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INFLUENCE OF CLIMATE CHANGE UPON THE OPERATING REGIME OF THE PRESSURE PUMPING STATIONS IN IRRIGATION FACILITIES

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Abstract. *Irrigating farmland in Romania has become an increasingly necessary technique as climate change has become a constant reality. Irrigation management is subject to particular urgency due to increased water consumption through evapotranspiration which requires higher flows from water sources, transported through channels and distributed under pressure to the crop land. During the process, pumping stations are the highly demanded elements of the hydrotechnical scheme, since they must have the ability to pump the required flow rates. Research to assess this issue was carried out in the Gostinu-Greaca Argeș facility, in the Prundu-Chirnogi Organization of Irrigation Water Users (OUAI). The increase in irrigation water needs was determined by comparing the irrigation regime calculated for two different climatic periods: the reference period when the climate was more stable and the current period characterized by climate change. Based on the data obtained, operating charts of the pumping stations were developed to show that they did not have the capacity to provide the necessary flow rates for irrigation during the times with maximum water consumption. The issue was solved by reorganizing watering application. There were also situations when, even after the reorganization of watering application, the installed flow rates were exceeded by the water needs, which required the adaptation of the watering rules according to the size of the installed flow.*

Key words: *pressure pumping stations (SPP), climate change, hydrotechnical scheme, irrigation plot, potential evapotranspiration, irrigation regime, watering schedule, functional flow.*

INTRODUCTION

In the hydrotechnical scheme of irrigation facilities, pumping stations are the components with the most complex technicality whose role is to take the flow from the water source and raise it by successive pumps to the elevations of the land to be irrigated.

The operation of the pumping stations is determined according to the size of the water shortage to be covered by irrigation, and is established in the design phase resulting from the climatic records characteristic of the landscaped area.

In Romania the major irrigation facilities were designed before 1970, based on climate data from the period when the climate was more stable. They were sized for a period of 80% exceeding water deficit.

Today, the climate manifests itself at atypical dynamics, which is appreciated by specialists by the term climate change. Therefore, the operating regime of the pumping stations must cope with the special demands generated by the increase in the water demand in the field. The increase in the flows to be pumped depends on the technical characteristics of the hydromechanical equipment, as well as on the availability of the water source to provide additional volumes of water. Under these circumstances, optimising the operating regime of the pumping stations must result in the best possible hydraulic/electric efficiency.

The real-life analysis of these problems is made for a complex land reclamation facility located on the Danube Meadow, within the Prundu-Chirnogi OUAI.

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The assessment of climate change effects on the operation of pumping stations is based on meteorological/hydrological records after 2000, compared to the features of the facility design, which is considered the reference period. In Romania, there has been a more significant increase in air temperature after 1961 which has generated ever more evident global warming *(https//www.meteoromania.ro).*

MATERIAL AND METHODS

The study was carried out at the Gostinu-Greaca-Arges hydro-ameliorative system, designed with complex works, damming (during 1964-1965) surface/underground drainage (1967), irrigation (1978), covering an area of 25,718 ha, located in the Danube Meadow, in Giurgiu and Călăraşi Counties.

The study area has variable rates, between 12 m and 19 m, with maximum rates on the Danube sandbank and minimum rates on the former lakes and ponds (Botzan M, 1991), with sand banks and low hollows (shallow ponds) (https://comunachinogi.ro/date-fizico-geografice) and a sub-humid to slightly deficit climate.

Climate observations from the reference period (1896–1955) show that, during the growing season, various water stress conditions occur, such as deficits during critical phenological stages and excess outside the vegetation period.

Soil formation both under floodplain conditions and within diked areas resulted in hydromorphic processes as well as gleying processes, except on the interior sandbanks. Thus, hydromorphic soils (marsh soils, gley soils, and alluvial soils) developed at different stages of evolution, gleying, and salinization.

