of irrigation systems after 1989 imposed a series of conditions determined by the political regime, the form of land ownership, the labor shortage and the influence of climate change in the last period of time. Irrigation plots in Romania, basic components of large irrigation systems built before 1989, are in an advanced wear phase and no longer meet the current technical requirements in terms of management. A requirement for the existence of an irrigation system is dictated by the presence of viable water sources in terms of volume and permanence during the irrigation season. The form of private ownership of agricultural land imposed a restructuring of irrigated areas according to the way of association of owners. Climate change coupled with labor shortages in the agricultural sector has necessitated the adoption of irrigation methods that reduce the rate of irrigation and use automated irrigation equipment. The paper aims to present a series of directions for refurbishment and modernization of irrigation plots based on studies and research conducted in irrigation systems in Moldova.

Key words: irrigated area, labour, modernization, water source, rehabilitation

In 1989, Romania had an area of about 3,000,000 ha for irrigation. Irrigation systems were developed at a technical level corresponding to existing technologies and construction materials nationally and internationally between 1970 and 1989. Each irrigation system was structured on sectors / irrigation plots, where the irrigation plot was the basic unit in operating process. The irrigation arrangement had a general infrastructure for capturing, transporting and supplying water to the irrigation plots (Cazacu *et al*, 1982).

After 1989, the irrigated areas in Romania were reduced by the partial or total abolition of the irrigation systems (Nicolaescu *et al*, 2005). The situation created in Romania is not found in the other former socialist states, where the irrigated area has decreased very little (Simionova *et al*, 2005, Kireycheva *et al*, 2005, Zhovtonog *et al*, 2005) or even increased (Ligetvari *et al*, 2005).

Research conducted in the area of Moldova in the last period of time (Luca, 2012, Luca, 2015, Luca 2016, Luca, 2018b) has highlighted the state of advanced degradation of the infrastructure of irrigation systems still in operation (basic and re-pumping pumping stations, supply channels, secondary and distribution, discharge and supply pipes, hydrotechnic nodes on canals and pipes, etc.). The state of degradation of the canals causes high water losses through infiltration and a significant decrease in operating yields (Luca, 2020).

In 2005, an analysis was performed on how to implement irrigation systems in Romania in the current agricultural and climatic conditions (Nicolaescu *et al*, 2005). The achievement of this goal is hampered by a complex of factors, among which excel those of an economic, administrative, legislative nature and low state intervention in this area.

Climate change in the last 30 years has affected water resources, becoming dangers that can cause disasters both by excess (floods, pondings) and by the lack of them (drought, desertification). An analysis of the impact of climate change in the states of Southeast Europe found that a common danger is drought (Nicolaescu *et al*, 2005, Ligetvari *et al*, 2005). In 2007, the most severe drought in the last 60 years was registered in the eastern part of Romania (Cismaru *et al*, 2007). This situation was repeated in 2020 when the long period of drought compromised a large part of agricultural and horticultural crops.

The objective of the paper is the critical analysis of the current state of irrigation plots in operation and modernization methods in the context of reducing irrigated areas, existing climate change and the absence of labor in the eastern part of Romania.

[1] Techical University "Gheorghe Asachi" of Iași, Romania
[2] Technical University "Gheorghe Asachi" of Iași, Romania

MATERIAL AND METHOD

The material used in the research consists of a series of irrigation plots located in the eastern part of Romania, especially in the counties of Iaşi and Vaslui (*figure 1*). Irrigation plots were analyzed by technical expertise on the structural and functional condition of the components.

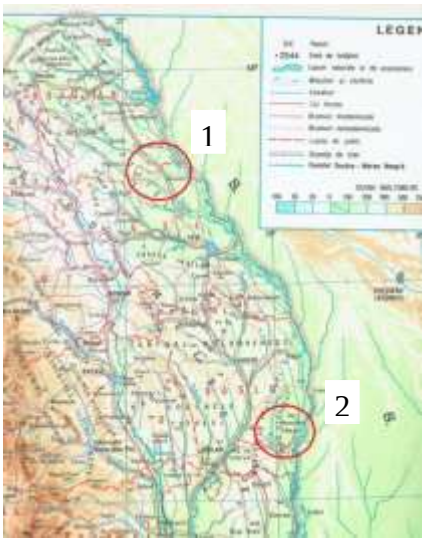

Figure 1 **Areas of study and research: 1 - South Soloneț irrigation system; 2 - Complex Irrigation and Drainage Development Albiţa - Fălciu**

The research area belongs to the arid climate zone of Romania (*figure 2*). The irrigation systems analyzed are fed from the Prut River.

