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WATER MANAGEMENT IN SELECTED EU MEMBER STATES IN 2010S

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Abstract*: Study overviews main issues for agricultural water-use and wastewater conditions in Czechia, Hungary, Romania, Slovakia, Bulgaria, Slovenia, Portugal, Spain in 1998 -2017. Analysis can provide possibility to compare water management and water cleaning avoiding wastewater in countries. Water management connects with irrigation mostly on permanent cultivated agricultural areas. Analysis focuses on agricultural value added contributing to GDP growth, share of agricultural GVA produced by irrigated agriculture, total renewable water resources per capita, produced municipal wastewater, the agricultural water withdrawal as % of total renewable water resources mainly on total agricultural water managed area concerning qualified level of cultivated lands.* ***Motivation/Background****: Aim of analyses is to clear some correlations of several economic variables mentioned as features of selected countries. Global warming and longer drought period in EU-28 need for more successful water management to balance scarcity of water.* ***Method****: Study compares water management feature of Spain and Portugal with some EU member states in Central – East European based on SPSS statistical analyse.* ***Conclusions****: Innovation prosperity should be developed by more educated and skilled human power resources in agricultural production. Share of production based on irrigated land by cleaning water should increase in total agricultural value added.*

Keywords: *Arable lands, Correlations, Gross value added, Irrigation, Permanent cultivated areas, Scarcity of water*

INTRODUCTION

Study overviews main issues for agricultural water-use and wastewater conditions in Czechia, Hungary, Romania, Slovakia, Bulgaria, Slovenia, Portugal, Spain in 1998 -2017. Analysis can provide possibility to compare water management and water cleaning avoiding wastewater in countries. Water management connects with irrigation mostly on permanent cultivated agricultural areas. Analysis focuses on agricultural value added contributing to GDP growth, share of agricultural GVA produced by irrigated agriculture, total renewable water resources per capita, produced municipal wastewater, the agricultural water withdrawal as share of total renewable water resources mainly on total agricultural water managed area concerning qualified level of cultivated lands. The main difficulties are continuously emerging, namely the longer and frequent drought period, which make also some more heavy irrigation possibility, which can result either less irrigated areas or less harvested crops from irrigated areas mostly in Slovakia, Hungary (FAO AQUASTAT, 2021). Additionally, the above-mentioned problem renewable water resources per capita, agricultural water managed area and share of agricultural GVA (gross value added) produced by irrigated agriculture also decreased in some countries, but produced waste water increased in some countries.

The hypotheses of the study:
1) Very strong correlations between human development index (HDI5) and produced municipal wastewater (PMunWasW8).
2) Strong correlations between arable land area (ArabLand1) and % of agricultural GVA produced by irrigated agriculture (IrAgrGVA6).
3) Strong correlations between human development index (HDI5) and the total renewable water resources per capita (ToReWaCap7).
Aim of analyses is to clear some correlations of several economic variables mentioned as features of selected countries. Global warming and longer drought period in EU-28 need for more successful water management to balance scarcity of water. In case of this research two main country-groups of EU member states were focused, namely Central-East European countries and two countries of the Mediterranean region, where Spain and Portugal have somehow mainly same measured areas or territories as territories of other six countries of another European region. Naturally the geographical and economic conditions are different between two main regions.
The typical measure of production management is productivity (Kryszak et al, 2021; see more in Mugera eat al, 2016). Palash and Bauer (2017) claim that a farm's profitability may be affected by land allocation to specific types of production. It is exact, but also, qualified level of the soils and their fertility can make influence on the profitability of the farms' production, therefore not only the land allocation determine the profitability of farms. Gloy and LaDue (2003), we assume that financial management decisions may further influence farm profitability (see more in Rogers eat al, 2002). Education and training of professional, technical staff and decision makers and others, including non-public organizations, on a wide range of subjects related to sustainable water management. b. Manpower build-up. Institutions to be staffed with qualified manpower (managers, engineers, technicians, social scientists) that should be adequately compensated (Chartzoulakisa – Bertaki, 2015).
Precision irrigation can be defined as an efficient collaboration and precise application of water to meet specific requirements of individual plants or management units and minimize related adverse environmental impacts. As a holistic coordinated performance, precision irrigation not only enables the emergence of more flexible and reactive operational systems, but also involves the optimal management and best operation of agricultural irrigation systems; therefore, it has been employed in response to the growing problem of water scarcity and the need for more effective irrigation management (Liang et al, 2020; Harmanny - Malek, 2019).
Our opinion is that additionally the other inputs of agricultural production the *efficiency of the water management* can impact on the qualified level of the *production management*, and finally on the productivity. In this case the water management is based on the unified measure of the water used, which means that as less amount of water used leads to more yield of agricultural production on farm. Therefore, the drop irrigation system is more profitable. Because in tropical-sub-tropical areas the reining irrigation system leads to 70% of water used evaporates. Also, the efficiency of the water management can increaseby less price level of unified water used. The difficulty of farms is to obtain the water resource by highly level of price, which can increase the production cost and finally the level of farm gate price, which cannot make agricultural production be efficient and profitable. The farmers by the highly level of farm-gate price can loss their market share.