For the quantitative assessment of the climate change effects reflected in the irrigation management of field crops, a programme of climatic studies and research was organized for two distinct time periods: the years 1896–1955 as the reference period, and the years 2000–2024 as the current period characterized by climate change. The results obtained through this programme of studies and research culminate in a quantitative expression of the increase in irrigation water requirements.

The capacity of the pressure pumping stations to meet water demand is reflected in their operating schedules, developed on the basis of the irrigation application programme for each irrigation plot. These schedules highlight the flow rates that must be delivered through the underground pipeline network. When irrigation periods for different crops overlap, maximum flow rate values are obtained and further compared with the installed capacity flow rate of the station (SPP).

If the required flow rate exceeds the installed flow capacity, solutions must be found to mitigate peak consumption by adjusting the irrigation scheduling dates. The recommended approach is to reschedule the irrigation dates in advance. According to specialized studies, the irrigation initiation dates may be shifted by up to 10 days before, without adverse effects on crops. Consideration is given to the dynamics of each irrigation application, which begins when soil moisture reaches the minimum irrigation threshold and ends ten days later, at a moisture level below this hydro-physical indicator.

If this solution is insufficient, a reduction in the irrigation application rate may be used without significantly affecting its magnitude. In this case, the depth of the active soil layer may be reduced by 10 cm in the wheat crop and by 20 cm in other crops. By modifying the irrigation application rates, the flow rates required for irrigation are reduced, which consequently necessitates the reorganization of the irrigation scheduling.

RESULTS AND DISCUSSIONS

The programme of studies and research conducted in the study area highlighted an increase in potential evapotranspiration, as shown in Table 1. It can be observed that potential evapotranspiration during the reference period was constant, indicating climatic stability, compared with the current period, when it increased across all three locations. from Giurgiu to Călărași (STANCIU M., 2025).

Table 1

Impact of changes in the climatic regime upon potential evapotranspiration (mm) in the research area

.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Călărași													
a.2000-2024	16	27	58	*91*	*128*	*149*	*169*	*152*	*97*	48	23	14	972
b.1896-1955	0	0	16	*52*	*98*	*129*	*156*	*127*	*86*	48	17	1	730
a - b	16	27	42	39	30	20	13	25	11	0	6	13	242
Oltenița													
a.2000-.2024	15	22	50	*81*	*122*	*138*	*157*	*139*	*87*	42	19	13	885
*b.1896-1955	0	0	18	54	99	133	151	132	86	47	14	1	735
a - b	15	22	32	27	23	5	6	7	1	-5	5	12	150
Giurgiu													
a.2000-2024	-	3	21	*53*	*100*	*141*	*164*	*150*	*91*	70	25	15	833
18b22.1896-1955	0	0	18	54	99	133	151	132	86	47	14	1	735
a - b	0	3	3	-1	1	8	13	18	5	23	11	14	98

*estimated data

The quantitative assessment of the increase in potential evapotranspiration is expressed through the irrigation application rates of agricultural crops, by developing the irrigation regime. For this purpose, potential evapotranspiration is adjusted according to the crop using specific coefficients. For the current period, we used the correction coefficients obtained from research conducted at ICITID Băneasa Giurgiu in the Gostinu–Greaca–Argeș experimental area (GRUMEZA N., KLEPȘ C. 2005) while for the reference period, we used data from the design guidelines (Botzan M. Pricop Gh., Merculiev O., Grumeza N., Răsuceanu E.- 1969).

Knowing the crop structure practiced on the 6,268 hectares of the OUAI Prundu-Chirnogi and the irrigation regime of the crops, it is possible to determine the irrigation water requirement for each of the two research periods - the reference (control) period and the current period - in order to estimate the additional water volume generated by climate change. The results are presented in Table 2. The current climate leads to an increase in irrigation water demand at the Prundu-Chirnogi OUAI during a growing season of 8,948 thousand m³, corresponding to 1,427 m³/ha.

