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EFFECTS OF CLIMATE CHANGE UPON IRRIGATION MANAGEMENT IN THE GOSTINU GREACA ARGEȘ INTEGRATED AGRICULTURAL LAYOUT

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Abstract. *The increasingly pronounced climatic variability induced by climate change affects all human activities, particularly those conducted in open environments, such as agricultural practices. Crop irrigation is among the agricultural techniques subject to adjustments in their implementation, which ensures the optimal soil moisture level according to the water requirements of the crops. For an effective organization of the irrigation process, it is necessary to assess the extent to which climate change influences the water consumption of agricultural crops, as this factor determines the characteristics of the irrigation regime. The research in present paper was conducted at the Gostinu-Greaca-Argeș integrated agricultural layout which based on the recordings performed at the Giurgiu, Oltenița and Călărași meteorological stations. In order to highlight the effect of climate change on the management of irrigation application to field crops, two distinct periods of time were studied comparatively: the first period: 1896 – 1955, which are regarded as indicative of a stable climate, and the second period, from 2000 to 2024, considered to be a climate exhibited obvious variability. The Gostinu-Greaca-Argeș integrated agricultural layout is situated on the Danube Plain, having a surface approximately 28,000 ha of agricultural lands and it is flood protected by a 41.6 km long dam. In this integrated agricultural layout, the average crop plan practiced by the Irrigation Water User Organizations (IWUs) is as follows: grain maize: 30%, winter wheat: 20%, soy: 20%, sunflower: 20%, old alfalfa: 10%.*

Key words: *Climate change, soil water balance, water consumption, irrigation regime, Irrigation Water User Organizations*

INTRODUCTION

The increasingly pronounced climatic variability induced by climate change affects all human activities, particularly those conducted in open environments, such as agricultural practices.

Crop irrigation is among the agricultural techniques subject to adjustments in their implementation, which ensures the optimal soil moisture level according to the water requirements of the crops.

For an effective organization of the irrigation process, it is necessary to assess the extent to which climate change influences the water consumption of agricultural crops, as this factor determines the characteristics of the irrigation regime.

MATERIAL AND METHODS

The impact of climate change upon irrigation management can be highlighted through a comparative analysis of the irrigation practices for agricultural crops across two distinct time intervals characterized by differing levels of climate variability.

This study focuses on the reference period comprising the climate data series between 1896 and 1955, which are regarded as indicative of a stable climate. Also, the data series from

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2000 to 2024 were included, as it was a period when the climate exhibited obvious variability (STANCIU, 2025).

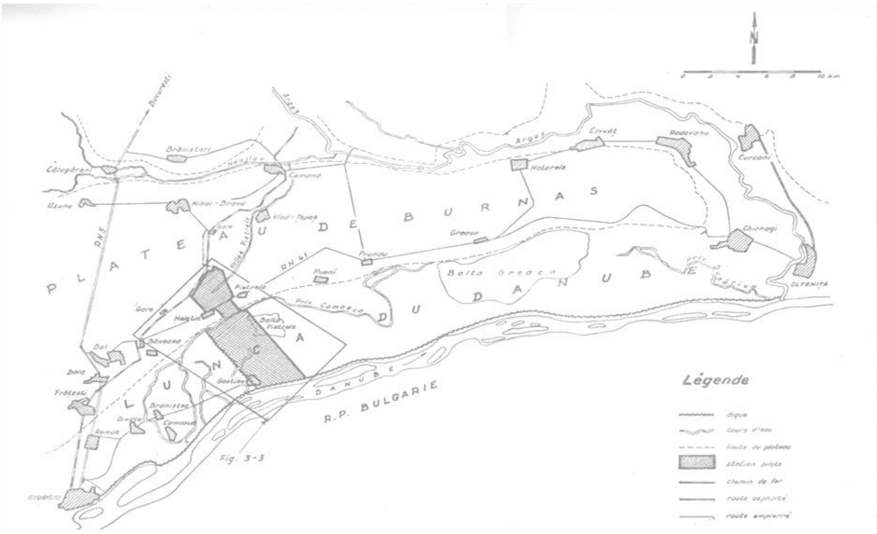
The climate data processing for the two time intervals consisted in the following activities:

- calculation of characteristic climatic indices;
- determination of potential evapotranspiration;
- evaluation of the irrigation regime for agricultural crops;
- assessment of the water requirements for the irrigation of agricultural land;
- comparative analysis of the research intervals.