Figure 2 **Characterization of the climate zone in N-E Romania**

Irrigation plots are located in the meadow and terrace areas of the Prut River. The basic pumping stations (SPB) take water from the Prut River and discharge it through pipes into the canals in the meadow and terrace area. The terrace area is supplied by the discharge pipes of SPB and SRP (pumping stations), which are connected to the supply and distribution channels. The pumping and pressurization stations (SPP and SPPM) of the irrigation plots are fed from the canals (Luca, 2015). The detailed description of the expert irrigation plots is presented in the works published by the authors (Luca *et al*, 2016; Luca *et al*, 2018; Luca *et al*, 2019).

A technical documentation was prepared for each irrigation plot. Technical expertise was performed for a series of irrigation plots. Field documentation analyzed the structural condition of the plot components based on known and accessible data. The data obtained through the technical expertises allowed the analysis of the current state of the constructive structure of the pumping stations, of the pipeline network, of the supply channels and of the hydrotechnical constructions related to the pipelines and roads, etc.). It should be mentioned that the structural elements of irrigation plots have been in operation for about 40 years (Luca, 2012; Luca, 2016; Luca *et al*, 2018; Luca, 2020).

The research method is the one used to carry out technical expertise for land improvement objectives and in particular, for systems with irrigation plots fed from pipes and canals (Luca *et al*, 2018).

For old and in-use irrigation plots, the updated topographic plans of the sites were used. Also, where possible, initial design documentation was analyzed. Through the analysis of the situation plans, the changes brought to the land surfaces were highlighted through rehabilitation works, but also for the formation of the new plot. The data processing followed the methodology used in the technical and scientific analyses developed for irrigation systems with canal and pipe networks.

RESULTS AND DISCUSSIONS

Modern irrigation systems in Romania were developed in 1965 - 1989 based on well-developed standard projects by design institutes. The source of water for irrigation was provided by the Danube River and its tributaries, the Olt, Siret, Argeş, and Prut rivers. Almost 70% of the irrigated area in 1989 had as a source of water the Danube River. Approximately 34% of Romania's irrigated area is located in the plain area (low and high) and approx. 40% in the area of hills and plateaus (Cazacu *et al*, 1989). The total irrigated area in 1989 was 3,006,092 ha, of which 2,664,799 ha by sprinkling, 291,583 ha by furrows and 49,730 ha by flooding (Nicolaescu *et al*, 2005).

Irrigation systems built before 1990 were structured on the following components: water intake construction, pumping stations (basic, pumping) for raising water at different levels, water transport channels (supply, distribution), water treatment plants pumping and pressurization of the pipeline network, hydrotechnical nodes with constructions and water diversion installations,

protection and control installations of the exploitation process, etc. (Cazacu *et al*, 1982).

The watering equipment used before 1990 was of the modern type for furrow watering (eg EUBA tubes) and sprinkler watering (self-moving aluminium pipes, pivot installations, self-moving hose drum etc.), but the automation of the watering process was deficient.

Agricultural production on irrigated land has decreased considerably. In 1992 and 1993 only about 20% of the landscaped area was irrigated, compared to 60-70% before 1989. Most of the sprinkler watering equipment and furrows were alienated and no longer belong to the irrigation sector. Failure to maintain the water pumping and transport facilities led to their degradation to the point of total destruction.

Much of the irrigation systems were dismantled after 1990 due to changes in land ownership and government decisions. The irrigated agricultural area at present in Romania is extremely small compared to the need (*table 1*).

Table 1

Irrigated areas in Romania after 1990 (Nicolaescu *et al*, 2005)

	1990	1992	1998	2000	2002	2003
AL	3,169	3,200	3,180	3,175	3,177	3,176
IA	70.0	15.9	7.40	6.80	15.4	17.9
AS – agricultural land area reclaimed for irrigation (thousand ha); IA - out of which: effectively irrigated (%)						

The infrastructure of large irrigation systems (catchment, basic pumping stations, supply channels, discharge pipes, etc.) is currently operated by the territorial administrations of land improvements. The management of the irrigation plots is done by the private units that own the irrigated lands. The predominantly current method of watering is sprinkler watering.

