IRRIGATION AS A FACTOR OF ECONOMIC SUSTAINABILITY OF AGRICULTURAL PRODUCTION

Nataša Kljajić[1], Zorica Sredojević[2]

Abstract

The subject of research in this paper are the economic parameters of application of irrigation, as important agro-technical measure in agricultural production of the Republic of Serbia. Measures considered are based on the available data of the SORS and the records of other relevant institutions, ten-year trends of irrigated areas, sources of water intake, and more importantly ways of applying irrigation. The aim of the research is to analyze the results of the development so far, to consider the shortcomings and the possibility of improving the irrigation measure in the agricultural practice of the Republic of Serbia.

Key words: *water abstractions, areas, irrigation methods.*

Introduction

The Republic of Serbia has favorable land and water potential for intensive agricultural production. Areas suitable for agricultural production are most common in the north of the Republic of Serbia and in the valleys of watercourses. "Serbia experienced considerable land use changes in the first half of the nineteenth century due to an increased demand for agricultural products" *(Tolimir et al., 2020)*. Efficient, high and stable agricultural production is limited by a large number of factors, among which are among others, insufficient but also unevenly distributed precipitation in the vegetation period as well as the occurrence of shorter or longer dry periods *(Kljajić, 2014)*. Therefore, in our climatic conditions, the need for irrigation is more and more pronounced, both through the construction of new systems and through a higher degree of utilization of existing ones. The application of irrigation leads to multiple benefits, such as: rational use of natural resources; reduction or complete elimination of the effects of drought; favorable harmonization of soil-water-plant-atmosphere relations; high yields (production volume); higher income, and thus a better standard of living *(Sredojević & Gajić, 2020)*.

1 Nataša Kljajić, Ph.D., Research Associate, Institute of Agricultural Economics, Volgina Street no. 15, 11060 Belgrade, Serbia, Phone: +381 60 484 95 550, E-mail: natasa_k@iep.bg.ac.rs

2 Zorica Sredojević, Ph.D., Full Professor, University of Belgrade, Faculty of Agriculture, Nemanjina no. 6, 11080 Belgrade, Phone: +381 11 441 32 97, E-mail: zokas@agrif.bg.ac.rs

In general, irrigation is very important in modern plant production, especially on landscaped areas with regulated excess water. When applied correctly, more advanced cultivation of agricultural crops with safe, high and quality yields is achieved, according to the needs of industry and the market. In order for irrigation to give the maximum effect, it is necessary to pay attention to the appropriate choice of technology that will be applied and the choice of irrigation method, i.e. type of system, all with the goal of rational and economical supply of water to plants. Appropriate watering norms must be determined, and attention must be paid to the quality of water used for irrigation, due to the consequences of increasing pollution of the affected waters *(Kljajić, 2012)*. When planning production in irrigation conditions, it is necessary to consider in detail the economic advantages and disadvantages, as well as the environmental consequences. "Costs that address the issue of environmental liability, in some cases, exceed the value of the assets in many cases, so that their precise calculation requires determination of the ecological, physical, geological and hydro-geological characteristics of the site, as well as the type and quantity of harmful substances"*(Sredojević et al., 2019)*.

Therefore, the subject of research in this paper is the analysis of selected economic parameters of the current development of irrigation in our country. The aim of the research is to examine the trends in the movement of irrigated areas, sources of intervention and methods of irrigation in the past ten years, in order to improve and more efficient application of this agro-technical measure.