The research aimed at addressing this issue was conducted at the Gostinu-Greaca-Argeș integrated agricultural layout, based on the recordings performed at the Giurgiu, Oltenița and Călărași meteorological stations. The reference climate data were obtained from official sources (The Climate of the Popular Republic of Romania, Vol. II. Climatological Data. State Weather Committee, the Meteorological Institute, 1961**).**

The Gostinu-Greaca-Argeș integrated agricultural layout is situated on the Danube Plain between km 473+600 and km 432+000. It is flood protected by a 41.6 km long dam, with the dammed area encompassing 27,830 ha agricultural lands (BOTZAN, 1991).

The Danube Plain is made up of the Danube river bank, the terrace base, the inner depression, slope area. The land displays a logitudinal slope of 0.2-0.3 %o and a transverse slope of 0.5-0.7%o, from the river towards the slope (Figure 1).



Source: 1971, Dieleman P.J. et al.

Figure 1. Natural setting of Gostinu-Greaca-Argeș integrated agricultural layout

Table 1 shows the climatic characterization of the study area for the reference time interval. It displays a consistent thermal regime across the entire development area, with precipitations decreasing slightly and evapotranspiration increasing significantly at Călărași.

These observations show the climate stability in the reference time interval and account for the choice of the interval as a reference for our study.

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Table 1

Average weather conditions during the reference time interval

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average/Amount
Air temperature, ^{0}C, Giurgiu	-2.5	-0.2	5.5	12.0	17.3	20.9	23.2	22.4	18.3	12.2	5.9	0.3	11.3
Air temperature, ^{0}C, Călărași	-2.0	0.0	5.3	11.6	18.1	20.9	23.1	22.0	18.1	12.3	6.2	0.7	11.3
Precipitations, mm, Giurgiu	36.3	29.0	33.2	43.8	62.7	80.4	62.8	49.3	34.2	41.4	42.7	42.6	553.0
Precipitations, mm, Călărași	38.0	31.0	30.9	37.2	51.9	72.2	56.4	34.5	37.8	34.2	40.7	39.2	504.0
Potential gross evapotranspiration, mm, Giurgiu	0	0	0	18	54	99	133	151	132	56	14	1	658
Potential gross evapotranspiration, mm, Călărași	0	0	16	52	98	129	156	127	86	48	17	1	730

RESULTS AND DISCUSSION

In order to determine the climate type, we used the methodology proposed by ICPA as it determines some climatic indices, depending on the values resulting in the climate type (MĂRĂCINEANU, 2019).

Calculation of climate indices is based on the relations below, using the multiannual mean values for precipitation (P), potential evapotranspiration (ETP) and air temperature (T):

-balance index, I_b= P – ETP

-hydroclimatic index, I_h = (P /ETP) * 100

-aridity index, Ia= P / (T + 10)

Table 2 presents the results. It shows a variable climate reference, ranging from slightly deficient to moderately deficient, from Giurgiu towards Calarasi.

The climate changes recorded in the present time interval have increased the deficient climate type which has become moderately deficient at Giurgiu and highly deficient at Calarasi (Table 3).