MATERIALS AND METHODS

Study compares water management feature of Spain and Portugal with some EU member states in Central – East European based on SPSS (Statistical package for social sciences) statistical analyse (Csallner, 2015; Sajtos-Mitev, 2007; SPSS Base 15.0 User's Guide, 2006). The statistical analyse can provide compare among researched countries based on their economic features and water-use conditions concerning the weather issues. The economic features and water-use conditions are covered by ten economic variables, namely these are as arable land area (ArabLand1), permanent crops area (PerCropAre2), percent of cultivated land irrigated [harvested crop] (CultIrLand3), agriculture, value added in percent of GDP (AVAtoGDP4), Human Development Index (HDI5), percent of agricultural GVA produced by irrigated

agriculture (IrAgrGVA6), total renewable water resources per capita (ToReWaCap7), produced municipal wastewater (PMunWasW8), agricultural water withdrawal as percent of total renewable water resources (AgWaWiRWR9) and also total agricultural water managed area (TAgWMA10). The data for analysing come from the FAO AQUASTAT, 2021 and Eurostat between 1998-2017.
Within the SPSS statistical analyse the Pearson correlations of economic variables, variance explained by principal components, the rotated component, cluster membership and the principal component analysis map of countries using components were used to overview the difference and their measures among researched countries based on their economic and water conditions. This statistical analyse helps to strengthen the hypotheses of the scientific research by cleaning the conclusions.

STATISTICAL ANALYSIS AND GRAPHICAL PRESENTATION

The SPSS statistical analyse includes some main statistical data bases, from which the proofing process can make possibility to obtain scientific results concerning water use and water management by irrigation conditions for agriculture accompanying with wastewater conditions in researched EU member states, namely Czechia, Hungary, Romania, Slovakia, Bulgaria, Slovenia, Portugal and Spain.

Table 1. Water use for agriculture and wastewater conditions in Czechia, Hungary, Romania, Slovakia, Bulgaria, Slovenia, Portugal, Spain from 1998 -2017 in percent based on hectare and m^3

Economic Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Czechia	-14	-40	28	-1	10	1	-4	-7	-2	-2
Hungary	-6	-2	-23	-1	7,7	-1	5	1	-1,2	10
Romania	-9	-14	40	-7	12,5	1,3	11	-80	1,1	-77
Slovakia	-5	-36	-76	1	10	-9,4	-1	-43	-1	-46
Bulgaria	-2	-35	-1	-5,7	11	-2	11	-12	-13	10,5
Slovenia	9,5	80	0,1	-1	6,6	0,1	-7	30	-0,3	-95
Portugal	-42	-1	13	-1	7	18	1	42	-2,7	-23
Spain	-5	-5	-1	-1	7	-1,3	-10	68	-4	-2

Source: Selected countries: Czechia, Hungary, Romania, Slovakia, Bulgaria, Slovenia, Portugal, Spain
FAO AQUASTAT, 2021. http://www.fao.org/aquastat/en/databases/maindatabase/
Total areas of Czechia, Hungary, Slovakia, Romania, Bulgaria and Slovenia = 59 060 000 hectare
Total areas of Portugal, Spain = 59 817 000 hectare
For Period of **1998-2017, 1998-2002 = 100**