Material and Methods

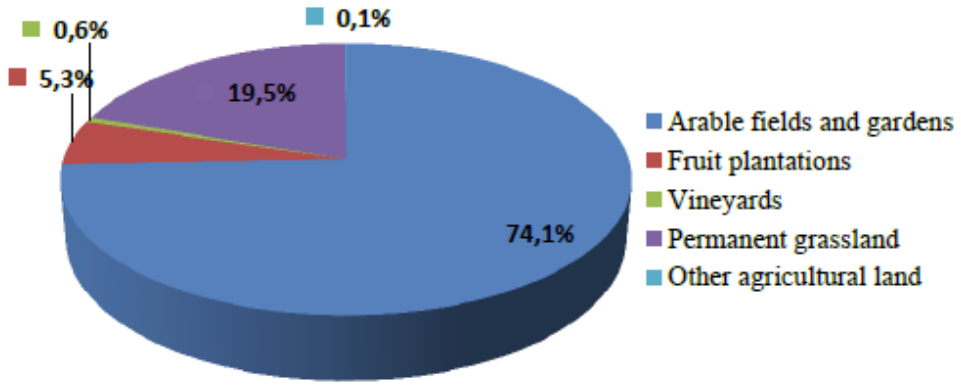
For the research in this paper, the databases of statistical data of the Statistical Office of the Republic of Serbia were used, as well as data from the records of other relevant institutions in the Republic of Serbia. The structure of use, agricultural areas ten - year trends in the representation of areas under irrigation, the distribution of areas suitable for irrigation, sources of water abstraction, as well as areas under certain ways of irrigation application are considered.

Results and Discussions

Irrigated areas in the Republic of Serbia - Out of the total available land area in the Republic of Serbia, the used agricultural area is 3,481,567 ha *(SORS, 2020)*. Of that, 2,578,898 ha are arable land and gardens, 675,314 ha are grasslands (meadows and pastures), then 206,228 ha are under perennial plantations (orchards, vineyards, nurseries, etc.), and 21,127 ha are backyards. In

the total used agricultural area in 2019, arable land and gardens participated with 74.1%, orchards with 5.3%, vineyards with 0.6%, meadows with 9.9% and pastures with 9.5% (Graph. 1).

Figure 1. Structure of used agricultural land, 2019.



Source: https://publikacije.stat.gov.rs/G2020/Pdf/G20201006.pdf

From the aspect of convenience of application of irrigation measures, the following classes of land can be distinguished *(Miljković, 2005):*

- *Class I* - deep soils suitable for irrigation without restrictions, with systematic periodic control of the quantity and quality of irrigation water and groundwater regime "first" issued;
- *Class II* - deep and medium deep soils suitable for irrigation with some caution, due to degradation processes under the influence of which they were in the past;
- *Class IIa* - medium-deep soils suitable / conditionally suitable for irrigation (valley soils with present variability in morphological, physical, water-physical and chemical terms);
- *Class III* - soils conditionally suitable for irrigation, clay mechanical composition, stagnation, salinity and alkalinity;
- *Class IIIa* - deep soils (mostly hydromorphic), which requires appropriate drainage and dispersal of unfavorable layers;
- *Class IIIb* - medium-deep soils, which requires appropriate drainage, application of small amounts of physical and chemical means for soil repair and other land reclamation measures;

- *Class IIIv* - deep, medium deep to shallow soil, which requires appropriate drainage and application of significant physical and chemical means for soil repair.

Suitable lands for irrigation include all class I and class II (IIa) lands, as well as class III lands that require partial (IIIa) or complex reclamation (hydro, agro and chemical - IIIc). Class I and II land is dominant in the northern part, and class IIa land is represented in the central and southern part of the Republic of Serbia. Class IIIa and IIIb land is evenly represented on the entire territory of the Republic, while class IIIc covers longer parts of the Podrinje-Kolubara area and the entire territory of the upper Morava area. In our country, without restrictions or with some caution, about 1.9 million ha can be irrigated, of which about 70% on the territory of AP Vojvodina. Conditionally suitable lands for irrigation, with significant previous investments, cover about 2.6 million ha, which together with the previous classes makes almost 4.5 million ha (Table 1).

Table 1. Distribution of areas suitable for irrigation (ha)

The class land	Water areas						Total
	Bačka and Banat	***Srem***	***Belgrade***	***Sava***	***Morava***	***Lower Danube***	
I	444,749	98,633	14,414	1,470	23,000	51,224	633,490
II	706,622	105,560	36,249	7,553	2,636	23,471	883,091
IIa	14,685	1,176	32,690	48,352	221,160	63,990	382,053
IIIa	241,488	42,101	78,600	18,109	278,784	129,181	788,263
IIIb	285,080	92,405	105,841	43,600	413,220	90,618	1,030,764
IIIv	79,122	21,718	38,463	269,692	179,600	150,245	738,840
Un-suit-able	1,803	14,463	18,427	631,003	2,063,202	561,866	3,290,764
Svega:	1,773,549	377,056	324,684	1,019,779	3,181,602	1,070,595	7,747,265