Table 2

Climate characterization in the reference time interval

Station	Climatic indices			
	Balance index (I_b):	Hydroclimatic index (I_h)	Aridity index (I_a)	Climate type
Giurgiu	-105	84	26	Slightly deficient
Călărași	-226	69	24	Moderately deficient

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Table 3

Climate characterization in the present time interval

Station	Climatic indices			
	Balance index (I_{bl})	Hydroclimatic index (I_h)	Aridity index (I_a)	Climate type
Giurgiu	-217	74	27	Moderately deficient
Călărași	-414	57	24	Highly deficient

The pluviometric regime has also changed due to climate change, as shown in Table 4.

It is found that the pluviometric regime did not undergo radical changes, except for months VII–VIII, i.e. the crop maturation period, when the moderately dry climate became dry. In October-March, the current pluviometric regime was more favorable, being optimal compared to the reference time interval.

This characteristic was maintained throughout the entire agricultural year.

Table 4

Changes in pluviometric regime due to climate change at Giurgiu

Typical vegetation intervals	Vegetation stage	Reference time interval		Current time interval	
		Average precipitations amount, mm	Pluviometric characterization	Average precipitations amount, mm	Pluviometric characterization
IX – X, autumn	sowing-emergence, winter grain crops	76	moderately dry	105	optimal
XI – III, cold period	cold season, period of water accumulation in soil	184	moderately dry	238	optimal
IV first vegetation month	sowing - emergence, summer grain crops	43,8	optimal	45	optimal
V – VI, rapid growth of crops	period of maximum water requirements in winter wheat	143	dry	131	moderately dry
VII – VIII, crop maturity	period of maximum water requirements in maize	112	moderately dry	99	dry
IV – X, Vegetation period	active vegetation season	375	moderately dry	380	moderately dry
IX – VIII, entire agricultural year	Agricultural year	553	Moderately dry	618	optimal

The thermal air regime (Table 5) shows an increase in the average multiannual temperature by 1.3°C at both weather stations. The characteristic thermal indices for the

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vegetative growth stages of the crops are higher in the current time interval than in the reference one.

Table 5

Change in thermal air regime due to climate change

Thermal air indices	Giurgiu		Oltenița
	2000-2024	1896-1955	2000-2024
Average monthly temperature, °C	12.6	11.3	12.7
Air temperature sum > than 0°C:	4,794	4,250	4,365
Air temperature sum > than 10°C	4,245	3,863	4,365
Air temperature sum > de 10°C effective	1,966	1,713	1,947

The cumulative effect of the change in the pluvio-thermal regime in the area under study is expressed by the increase in potential evapotranspiration (Table 6). It is found that the potential evapotranspiration increases in the current time interval from Giurgiu (98mm) to Calarasi (242mm), which results in an increase in the volume of irrigation water.

Table 6

Change in potential evapotranspiration (mm) due to climate change

Luna	**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
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

The overall assessment of the effects of climate change on watering application management of agricultural crops was made by calculating the soil water balance (Table 7). It is found that this balance was deficient both in the reference and in the current time interval.

Due to climate change, water scarcity increased from Giurgiu to Călărași, compared to the reference time interval.

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Table 7

Water balance rate in the area under study

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Amount
Călărași														
Reference time interval 1896-1955														
ETP- P mm	Deficit				15	46	57	100	92	48	14			372
	Surplus	38	31	15								29	38	151
Research time interval 2000-2024														
ETP- P mm	Deficit			19	50	76	78	118	109	49	1			500
	Surplus	30	1									33	30	94
Giurgiu														
Reference time interval 1896-1955														
ETP- P mm	Deficit						19	70	107	94	45	4		339
	Surplus	36	29	33	26	9							29	163
Research time interval 2000-2024														
ETP- P mm	Deficit				8	76	76	112	103	38	18			355
	Surplus	52	32	28								25	35	178

The evolution of the climatic factors in the Gostinu-Greaca-Arges integrated agricultural layout determines the increase of the water requirements to be ensured by irrigation. Changes occurring in irrigation management can be measured by calculating the crop irrigation regime in the two time intervals under study and by performing a comparative analysis of the results obtained.