Table 2

Effect of climate change upon water requirements for crop irrigation

\Plot		SPP 11	SPP 12	SPP 13	SPP 16	SPP 14	SPP 15	Total thou m^3
Total consumption, thou m^3	Control	3,899	4,048	4,375	4,835	1,723	2,496	21,376
	Actual	5,544	5,757	6,222	6,801	2,451	3,549	30,324
Total consumption difference, thou m^3		**1,645**	**1,709**	**1,847**	**1,966**	**728**	**1,053**	**8,948**

In the current period, irrigation management includes the soil water deficit determined by the present climate, which leads to changes compared to the irrigation regime in the reference period.

The scheduling of irrigation applications for each plot highlights the date and duration of each irrigation event, as well as the flow rate that must be ensured by the pressure pumping station (SPP). As an example, the irrigation programme for plot 16 is presented in Table 3. The table includes the starting date of each irrigation and the duration of the irrigation. If the duration of an irrigation exceeds the ten-day period in which it begins, this is marked by the symbol ◘ attached to the irrigation end date. Thus, the total flow rate for irrigation applications in each ten-day period (decade) can be determined. The total flow rate obtained is used to develop the operating schedule of SPP 16, which is presented in Table 4.

The operating schedule of SPP 16 presents the technical characteristics of the station, the flow rate required to be delivered to the field, and the number of pumping units capable of achieving this flow rate. This required flow rate is compared with the installed capacity of the SPP, thereby determining whether the pumping station can ensure the water demand for crop irrigation. It is observed that the required flow rate exceeds the installed capacity starting from the second decade of May until the end of August.

This situation requires the reorganization of irrigation scheduling by using the two available techniques for this purpose: adjusting the irrigation start dates and reducing the irrigation application rate. The result is presented in Table 5, where the values modified through reorganization (irrigation date and application rate) are marked in red.

The operating schedule of SPP 16, shown in Table 6, indicates that even after the reorganization of irrigation scheduling - in the third decade of June, the second decade of July, and the first decade of August - SPP 16 cannot ensure the required flow rates for crop irrigation. Under these conditions, maintaining sufficient soil moisture can be achieved by proportionally reducing irrigation application rates to the level of the installed capacity of the SPP.

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Table 3

Irrigation scheduling in plot 16 under current climatic conditions
* the same values are used as for the other irrigations of the respective crop

Crop	Area, ha	Elements of irrigation regime	Irrigation scheduling in plot 16																				
			March			April			May			June			July			August			September		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Grain maize	395	Date								19	28■			20		14	23■	6	15■				
		Flow l/s								651				651		651		651					
Wheat	263	Date			20		14	23■	2	18	27■	7	16■										
		Flow l/s			347		347		347	347		*											
Soy	263	Date									24	2		20		14	23■	8	17■				
		Flow l/s									434			434		434		434					
Sunflower	263	Date											16	25■		14	23■	7	16■	24	2■		
		Flow l/s											434			434		434		434			
Old alfalfa	132	Date											10		2		20		10		1		
		Flow l/s											422		*		422		422		422		
Silo maize, cII	(263)	Date													2				18	31		18	27■
		Flow l/s													*				434	434		434	
Total	1316	Flow in current decade, l/s			347		347	347	347	998	434	347	856	1085	856	1519	422	1519	856	868	422	434	434
		Flow in previous decade, l/s ■									998	434	347	434			1519		1519		434		
		Required flow, l/s			347		347	347	347	998	1432	781	1203	1519	856	1519	1941	1519	2375	868	856	434	434

Table 4

Operating regime of SPP 16 under current climatic conditions

Pump type	Pump number	Pump flow, l/s	Pump unit power, kW	Pressure. mca	Installed flow rate, l/s	Installed power, kWh	Specific consumption kw/h for 1000 m^3: 385,15
CAPRARI	4	169	160	66	758	1051	
MA200x7	3	60	75	75			