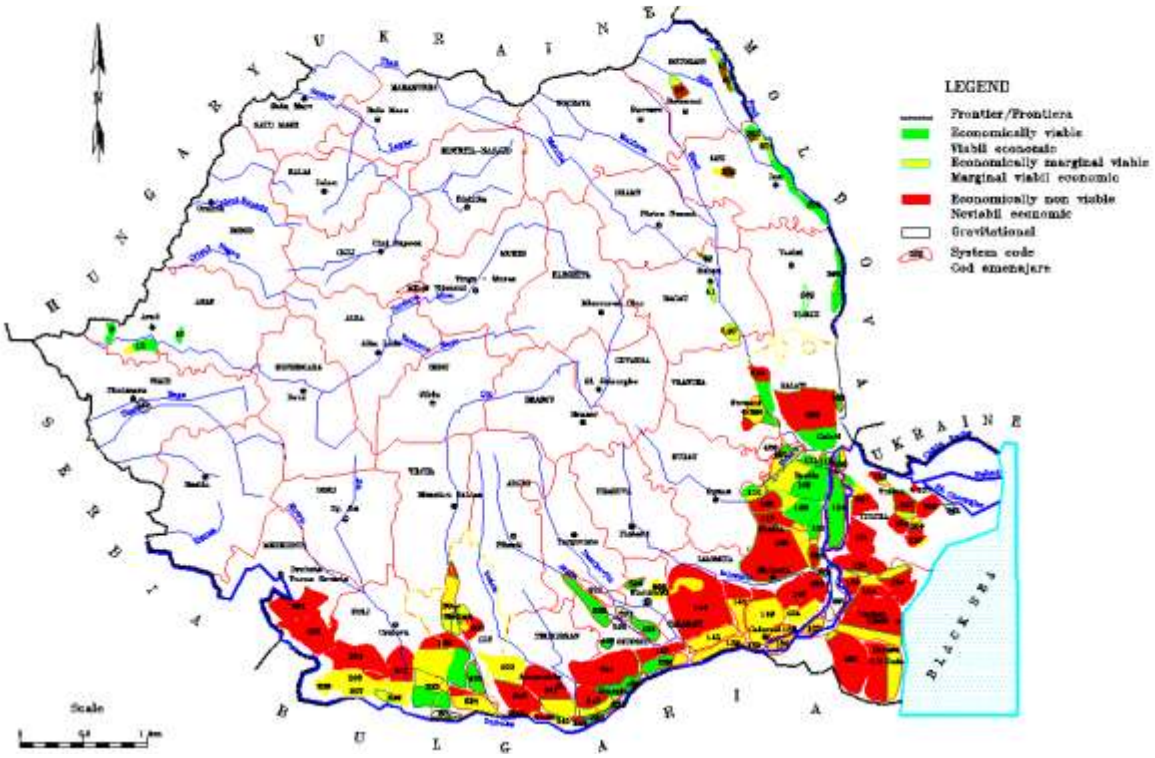

Figure 3 **Possible irrigated areas in Romania depending on economic indicators** (Nicolaescu *et al*, 2005)

Romania must comply with EU policies and directives on agriculture and rural development upon accession to the EU. Legislation in the field of agriculture and implicitly of irrigation must be adapted to the new requirements. The agricultural directives call for market liberalization, decentralization of the decision-making process and implementation of support programs. At the same time, a consolidation of the status of farmers is required, and implicitly those within the associations for the use of water for irrigation. The application of irrigation must not have a negative impact on the environment.

An analysis performed on potentially irrigable agricultural areas in Romania (Nicolaescu *et al*, 2005) indicates a series of areas (*figure 3*) that are viable in the current economic conditions. These areas are located near water sources that can provide the necessary volumes for irrigation with acceptable investments. The analysis of the map highlights the area of the Prut River (meadow and the first terrace) where there is still an irrigation infrastructure for a series of systems with large

areas. The Prut River has flows and volumes of irrigation water controlled by the accumulation from Stânca-Costești.

The irrigation systems built along the Prut River had as irrigation unit the irrigation plot. Irrigation plots were designed before 1990 to irrigate an area of 500 - 3000 ha. The pipe network of the plot for bivalent watering (*figure 4*) is supplied by a pumping and pressurizing station (SPP), or by a number of monofilament pumping stations (SPPM). The supply of pumping stations (SPP, SPPM) is made from a supply or distribution channel.