Table 2. Abbreviation of economic variables

Variable Abbreviation	Variable name	Period	Source/database
ArabLand1	Arable land area (1000 ha)	1998-2017	FAO AQUASTAT, 2021
PerCropAre2	Permanent crops area (1000 ha)	1998-2017	FAO AQUASTAT, 2021
CultIrLand3	% of cultivated land irrigated [harvested crop] (%)	1998-2017	FAO AQUASTAT, 2021
AVAtoGDP4	Agriculture, value added (% GDP) (%)	1998-2017	FAO AQUASTAT, 2021
HDI5	Human Development Index (HDI) [highest = 1] (-)	1998-2017	FAO AQUASTAT, 2021
IrAgrGVA6	% of agricultural GVA produced by irrigated agriculture (%)	1998-2017	FAO AQUASTAT, 2021
ToReWaCap7	Total renewable water resources per capita (m^3/inhab/year)	1998-2017	FAO AQUASTAT, 2021
PMunWasW8	Produced municipal wastewater (km^3/year or 10^9m3/year	1998-2017	FAO AQUASTAT, 2021
AgWaWiRW	Agricultural water withdrawal as % of total	1998-2017	FAO AQUASTAT, 2021

R9	renewable water resources (%)		
TAgWMA10	Total agricultural water managed area (1000 ha)	1998-2017	FAO AQUASTAT, 2021

Source: FAO AQUASTAT, 2021.

Table 3. Pearson correlations of economic variables

	2	3	4	5	6	7	8	9	10
Correlation	,321	-,254	-,066	,099	**-,797**	-,115	-,158	-,086	-,265
PerCropAre2		,113	,162	**-,631**	,227	-,390	,420	,295	**-,606**
CultIrLand3			**-,615**	,171	**,561**	,158	,031	,015	-,080
AVAToGDP4				**-,690**	-,081	**-,649**	,463	,340	,183
HDI5					-,356	**,698**	**-,889**	-,127	-,060
IrAgrGVA6						,026	,397	,061	,003
ToReWaCap7							**-,686**	-,278	,091
PMunWasW8								-,206	,301
AgWaWiRWR9									**-,560**
TAgWMA10									1,000

Source: Owned calculations based on the basic statistical data of FAO AQUASTAT, 2021.

Value for the correlations among the economic variable is very strong between 0,800 -1,000 (as 80-100%), and strong between 0,500 -0,800 (as 50-80%) and weak less than 0,500 (50%). Minus for the economic variable means that the given variable has contradictive correlations with other positive variables. Negative economic variables decrease, but the positive variables increase in fields of their correlations. But negative economic variables within their own correlations can be either increasing or decreasing in cases of principal component analysis map of countries using components. In the Table 3 the most important correlations among economic variables are written in bold numbers. Negative variables are as follows: (-)HDI5, (-)ToReWaCap7, (-)TAgWMA10, (-)ArabLand1, (-)AVAToGDP4 (Table 3; Table 5; FAO AQUASTAT, 2021). HDI includes purchase power parity, standard of living; education level and health care.

The Table 4 shows the variance explained by principal components, which means in this study, that the four principal components cover 90,63% of the cumulative belonging to the initial eigenvalues. Therefore, this statistical analyse is proofed by 90,63% based on the four principal components. The Table 5 shows the rotated component matrix, which gives the overview for four components with their economic variables.The highest value of economic variable in its given line of the table determines that to which the given variable can be included into the component. The bold figures are included into one component in columnof each component. According to the Table 6, generally, researchers determine that how many clusters are used in this SPSS analyse. Often 5 clusters are used in SPSS statistical analyse, also, even one country can be one cluster, but this means that 8 clusters would be used in this study. In cases of 5 clusters the research can be more successful, because within a country group as a cluster, those countries can be classified into one cluster, of which economic features are somehow similar or closed to each-others.