For this purpose, an average crop plan will be considered, according to the Irrigation Water Users' Organization (OUAI) of the Gostinu-Greaca-Arges integrated agricultural layout: grain maize 30%, winter wheat 20%, soy 20%, sunflower 20%, alfalfa 10%. The irrigation regime will be calculated on the basis of the above climatic factors, together with the physical and hydro-physical characteristics of the clayey-sandy soil that predominates in the area (STANCIU, 2025).

The irrigation regime is calculated with the evapotranspiration characteristic of each crop, according to the correction coefficients established by ICITID Băneasa Giurgiu which is a research station located in the area of the Gostinu-Greaca-Argeș integrated agricultural layout (GRUMEZA, 2005). The input data for the calculation of the irrigation regime in Table 8 was used to develop the soil water balance sheets for each crop.

Table 8

Basic data for calculationg the irrigation regime of field crops

Crop	Active soil layer depth, m	Bulk density, t/m^3	*Volumetric field capacity, t/m^3	*Wilting coefficient %	*Permanent wilting point, %	Watering rate, m^3/ha
Grain maize	0.8	1.34	2,734	7.4	16	1,000
Winter wheat	0.6		2,042	7.5	16	1,000
Soy	0.8		2,734	7.4	16	1,000
Sunflower	0.8		2,734	7.4	16	1,000
Old alfalfa	1.0		4,636	7.3	16	1,100
Silo maize	0.6		2,042	7.5	16	1,000

*Values calculated for active soil layer depth

Table 9

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Crop irrigation regime
in the reference (A) and current (B) time interval

Crop Month	Variant	III	IV	V	VI	VII	VIII	IX	Irrigation rate, m^3/ha	Irrigation rate, m^3/ha	Watering number
Grain maize	A			1	1	1			3,000		3
	B			1	1	1	1		4,000	1,000	4
	B-A			**0**	**0**	**0**	**1**		**0**	-	**1**
Winter wheat	A		1	1					2,000		2
	B	1	1	1					3,000	1,000	3
	B-A	**1**	**0**	**0**					**1,000**		**1**
Sya	A				1	1	1		3,000		3
	B			1	1	1	1		4,000	1,000	4
	B-A			**1**	**0**	**0**	**0**		**1,000**		**1**
Sunflower	A				1	1	1		3,000		3
	B				1	1	2		4,000	1,000	4
	B-A				**0**	**0**	**1**		**1,000**		**1**
Old alfalfa	A				1	2	1		4,400		4
	B				1	2	1	1	5,500	1,100	**5**
	B-A				**0**	**0**	**0**	**1**	**1,000**		**1**
Silo maize	A					1	1		2,000		2
	B					2	1	1	4,000	1,000	4
	B-A					**1**	**0**	**1**	**2,000**		**2**

The comparative analysis of the crop irrigation regimes shows that, due to climate change, the number of waterings increased by 1-2 waterings whereas the watering rate was constant. The increase in the number of waterings resulted in a higher water volume to be taken from the source and conveyed to the pressure stations (Table 9).

Table 10

Synthesis of climate change effects upon water requirements for crop irrigation

Crop/Plot		SPP 11	SPP 12	SPP 13	SPP 16	SPP 14	SPP 15	Total mii m^3
Grain maize								
Area,ha		350	364	393	395	155	224	
Irrigation rate	Control	3,000						
	Current	4,000						
Total water consumption, thou m^3	Control	1,050	1,092	1,179	1,185	465	672	5,643
	Current	1,400	1,456	1,572	1,580	620	896	7,524
Consumption difference, thou m^3		**350**	**364**	**393**	**395**	**155**	**224**	**1,881**
Winter wheat								
Area,ha		233	242	262	263	103	149	
Irrigation rate	Control	2,000						
	Current	3,000						
Total water consumption, thou m^3	Control	466	484	524	526	206	298	2,504
	Current	699	726	786	789	309	447	3,756
Consumption difference, thou m^3		**233**	**242**	**262**	**263**	**103**	**149**	**1,252**
Soy								
Area,ha		233	242	262	263	103	149	
Irrigation rate	Control	3,000						
	Current	4,000						
Total water consumption, thou m^3	Control	699	726	786	789	309	447	3,756
	CUrrent	932	968	1048	1052	412	596	5,008
Consumption difference, thou m^3		**233**	**242**	**262**	**263**	**103**	**149**	**1,252**