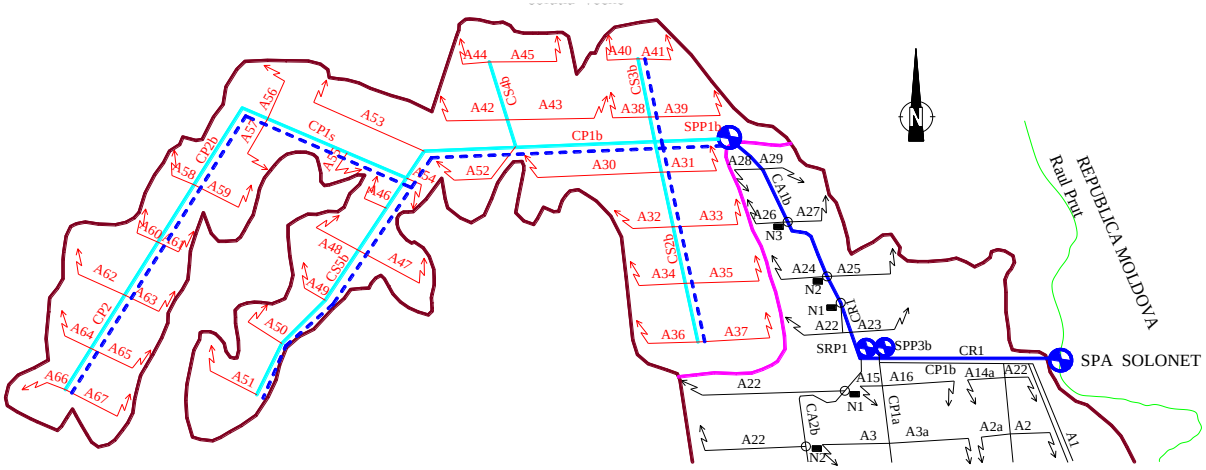

Figure 4 **Scheme for arranging the SPP1b South Soloneţ irrigation plot before 1990: continuous line - main / secondary high pressure pipelines; interrupted line - main / secondary medium pressure pipes** (Luca, 2015)**.**

A large part of the existing irrigation plots in the analyzed area have a network of pressure pipes fed by a pumping station (SPP) to serve bivalent watering (sprinkling + surface drainage). The network is branched, consisting of two rows of main and secondary pipes, which transport water to the irrigation equipment (Luca, 2012).

The pumping and pressurizing station (SPP) is equipped with two sets of pumps with differentiated flow and pressure. Pumps for surface drainage have high flow rates and medium pressures (P = 3.5–4.5 bar), and those for spraying have lower flow rates and high pressures (P = 7.0 – 8.0 bar). An example is represented by the pumping station from the SPP1b Irrigation Plot Solonet South with an area of 1428 ha, where the two types of pumps is present (*table 2*) (Luca, 2012).

Table 2
SPP 1b pumping aggregate parameters (Luca, 2012)

Vertical pump MV 253 x 4	**Vertical pump MA 200 x 5**
Q = 504 m³/h	Q = 230 m³/h
P = 8.50 bar	P = 4.50 bar
n = 1500 rot/min	n = 1500 rot/min
N = 200 kW	N = 55 kW
U = 380/660 V	U = 380/660 V
η = 60%	η = 55%
5 pumps	5 pumps

The modernization of the irrigation plots in the analyzed area, with a constructive and functional restructuring is imposed by the following requirements:

Figure 5 **Hydromechanical equipment at SPP1b Soloneț South for bivalent watering** (Luca 2012)

A - Restructuring the organization scheme of irrigation plots in order to correlate with the administrative conditions of agricultural land exploitation.

B - Restructuring the scheme of organization of irrigation plots to correlate with the existing volumes of water in the area and how to use them economically.

D - Restructuring the organization scheme of irrigation plots to correlate with the volume and presence of labour in the site area.

E - Restructuring the scheme of organizing old-type irrigation plots to correlate with the use of

modern irrigation equipment in order to increase operational safety.

The change of the political regime after 1990 in Romania determined important changes in the territorial and functional structure of the irrigation arrangements. The new land fund law, which returned the agricultural land to the original owners, changed the shape and size of the surface of the irrigation systems.

The division, but also the merging of the agricultural land in the new economic situation of agriculture contributed to the reorganization of the irrigation plots. In most cases, the catchments (outlets, pumping stations), water supply and distribution (canals, pipes) have remained intact and are in the state patrimony. The agricultural land with the irrigation plots was totally or partially reunited in associations coordinated by OUAI. New irrigation systems and plots no longer correspond in some situations in area to those designed 50 years ago. It follows in this case the need to restructure the irrigation plots as surface and as a network of pipes for water transport and distribution.