Table 4. Variance explained by principal components

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Principal Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,490	34,903	34,903	3,245	32,446	32,446
2	2,306	23,058	57,961	1,980	19,802	52,248
3	2,033	20,334	78,295	1,977	19,767	72,015
4	1,264	12,641	**90,936**	1,892	18,921	90,936

Source: Owned calculations based on the basic statistical data of FAO AQUASTAT, 2021.

Table 5. Rotated Component Matrix[a]

	Component			
	1	2	3	4
HDI5	**-,956**	-,044	-,147	,166
PMunWasW8	**,932**	-,294	,169	,028
ToReWaCap7	**-,774**	-,175	,066	,323
PerCropAre2	**,682**	,534	-,248	,329
TAgWMA10	,013	**-,882**	,243	-,247
AgWaWiRWR9	,012	**,879**	,223	-,291
ArabLand1	,043	,096	**-,977**	,007
IrAgrGVA6	,300	,062	**,818**	,448
CultIrLand3	-,040	,074	,341	**,818**
AVAToGDP4	,552	,086	,114	**-,797**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 9 lterations.

Source: Owned calculations based on the basic statistical data of FAO AQUASTAT, 2021.

Negative variables: (-)HDI5, (-)ToReWaCap7, (-)TAgWMA10, (-)ArabLand1, (-)AVAToGDP4

Other variables: PerCropAre2, CultIrLand3, IrAgrGVA6, PMunWasW8, AgWaWiRWR9

Table 6. Cluster Membership

Case	5 Clusters	4 Clusters	3 Clusters	2 Clusters
1:Czechia	1	1	1	1
2:Hungary	1	1	1	1
3:Romania	2	2	2	2
4:Slovakia	1	1	1	1
5:Bulgaria	3	2	2	2
6:Slovenia	4	3	1	1
7:Portugal	5	4	3	1
8:Spain	1	1	1	1

Source: Owned calculations based on the basic statistical data of FAO AQUASTAT, 2021.

Based on the separating into five clusters based on the SPSS (Sajtos-Mitev, 2007).

Cluster-1: Czechia, Hungary, Slovakia, Spain; Cluster-2: Romania; Cluster-3: Bulgaria

Cluster-4: Slovenia; Cluster-5: Portugal

RESULTS AND DISCUSSION

According to the economic variables of selected countries the main issue is *to use renewable natural water resources by more efficiently.* There are very strong correlations between human development index (HDI5) and produced municipal wastewater (PMunWasW8) by minus 0,889 as 88,9% (Table 3, FAO AQUASTAT, 2021). The human development index consisting of three main elements, namely (1) purchase power parity, standard of living; (2) education level and (3) health care. From point of view of HDI the educational level can ensure such human experiences to help for decreasing the municipal waste water in different establishments, like towns, villages. Therefore, the contradictive correlations are between both sides are proofed. Also, the less produced municipal wastewater can contribute to increase the standard of living by cleaning natural resources to sustain adequate human health level. In case of the efficient water use means