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Sunflower								
Area,ha		233	242	262	263	103	149	4,552
Irrigation rate	Control	3,000						
	Current	4,000						
Total water consumption, thou m^3	Control	699	726	786	789	789	447	3,756
	Current	932	968	1,048	1,052	1,052	596	5,008
Consumption difference, thou m^3		**233**	**242**	**262**	**263**	**263**	**149**	**1,412**
Old alfalfa								
Area,ha		118	122	131	232	52	76	
Irrigation rate	Control	4,400						
	Current	5,500						
Total water consumption, thou m^3	Control	519	536	576	1,020	228	334	3,213
	Current	649	671	720	1,276	286	418	4,020
Consumption difference, thou m^3		**130**	**135**	**144**	**256**	**58**	**84**	**807**
Silo maize, relay cropping								
Area,ha		233	242	262	263	103	149	
Irrigation rate	Control	2,000						
	Current	4,000						
Total water consumption, thou m^3	Control	466	484	524	526	206	298	2,504
	Current	932	968	1,046	1,052	412	596	5,008
Consumption difference, thou m^3		**466**	**484**	**522**	**526**	**206**	**298**	**2,502**
Total consumption, thou m^3	Control	3,899	4,048	4,375	4,835	2,203	2,496	21,856
	Current	5,544	5,757	6,220	6,801	3,091	3,549	30,962
Total consumption difference, mii m^3		**1,645**	**1,709**	**1,845**	**1,966**	**888**	**1,053**	**9,106**

Table 10 shows that climate change has increased water consumption by 9,106,000 m^3 (41%) through evapotranspiration in the area under study (6268 ha) compared to the water consumption in the reference time interval.

The effect of climate variability in the current time interval has increased irrigation water consumption to an average of 1462 m^3/ha in the Gostinu-Greaca-Argeș integrated agricultural layout.

The increase in water consumption leads to an increase in the flow taken from the water source through the basic pumping station if the hydromechanical equipment allows and if the water level from the source provides their operation.

For this purpose, the technical-functional characteristics of the basic pumping station must be checked to meet the new flow requirements and for the measures to be taken to meet the requirements.

CONCLUSIONS

Based on the comparison between elements of the irrigation regime in two typical time intervals, the research for determining the impact of climate change on irrigation management in the Gostinu-Greaca-Arges integrated agricultural layout highlights the following conclusions and recommendations below:

1. The Gostinu-Greaca-Argeș integrated agricultural layout is located in the Danube Plains, which is an area whose climate is characterized by the recordings from the Giurgiu, Oltenita and Calarasi meteorological stations.

2. Climate change in the current time interval has increased the defective climate which becomes moderately deficient at Giurgiu and highly deficient at Călărași.

3. The pluviometric regime does not show radical changes, except for VII–VIII months (the period of crop maturation), when the moderately dry climate becomes dry.

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4. Throughout the October-March period, as well as throughout the entire agricultural year, the current pluviometric regime is more favorable, i.e. optimal.

5. The thermal air regime shows an increase in the average multiannual temperature by 1.3℃ and the characteristic thermal indices for the vegetative growth stages of the crops are higher in the current time interval than in the reference one.

6. Potential evapotranspiration increases in the current time interval from Giurgiu (98mm) to Călărași (242mm).

7. The soil water balance is deficient both in the reference and current time intervals. However, the soil water deficit increases from Giurgiu to Călărași, compared to the reference time interval.