An example in this case is represented by the VII Doniceasa-Fălciu Irrigation Plot from the Albița - Fălciu Complex Irrigation and Drainage Development. The irrigated area after 1989 is reduced from 1664 ha to 1171 ha (Luca 2016). This situation requires a resizing of the structural and functional components of the irrigation plot.

Restructuring the scheme of organizing irrigation plots to be correlated with the existing volumes of water in the area requires the adoption of a method of watering with smaller volumes of water (sprinkling, dripping). At the same time, correct irrigation management must be achieved, taking into account the reduction of viable water sources and their high degree of pollution (Dimit *et al*, 1992). In this context, the following are required:

- recalculation of the irrigation regime parameters (irrigation norms, irrigation norm, module flow, SPP supply flow) considering the modification of the irrigated surface and water consumption in the modified climatic conditions (Luca *et al*, 2018a Luca *et al*, 2019); will be recalculated:

a – the watering hydromodule is determined by the relationship (Cazacu *et al*, 1982):

$$q_u = \frac{1000\, m}{T\, t} \quad (1)$$

b – the relationship of the irrigation plot sizing flow calculation is (Stăncescu *et al*, 1984):

$$Q_{PI} = S q_{u,pond} \frac{1}{\eta_c} \frac{1}{\eta_r} \frac{24}{t} \quad (2)$$

which is verified with the relationship

$$Q_v = \sum Q_{av} \frac{1}{\eta_r} \quad (3)$$

where the notations in relations (1), (2) and (3), used have the meaning: q_u is the watering hydromodulus; q_{up} - medium weighted watering hydromodulus; m - watering norm; T - the number of days considered in the peak month; t - watering time per day; S - wetted area; η_c - watering efficiency in the field; η_r - network yield downstream of the pumping station; t - actual hours of operation of the watering equipment (in ec. 2); Q_v - verification Flow Q_{av} - the sum of flows downstream of the calculated item.

- resizing the parameters of the SPP pumping station operating point (Q_{SPP}, H_{SPP}) following the replacement of medium pressure pumps with high pressure pumps;

- resizing the network of pipes to supply modern sprinkler irrigation systems; design of supply nodes (irrigation hydrants) with appropriate diameters and flows.

The restructuring of the scheme of organization of irrigation plots in order to correlate with the current climatic conditions in the area of Moldova requires the following directions of rehabilitation and modernization:

- the climatic conditions in the area of Moldova are characterized by the presence of extreme and lasting droughts, returning to a few years; the precipitation volume in the period 1981 - 2010 on the Romanian territory was of 583.0 l/m^2, compared to 451.4 l/m^2 in the respective eastern area, by about 25% less;

- efficient use of irrigation water by reducing water losses in the transmission and distribution network (canals and pipes);

- the largest water losses occur on the network of canals and supply pipes belonging to the territorial operating units of the state; they are in an advanced state of degradation and very few segments have been rehabilitated recently;

- high water losses are on the network of pressurized pipes of the irrigation plots in operation of the owners or OUAI; a number of irrigation plots have been rehabilitated and modernized recently, but some of them not to the modern technical requirements (especially the pipeline network).

Restructuring and modernization of irrigation plots is required by reducing the volume of labour in the site area. This situation is obvious lately in the eastern part of Romania. The modernization requires the use of high-performance watering equipment with an automated watering process (pivot-type watering systems, longitudinally self-moving watering systems, etc.).

The use of modern sprinkler irrigation systems requires a restructuring of the pipeline network of the irrigation plot. The pipeline network was designed for a type of watering equipment (fixed sprinklers type IIA, IIAM and mobile IATL), little used today. The pipeline network needs to be redesigned as a scheme, diameters, material and supply nodes.

Bringing the infrastructure of the irrigation system to the level of current technology requires the realization of an extensive program of rehabilitation and modernization of the canal network, as well as the related constructions and installations.

The optimal exploitation of the irrigation systems in the conditions of the current administration of the territory, corroborated also with the influences of the climatic changes of the last years, as well as with their restructuring considering the labor force deficit, requires a series of rehabilitation and modernization works.

CONCLUSIONS

1. The infrastructure of the irrigation systems in operation in Romania is the least rehabilitated and modernized component after 1990.

2. The scheme of organization of irrigation plots needs to be restructured to correlate with the type of ownership of agricultural land.

3. The locations of the irrigation systems must be chosen to correlate with the volumes of water existing in the area and the way of access to the water source.