Source: https://www.jcerni.rs/oblasti/navodnjavanje-i-odvodnjavanje/

Irrigation in our country is not at a satisfactory level, neither in terms of volume nor in terms of technical equipment, and therefore not in terms of the degree of use. Economic problems have caused stagnation in all economic branches of our country, including agriculture and even irrigation. Looking back at a period of ten years, it can be stated that less than 1.5% of arable land is intensively irrigated. The most common reasons for the low level of use of existing irrigation systems are the unfavorable position of agriculture, insufficient equipment of farms with irrigation equipment, as well as the general lack of financial resources for maintenance of devices and operation of irrigation systems.

The unsatisfactory volume of irrigation in our country can be seen on the basis of the data in Table 2, which are for the period 2010-2019, where the areas and methods of irrigation are shown.

Table 2. Areas and methods of irrigation in the R. of Serbia, 2010-2019.

Years									
2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Used agricultural land (000 ha)									
5,091	5,058	5,056	5,069	3,505	3,468	3,440	3,438	3,437	3,437
Irrigated land (ha)									
25,128	34,175	52,986	53,086	44,882	54,696	43,486	50,366	46,937	46,863
The share of irrigated areas in the total used agricultural land (%)									
0.5	0.8	1.0	1.0	1.3	1.8	1.3	1.5	1.4	1.4
Surface irrigation (ha)									
1,261	1,525	2676	707	141	127	53	94	51	59
Sprinkling (ha)									
22,442	30,965	47,742	49,403	42,215	52,200	40,651	47,374	44,065	43,253
Dripping (ha)									
1,425	1,685	2,567	2,976	2,526	2,369	2,782	2,898	2,821	3,550

Source*:* https://publikacije.stat.gov.rs/G2020/Pdf/G20201006.pdf

Irrigation is applied in a small percentage in relation to the total used agricultural land. The dominant method of irrigation is sprinkling (artificial rain), followed by drip or drip system, while surface irrigation is applied to the least extent, to the least agricultural areas. There are about 2,000 ha on technically rounded systems on the experimental estates in agricultural schools, while locally, around the backyards, there are on about 10,000 ha of technically unrounded systems, so that under the built systems in public and private ownership there are about 145,000 ha, while some the form of irrigation covers a total of about 100,000 ha of agricultural land (Water Management Strategy on the territory of the Republic of Serbia until 2034). According to the data of the distributors of irrigation equipment, in addition to the mentioned areas, another 45,000 ha are irrigated with individual privately owned systems (Table 3).

Table 3. Irrigated areas in public and private ownership, 2012.

No.	Name of the water area	Surface area (ha)			Total in function
		Public property*	Private property **	Technically rounded	
1.	Bačka and Banat	29,028	10,136	6,055	45,219
2.	Srem	1,134	1,853	1,112	4,099
3.	Belgrade	1,912	2,435	1,095	5,442
4.	Sava	5,000	5,076	2,538	12,614
5.	Morava	3,840	6,000	2,400	12,240
6.	Lower Danube	no data	4,500	1,800	6,300
Total:		40,914	30,000	15,000	85,914

Source: Water Management Strategy on the territory of the Republic of Serbia until 2034, reference year 2012.

Notice: * data from public water companies

** equipment distributor data

Mostly surface water is used for irrigation by direct abstraction from rivers, regional hydro systems, reservoirs and canal networks. Groundwater sources for irrigation are most often wells within the "first" issued (groundwater reservoirs, formed in aquifers of the Late Quaternary), which is shown in Table 4.

Table 4. Use of water for irrigation, 2011-2019.

Abstracted / taken water, 1000 m3 per year									Average
2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
Underground waters									
1,400	5,768	4,535	1,26	7,131	2,094	3,322	3,437	3,466	3,642.1
Watercourse									
61,168	100,160	80,027	47,640	75,952	40,381	67,382	48,159	61,020	64,654.3
Reservoirs and lakes									
3,224	4,401	3,213	1,297	5,368	2,811	4,520	2,918	-	***3,469***
Plumbing system									
-	116	355	33	54	30	41	-	-	***104.8***
Total									
66,092	110,45	88,130	50,596	88,505	45,316	75,265	54,540	67,692	

Source: https://www.stat.gov.rs/

Observing the period 2011-2019, it can be stated that in Serbia, on average, a total of 71,8420,000.3 m3 of water is captured, namely 3,642,000.1 m3 from groundwater, 64,654,000.3 m3 from watercourses, 3,469,000 m3 from reservoirs and lakes and 104,000.8 m3 of water supply. About 70% of the world's water consumption goes to agriculture. That is why the topic of more rational consumption of water for irrigation is becoming more and more topical today *(Petković, 2003)*.