8. Due to climate change, the number of waterings in field crops increases by 1-2.

9. Climate change leads to an increased by 41% of water consumption by evapotranspiration in the area under study, compared to water consumption in the reference time interval.

10. The increase in water consumption results in an increase in the flow taken from the water source through the basic pumping station if the hydromechanical equipment allows and if the water level from the source ensures their operation.

11. It is recommended to check the technical and functional characteristics of the basic pumping station to see if they meet the new flow requirements and what measures should be taken to meet them.

BIBLIOGRAPHY

ALEXANDRU DANIEL POPESCU, 2019 *Raport de mediu pentru Planul urbanistic general al Comunei Gostinu*, județul Giurgiu

BÂRA C., IONESCU I., POPESCU C., POPESCU I., 1970 *Exploatarea sistemelor de hidroameliorații,* Editura Ceres, București

BOTZAN M., HARET C., STANCIU I.,VIȘINESCU I., BUHOCIU L., 1991. Valorificarea hiroameliorativă a Luncii Dunării românești și a Deltei / Hydro-ameliorative exploitation of the Romanian Danube Plainand Delta. Centrul de material și propaganda agricolă. Redacția de propaganda tehnică agricolă, București, Romania

DIELEMAN P.J., GENET M., 1971 - Etablisement et Operation d`une Station Pilote d`Irrigation dans la Plaine du Danube-Roumanie. Rapport tehnic nr. 2. Programme des Nations Unies pour le Developpement, Bucharestâ

GRUMEZA N., KLEPȘ C., 2005 - Amenajările de irigație din România / Irrigation facilities in Romania, Editura Ceres, București

MĂGDĂLINA I., MĂRĂCIEANU F.,CISMARU C.,MAN T.E. 1983 *Exploatarea și întreținerea lucrărilor de îmbunătățiri funciare*, Editura Didactică și Pedagogică, București

MĂRĂCINEANU FLORIN, NICOLAESCU ION, CONSTANTIN ELENA, 2017,*Contrubuţia amenjărilor de îmbunătăţiri funciare la evoluţia durabilă a spaţiului rural din România*, Academia de Științe Agricole și Silvice București, 10 octombrie 2017

MĂRĂCINEANU FLORIN, ELENA CONSTANTIN, 2019. Îndrumător pentru lucrări practice la disciplina Dezvoltare rurală. / Students' book for practical training in Rural Development. Editura Ex TerraAurum, București, Romania

POSTAMENTEL MARIANA, MĂRĂCINEANU FLORIN, CONSTANTIN ELENA,2016, *Tradiţie şi actualitate în managementul irigaţiilor din România.* Editura EX TERA Aurum, București

STANCIU MARIAN, 2025. Rezultate parțiale privind efectul schimbărilor climatice asupra irigației în amenajarea Gostinu-Greaca-Argeș / Partial results on the climate change effect upon irrigation in the Gostinu-Greaca-Argeș integrated agricultural layout. Raport științific nr.3. USAMV București

*** Adaptarea la schimbările climatice a sectorului de îmbunătățiri funciare în vederea prevenirii și gestionării riscului la secetă., 2014. Ministerul Agriculturii și dezvoltării Rurale

http://doi.org/10.59463/RJAS.2026.2.48

*** Clima Republicii Populare Române vol.II. Date climatologice. / Climate of the Popular Republic of Romania. Vol. II. Climatological data. Comitetul de Stat al Apelor, Institutul Meteorologic, 1961

*** Valorile indicilor fizici și hidrofizici ale principalelor grupe de soluri din teritoriul irigabil al României (după ICPA)

*** https:// ro.wikipedia. org/wiki /Schimbare_ climatic%C4%8).

*** https://www.anif.ro /articole-anif/2021/prezentare- Provocări de mediu cauzate de schimbările climatice în zonele amenajate cu lucrări de îmbunătățiri funciare din România,iun. 10, 2021