that the unite of water use accompanies with less produced wastewater.
In cases of eight EU member states in this study Romania has more favourable results in these fields, because Romania increased the HDI level by 12,5% by the highest level within these eight countries, while this country decreased produced municipal wastewater by 80%.
The second better conditions were in Slovakia, where the HDI increased by 10% and deceased the produced municipal wastewater by 43%. The most unfavourable conditions were in Spain, where the HDI increased only by 7%, but wastewater increased by 68%, while in Portugal HDI increased also by 7% as much as in Spain and wastewater increased by 42%, little less than in Spain. Also, Slovenia HDI increased by 6,6% and wastewater increased by 30% moderately increasing. In cases of Spain and Portugal the decrease of the produced municipal wastewater would have been more, because the water scarcity could be more than the other seven countries of this study.
In Hungary the conditions of HDI increase were somehow as much same as in Spain and Portugal by 7,7%, but the wastewater increased only by 1%, which cannot be seen as real increase. But also, in Hungary the transiting water resources abroad should have been saved more, because almost all of the water coming abroad go away from Hungary.
It can be declared that the most efficient water use can be realised by less produced municipal wastewater accompanying with increasing level of the HDI in cases of eight EU member states of this study for the period of 1998-2017.
The strong correlations are main issues in cases of correlations among the economic variables, which can show the better innovative production technologies in one country then the other one within researched countries. Contradictive strong correlations are between arable land area (ArabLand1) and share of agricultural gross value added (GVA) produced by irrigated agriculture (IrAgrGVA6) by 79,7%. The strong correlations are between human development index (HDI5) and the total renewable water resources per capita (ToReWaCap7) by 69,8%. There are strong correlations between the agriculture, value added in percent of GDP (AVAToGDP4) and Human Development Index (HDI5) by minus 69%. The total renewable water resources per capita (ToReWaCap7) and produced municipal wastewater (PMunWasW8) have strong correlations by minus 68,6%. The agriculture, value added in percent of GDP (AVAToGDP4) has strong correlations with the total renewable water resources per capita (ToReWaCap7) by minus 64,9%.Also, the permanent crops area PerCropAre2 are in strong correlations with Human Development Index (HDI5) by minus 63,1%. The share of cultivated land irrigated (harvested crop, CultIrLand3) has strong correlations with agriculture, value added in percent of GDP (AVAToGDP4) by minus 61,5%. While the permanent crops area (PerCropAre2) and total agricultural water managed area (TAgWMA10) are in strong correlation with each-others namely by minus 60,6%.
The share of cultivated land irrigated (harvested crop, CultIrLand3) and percent of agricultural GVA produced by irrigated agriculture (IrAgrGVA6) have reached strong correlations at the level of 56,1% for the researched period. The Table 3 also, shows how much strong correlations are between agricultural waterwithdrawal as percent of total renewable water resources (AgWaWiRWR9) and total agricultural water managed area (TAgWMA10), by minus 56% for period of 1998 and 2017.
From experiences of the above-mentioned strong correlations among economic variables it can be declared that the most efficient water use can be realised by less produced wastewater and increasing share of irrigated agriculture in gross agricultural gross value added even increasing the arable land or all cultivated areas by innovative developing irrigation system. The difficulty for the agricultural arable land increase, thathe innovative development mostly is missing. This difficulty can be followed in ceases of average results of selected eight EU member states. Naturally the lack of capital and less consumption of the fixed capital including irrigation system means somehow backwardness in this field. When the cropped areas are increasing, also the irrigation system should increase more than increasing rate of copped areas. The other difficulty that the self-financing power of farmers and agricultural companies is at low level to realise innovation development.
While the permanent crops area (PerCropAre2) decreases, the total agricultural water managed area (TAgWMA10) increases the strong correlation with each-others, because more withdrawal lands can be realised. In Slovenia the permanent crops area (PerCropAre2) has increased by 85%, but the total agricultural water managed area sharply decreased by 95%, in Czechia permanent crops area decreased by

40% and the total agricultural water managed area only little decreased by 2% for the researched period. Bulgaria has also considerable contradiction correlation between both of variables, crop area decreased by 35%, but the total agricultural water managed area increased by 10,5%. In case of Romania the position was the worst, because both of them decreased by 14% in case of crop area and by 77% in case of water managed area in the same period. This reason is that, in less areas the more innovative and advanced technology including the water management are used and consequently the yields and output of agricultural producers increases. Therefore, producers-farmers should decrease their permanent crop area in order that they do not exceed their quotas by increasing their yields. This is the reason is coming that the national yield quota cannot be exceeded by the rule of EU common agricultural policy. If the agricultural producers do not have well innovative and advanced techniques in their agricultural basic production by less yields per hectare, they can increase their permanent crop area within yields of their quotas given by national governments based on the common agricultural policy of the EU.

When the agricultural producers can have enough or *more purchase power (HDI5) for obtaining inputs* to invest into agricultural sector even for water management, the total renewable water resources per capita (ToReWaCap7). This also can be followed in the correlations both of variables. In Romania the HDI5 increased 12,5% as top level in this field and water resource per capita increased by 11%. Also, in Bulgaria both of them increased considerably by 11% in field of purchase power and by also 11% in field of water resource per capita. The human purchase power resource (HDI5) increased, while the share of the agricultural value added in GDP (AVAToGDP4) decreased. This can be explained that the *HDI5 as consumers increasingly purchased products of other economic sectors* and not considerably from agricultural sector. In Romania the HDI highly increased by 12,5% but sharply decreased by 7%, as toplevel within researched countries.