Irrigation improvement options - Experience from agricultural practice has recently shown that in our natural conditions, irrigation should not be treated only as an intervention measure to achieve high and stable yields. The importance of irrigation is far greater and is especially pronounced when introducing a modern and diverse sowing structure with plant crops that have fairly high water requirements. In some areas where irrigation is planned, there is a need to address drainage, so a double system should be applied. New irrigation systems should be built on lands of I, II, IIa, IIIa and IIIb classes of irrigation suitability. The water management bases of the Republic of Serbia envisage that the largest part of the system will be built by applying artificial rain, on over 90% of the areas. Drip irrigation will be applied in perennial plantations (orchards and vineyards), and only in newly designed ones. Surface irrigation (furrows, overflow) will be present on smaller local irrigation estates, and subrogation in the valleys of larger rivers, especially on those parts of alluvial plains (marshes) that are affected by slowdown on those rivers. The pace and direction of irrigation development will depend primarily on the strategy of agricultural production development (Water Management Strategy on the territory of the Republic of Serbia until 2034, "Official Gazette of RS", No. 3/2017).

According to *Sredojević et al*. (2020), "the realization of investments in irrigation achieves positive effects of sustainable use of natural resources, improvement of the quality of the environment and general, socio-economic and economic development of society". Economic indicators of investment justification are determined as the difference and the ratio between the amount of total investments made and night income that are achieved during the investment period. "In the case of public-private partnerships, with key indicators of economic viability and financial acceptability of the site, the analysis should show the financial effects that can be shared between the public and private sectors within the partnership" *(Stanković et al., 2013)*. Investments in the irrigation system depend on the type of mobile equipment, irrigation hydro module, location of water intake, distance of energy sources, terrain configuration and others. The real development of irrigation presupposes the provision of technical, economic and social conditions. As they state *Potkonjak & Mačkić (2010),* an important factor in the development of irrigation is the structuring of primary agricultural production. Identification of all water users and relevant natural and socio-economic factors has a significant impact on irrigation, defining the water balance, existing and potential users and investor decisions. As part of the analysis of society from the aspect of water management, an integral part is the identification of stakeholders.

Conclusion

Based on the stated facts related to the statistics on irrigated areas in the Republic of Serbia, the general assessment is that irrigation is not at a satisfactory level and is not harmonized with the needs and possibilities of agriculture and water management. In the structure of irrigated crops, about 93.5% are field and vegetable crops, while only about 4.3% are modern orchards. Over 88% of water is taken from rivers and canals, while other areas are irrigated from groundwater, lakes and reservoirs. Irrigation by sprinkling is most common (93.9%), and about 6% by drip irrigation (most often irrigation of modern orchards and vineyards), and now the prevailing understanding is that the production of vegetables and seed crops is possible without modern irrigation systems.

The share of modern irrigation equipment - typhoon and drip irrigation - as the most economical method of irrigation is gradually increasing. The results of research in this paper show that, despite good natural conditions for the application of irrigation, it is insufficiently applied and currently has a negligible role in the development of overall agricultural production in our country. When creating the optimal variant of the system, it is necessary to perform an economic analysis with detailed economic parameters, with the aim of finding the most accurate water prices at the water intake and the final price for the user.

Note: The paper is the result of research within the contract on the implementation and financing of scientific research in 2020 of the Ministry of Education, Science and Technological Development of the Republic of Serbia, researchers at the Institute of Agricultural Economics, Belgrade, and researchers at the Faculty of Agriculture, Belgrade-Zemun, No. 451-03-68/2020-14/200116.