Functional charateristics																						
Month		March			April			May			June			July			August			September		
Required flow, l/s				347		347	347	347	998	1432	781	1203	1519	856	1519	1941	1519	2375	868	856	434	434
Functional flow, l/s				349		349	349	349	856	856	796	856	856	856	856	856	856	856	856	856	458	458
Number of operating pumps	CAPRARI			1		1	1	1	4	4	4	4	4	4	4	4	4	4	4	4	3	3
	CAPRARI			2		2	2	2	3	3	2	3	3	3	3	3	3	3	3	3	2	2

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Table 5

Reorganization of irrigation scheduling in plot 16 under current conditions
*same flow is used, 347 l/s

Crop	Area, ha	Elememts of irrigation regime	Irrigation scheduling in plot 16																				
			March			April			May			June			July			August			September		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Grain maize	395	Date								10				20		10		1					
		Flow l/s								521				521		521		521					
Wheat	263	Date			20		14	23◘	2	10		1											
		Flow l/s			347		347		347	260		*											
Soy	263	Date									22			20		10		1					
		Flow l/s									434			347		347		347					
Sunflower	263	Date											10			10		1		21			
		Flow l/s											347			347		347		434			
Old alfalfa	132	Date											10		2		20		10		1		
		Flow l/s											383		383		422		383		383		
Silo maize, cII	(263)	Date													2				18		1	18	27◘
		Flow l/s													347				347		347	434	
Total	1316	Flow in current decade, l/s			347		347	347	347	781	434	347	730	868		1215	422	1215	730	434	730	434	
		Flow in previous decade, l/s ◘																					434
		Required flow, l/s			347		347	347	347	781	434	347	730	868	730	1215	422	1215	730	434	730	434	434

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Table 6

Operating regime of SPP 16 under current climatic conditions, after reorganization of irrigation scheduling

Pump type	Pump number	Pump flow, l/s	Pump unit power, kW	Pressure. mca	Installed flow rate,l/s	Installed power,kWh	Specific consumption kw/h for 1000 m^3: 385,15
CAPRARI	4	169	160	66	758	1051	
MA200x7	3	60	75	75			

Caracteristici funcționale																						
Month		March			Apri			May			June			July			August			September		
Required flow, l/s				347		347	347	347	781	434	347	730	868	730	1215	422	1215	730	434	730	434	434
Functional flow, l/s				398		398	398	398	758	458	398	758	758	758	758	458	758	758	458	758	458	458
Number of operating pumps	CAPRARI			2		2	2	2	4	2	2	4	4	4	4	2	4	4	2	4	2	2
	CAPRARI			1		1	1	1	3	2	1	3	3	3	3	2	3	3	2	3	2	2

CONCLUSIONS

Research on the effects of climate change upon irrigation scheme management, particularly regarding the operation of pressurization pumping stations (SPP), highlights the impacts upon irrigation management.

CONCLUSIONS :

1. Large irrigation systems in Romania were designed based on climatic conditions prior to the onset of climate change.
2. Climate change in recent decades has resulted in an increase in crop water consumption, which must be partially covered through irrigation.
3. Pumping stations within irrigation systems, even when modernized, must be able to accommodate the increased irrigation water demand by using the hydromechanical equipment with which they were originally designed.
4. In the study area, the increase in irrigation water requirement over a growing season is 1,427 m³/ha.
5. The SPP capacity to ensure the required irrigation flow rates is illustrated by the operating schedule developed based on irrigation planning.
6. The pressurie pumping station considered in this study cannot ensure the required flow rates from the second decade of May until the end of August.

RECOMMENDATIONS :

7. Crop irrigation requires the reorganization of irrigation scheduling by adjusting the irrigation start dates and reducing irrigation application rates, in accordance with technological recommendations.
8. By reorganizing irrigation scheduling within only two ten-day periods (decades), the installed flow capacity is exceeded, in which case a proportional reduction of irrigation application rates is recommended.
9. The modernization of irrigation pumping stations should be carried out by redesigning the irrigation water demand so that the installed flow capacity ensures crop irrigation in accordance with environmental requirements.

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