The other difficulty is that when the total renewable water resources per capita (ToReWaCap7) increase, by decreasing produced municipal wastewater (PMunWasW8). In Romania the water resources per capita by 11%, which could be resulted by decreasing municipal wastewater by 80%. The difficulty was in case of Spain, where the municipal wastewater increased by 68%, which led to decrease of water resources per capita by 10%. The cleaning system should develop in process of water use in fields either firm-company water uses or population water use. The law and regulation systems should strongly control water use of companies of different economic sectors even within the qualified demands for the production process concerning the water use.

But by the other side when the total renewable water resources per capita (ToReWaCap7) increases, often the agricultural value added in percent of GDP (AVAToGDP4) can decrease, because the more water use is realised in other economic sectors and not in agricultural one. In this case the water allocation was not successfully for interest of increasing agricultural production or the share of value added of other economic sectors in GPD by more water use could increase comparably to the agricultural value added in share of GDP. This means that the other economic sectors more developed than the agricultural sector by the more water use. In Romania water resources per capita increased by 11% and the agricultural value added in percent of GDP decreased by 7% as deepest level within researched countries. In Bulgaria water resources per capita also increased by 11% and the agricultural value added in percent of GDP decreased by 5,7% as the second deepest level within researched countries.

Also, when the permanent crops area (PerCropAre2) increased, this could be a reason, that number of farmers or employees (annual working unit) in agricultural sector withdrew from this sector, therefore, the Human Development Index (HDI5) decreased or little increased, which means that the mechanization and modernization in the agricultural sector could more substitute the considerable human resources in this sector. But when the permanent crops area (PerCropAre2) decreased and the Human Development Index (HDI5) increased, the land use could be separated into more small plots or farm-lands by increasing the number of annual working units or farmers. Also, this means that within a farm more children of farmers' families inherit lands, which resulted separation of the original plots. This can result less developed farm structure for the future. In Romania HDI5 increased by 12,5% as top level but the permanent crops area decreased 14%, in Czechia HDI5 increased by 10% but the permanent crops area decreased 40% as mostly deeply within researched countries. The other opposite example, in Slovenia HDI5 increased only by 6,6% as mostly deeply level but the permanent crops area sharply increased 80%, as top level in these countries.

Probably in Slovenia the land use and ownership concentration can be increasing, which can be explained by decreasing number of farmers, annual working units or landowners. In a fact only in Slovenia the permanent crops area has increased for the same period within researched countries. In cases of all other seven member states permanent crops area and arable land area decreased.
This part of the study shows measures of economic variables, as features according to eight EU member states of this research. General correlations among economic variables concerning the renewable natural resource water and water management including possible advanced irrigation system can demonstrate the *economic developing trends* of each EU member state. This economic developing trend focuses on the creating innovative irrigation system by *advanced using technologies* and water management. All of these developing aims need for *enough purchase power capacity* of farmers and agricultural producers, firms, companies or transnational corporations based on the structure of agro-business and vertically integrated product channel from land to table of consumers. Also, the increasing yields and outputs of producers are limited by the *quota system* in EU. This quota system would like to make *balance between market supply- demand sides* of the agricultural single market.

CONCLUSIONS AND RECOMMENDATIONS

The hypotheses of the study were proofed by the results and analyses. 1) Very strong correlations between human development index (HDI5) and produced municipal wastewater (PMunWasW8). 2) Strong correlations between arable land area (ArabLand1) and share of agricultural GVA produced by irrigated agriculture (IrAgrGVA6). 3) Strong correlations between human development index (HDI5) and the total renewable water resources per capita (ToReWaCap7). Solutions of the difficulties of these EU member states, that the innovation prosperity should be developed by more educated and skilled human power resources in agricultural production. Share of production based on irrigated land by cleaning water should increase in total agricultural value added. It is important to increase the subsidies for farmers for available water resources to irrigate in order to obtain increasing yield based on the efficient allocation of water resource accompanying with the possible international cooperation beyond borders.

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