Literature

1. Kljajić, N. (2012): *Ekonomska efikasnost investicija u različitim uslovima proizvodnje maline.* Doktorska disertacija, Poljoprivredni fakultet Univerziteta u Novom Sadu. [in English: Kljajić, N. (2012): *Economic efficiency of investments in different conditions of raspberry production.* Doctoral dissertation, Faculty of Agriculture, University of Novi Sad]
2. Kljajić, N. (2014): *Efikasnost investicija u proizvodnji maline*. Monografija, Institut za ekonomiku poljoprivrede, Beograd, str. 197 [in English: Kljajić, N. (2014): *Efficiency of investments in raspberry production.* Monograph, Institute of Agricultural Economics, Belgrade, p. 197]

3. Miljković, N. (2005): *Meliorativna pedologija*. Univerzitet u Novom Sadu, Poljoprivredni fakultet, JVP "Vode Vojvodne", N. Sad, str. 550 [in English: Miljković, N. (2005): *Reclamation pedology.* University of Novi Sad, Faculty of Agriculture, JVP "Vode Vojvodne", N. Sad, p. 550]
4. Petković, S. (2003): *Strategija razvoja navodnjavanja u Srbiji*. Vodoprivreda, Vol. 35, br. 1-2, str. 50-60. [in English: Petković, S. (2003): *Irrigation development strategy in Serbia*. Vol. 35, no. 1-2, p. 50-60]
5. Potkonjak, S., Mačkić, K. (2010): *Proizvodno-ekonomski efekti navodnjavanja sa posebnim osvrtom na male površine*, Savremena poljoprivredna tehnika. Vol. 36, No.3, str. 256-266. [in English: Potkonjak, S., Mačkić, K. (2010): *Production-economic effects of irrigation with special reference to small areas*, Modern agricultural technology. Vol. 36, No.3, p. 256-266]
6. Sredojević, Z., Gajić, B. (2020): *Analiza troškova i koristi kao deo procene održivosti projekta za sanaciju zemljišta: Studija slučaja.* Knjiga sažetaka, Simpozijum – Navodnjavanje i odvodnjavanje u svetlu klimatskih promena, 9-11. Sept., Vršac, str. 17 [in English: Sredojević, Z. & Gajić, B. (2020): *Cost-Benefit Analysis as Part of a Land Remediation Project Sustainability Assessment: a Case Study.* Book of Abstracts, Symposium - Irrigation and Drainage in the Light of Climate Change, 9-11. Sept, Vršac, p. 17]
7. Sredojević, Z, Kljajić, N., Gajić, B. (2019): *Brownfield Investments as Possibility of Revitalization and Sustainability of Locations*. Economics of Agriculture, Belgrade, Year 66, No 2, pp. 589-599.
8. Stanković, B. & Vignjević-Dordević, N. (2013): *Javno-privatno partnerstvo i koncesije, kao posebni oblici stranih ulaganja u Srbiji*. Banja Luka: Časopis za ekonomiju i tžišne komunikacije, God./Vol. 3 br. 2, pp. 285-298. [in English: Stanković, B. & Vignjević-Dordević, N. (2013): *Public-private partnership and concessions, as special forms of foreign investments in Serbia*. Banja Luka: Journal of Economics and Communications, God./Vol. 3, No. 2, pp. 285-298]
9. *Strategija upravljanja vodama na teritoriji Republike Srbije do 2034 godine* ("Sl. glasnik RS", br. 3/2017) [in English: Water management strategy on the territory of the Republic of Serbia until 2034 ("Official Gazette of RS", No. 3/2017)]

10. Tolimir, M., Kresović, B., Zivotić, Lj., Dragović, S., Dragović, R., Sredojević, Z., Gajić, B. (2020): *The conversion of forestland into agricultural land without appropriate measures to conserve SOM leads to the degradation of physical and rheological soil properties*. Scientific Reports 10, 13668, https://doi.org/10.1038/s41598-020-70464-6
11. *Vodoprivredna osnova Republike Srbije*, 2001, Ministarstvo poljoprivrede, šumarstva i vodoprivrede Republika Srbija, Istitut za vodoprivredu "Jaroslav Černi" Beograd, juni 2001. [in English: *Water Management Basis of the Republic of Serbia*, 2001, Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, Institute of Water Management "Jaroslav Černi" Belgrade, June 2001]