4. The scheme of organization and management of irrigation plots must be modernized to correlate with the presence and volume of the existing workforce in the site area.

5. Functional parameters of irrigation plots must be recalculated to correlate with the conditions imposed by current climatic characteristics, and in particular by the prolonged presence of droughts in the eastern part of Romania.

6. The scheme of organizing old-type irrigation plots needs to be completely modernized for the use of modern irrigation equipment, but also in order to reduce energy consumption and increase the runoff in operation.

7. Reducing water losses from the source to its distribution to plants throughout the network of pipes and irrigation equipment is a current requirement for modernization of irrigation plots.

REFERENCES

Cazacu E., Dorobanţu M., Georgescu I., Sârbu E., 1982 - *Amenajări de irigaţii*. Edit. Ceres, Bucureşti.

Cismaru C., 2004 – *Irigaţii: amenajări, reabilitări şi modernizări*. Ed. Politehnium, Iaşi.

Dimit A. K., McLaughlin K. I., Kamand F. Z., Welc D. G., **1992 -** *Planning for water conservation though irrigation system modernisation and rehabilitation*. Proceedings of the Irrigation and Drainage Sessions at Water Forum, ASCE, 294 – 299.

Kireycheva L. V., Glazunova I. V., Belova I. V., 2005 - *Irrigation sector reform in central and eastern European country, Russian Report*. Ed. Deutsche Gesellschaftfur technische Zusammenarbeit (GYZ) Gmbh, 463-524.

Ligetvari F., Cselotei L., *et al*, 2005 - *Irrigation sector reform in central and eastern European country, Hungarian Report*. Ed. Deutsche Gesellschaftfur technische Zusammenarbeit(GYZ) Gmbh, 161-250.

Luca M., 2012 - *Expertiza tehnică a Staţiei de pompare SPP 1b din obiectivul de investiţii „Modernizarea si retehnologizarea staţiilor de pompare pentru irigaţii a Aqua Soloneţ Nord Bivolari, judeţul Iaşi*. S.C Polias – Instal S.R.L. Iaşi.

Luca M., 2015 - *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Agro Irig Prut Berezeni", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Luca M., **2016 -** *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Doniceasa-Fălciu", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Luca M., Luca Al. L., Toma D., Tămăşanu F., 2018a - *Considerations on the modernisation of monofilament pumping stations for sprinkling irrigation*. Lucrări Ştiinţifice vol. 61, nr. 2/2018, seria Agronomie, USAMV Iaşi, 157-16.

Luca M., Luca A.L., Toma D., Tămăşanu F., 2018b - *Considerations on the expertise of pumping plants from irrigation systems*. Lucrări Ştiinţifice vol. 61 nr. 2/2018, seria Agronomie, USAMV Iaşi, 163-168.

Luca, Al. L., Logigan I., Luca M., Tămăşanu F., 2019 - *Researches on the modernization of the conduct network from old pressure irrigation systems*. Lucrări Ştiinţifice, vol. 62(1)/2019, seria Agronomie, USAMV Iaşi, 23-29.

Luca M., 2020. - *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Oţetoaia", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Luca Al., L., Luca M., Juncanaru Oana-Ştefania, Ilie G., 2016 - *Considerations on rehabilitation of irrigation sprinkler plots - rehabilitation of the pumping stations*. Lucrări Ştiinţifice, vol. 59/2016, seria Agronomie, USAMV Iaşi, 117-120.

Nicolaescu I., Bunociu L., *et al*, 2005 - *Irrigation sector reform in central and eastern European country, Romanian Report*, Ed. Deutsche Gesellschaftfur technische Zusammenarbeit (GYZ) Gmbh pp. 385 - 461

Simionova S., Yusuf S., Florov V., Ninova M., 2005 - *Irrigation sector reform in central and eastern European country, Bulgarian Report*. Ed. Deutsche Gesellschaftfur technische Zusammenarbeit(GYZ) Gmbh, 41-103.

Stăncescu, L., Moraru, N., Ionescu, V., Leinweber, L., **1984 -** *Îndrumător tehnic pentru lucrări de îmbunătăţiri funciare*. Edit. Ceres, Bucureşti.

Zhovtonog O.,Kovalenko P., Filipenko L., *et al*, **2005**. *Irrigation sector reform in central and eastern European country, Ukranian Report*. Ed. Deutsche Gesellschaftfur technische Zusammenarbeit(GYZ) Gmbh, 607-667.