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Irrigation Investment and Agricultural Efficiency

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Abstract – The main scope of the paper is to make an empirical analysis regarding the relationship between irrigation and efficiency in agriculture sector, the use of water in irrigation and the share of agriculture sector in GDP related to European and world environmental policies, in the frame of water resource management and climate change conditions. We concluded there is a shy relationship between irrigation and agriculture crop. Furthermore, irrigation has no significant effects on GDP. The study is based on data collection using EUROSTAT and Romanian databases. We conclude that water management reform is necessary.

Keywords: Climate Change, Economic Efficiency, Irrigation System

I. INTRODUCTION

The objective of the paper is to analyze the sustainability of irrigated agriculture in European countries in the context of post-Agenda 2000 Common Agricultural Policy Reform and of Water Framework Directive and the responses of agricultural irrigated systems to environmental policies [3].

Table 1. Indicators for sustainable agriculture

Domain	Indicator
Economic balance	Farm income
	Farm contribution to GDP,
	Public support
Social impact	Farm employment
	Seasonality
Landscape and biodiversity	Genetic diversity
	Soil cover
Water use	Irrigation technology
	Water use
	Marginal value of water
Nutrients and pollutants	Nitrogen balance
	Pesticide risk
	Energy balance

Source: adapted from Europe 2020 strategy [5]

OECD [6] has proposed a set of indicators to check the sustainability of agricultural practices, from which we may mention the following indicators (Table 1):

- Economic balance: Farm income, Farm contribution to GDP, Public support.
- Social impact: Farm employment, Seasonality.
- Landscape and biodiversity: Genetic diversity, Soil cover.
- Water use: Irrigation technology, Water use, Marginal value of water.
- Nutrients and pollutants: Nitrogen balance, Pesticide risk, Energy balance.

Theoretically, economic efficiency level is represented by the point where marginal cost equals marginal benefits. However, but irrigation water pricing may include transfer of water rights (technical efficiency), may exclude water rights (allocative/economic efficiency based on opportunity cost of water), or may include environment cost (ecological/environmental efficiency and sustainability).

In order to measure the economic activity in the agricultural sector there were identified a lot of indicators such as: Gross Domestic Product (GDP per capita, GDP at market prices), agriculture production value (gross value added of the agricultural industry), agricultural land (total agriculture area), number of holdings, utilized agricultural area (UAA), arable crops (crop output, cereal crops), irrigation indicators (share of irrigable and irrigated areas in the utilized agricultural area), number of farms, productivity of production factors and resources (energy consumption by agriculture, water resource productivity, agriculture labor productivity), international trade activity (food trade turnover – retail trade turnover, extra-EU food trade – share of foods in imports), agriculture-environment relationship (gross-nutrient balance, pesticides sales, consumption of inorganic fertilizers, air pollutant, estimated soil erosion by water, greenhouse gas emission by agriculture sector).

The main scope of the paper is to make an empirical analysis regarding the relationship between irrigation and efficiency in agriculture sector, the use of water in

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irrigation and the share of agriculture sector in GDP related to European and world environmental policies, in the frame of water resource management and climate change conditions. Also, irrigation has a major role in food security, water save and agriculture sector independence in the context of quickly rise in population, climatic changes, and agriculture sector activities. In this area research, literature is poor.

II. METHODOLOGY

The findings and data are very poor from main European and world database Eurostat. From this reason, paper's methodology is classic one, based on comparative analysis between European countries and consists in analyzing economic activity, comparisons (between European countries) and synthesis of available information.

III. PLEA FOR IRRIGATED AGRICULTURE

The water used in agriculture can come from natural rain or from irrigation systems. The climate change challenges (irregular rainfalls, dry times or drought, global warming, etc.) can produce huge damages to the farmers` crop with grate implication over the market price of the foods. Irrigation represents the artificial use of water in agriculture field, through many and different systems of tubes, pumps, and sprays. The basic methods of irrigation system (Figure 1) are: surface irrigation (using gravity and no mechanical pump), sprinkler irrigation (using high-pressure sprinklers or guns from fixed or moving platforms) and drip irrigation (deliver the drop of water near the root of the plant). But also, it can exist localized irrigation, center pivot irrigation, lateral move irrigation, sub-irrigation, and manual irrigation.

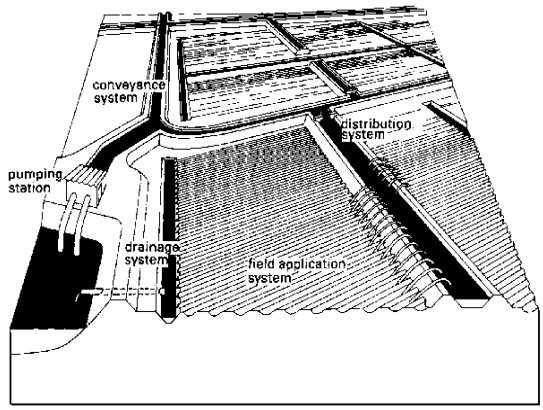

Fig. 1. Irrigation system [2]

Specific reports and studies from around the year 2000, mention that irrigated agriculture obtained a third of world's total food supply, and about 40% from world cereals production come from irrigated agriculture [7] and it was used in 18% of arable area of the planet increasing slowly at 20% in this moment (from the 1.5 billion hectares of arable land almost 300 million hectares are irrigated). USA, India and China hold together a half of total irrigated land in the world. Furthermore, irrigation and irrigated lands contribute in 30% to the people employment. It is noticed that the grow rate of irrigation settlements fell from 3% in `80s to 0.6 in 2010.

According to specialist`s work in order to produce a single kilo of wheat, it is necessary to use from 400 to 2,000 liters of water from the sowing till crop, depending on the dryness of the land.

The decision to invest and use irrigation equipment could take into consideration some aspects such as: the type of the crop, the water resource necessity and accessibility (from surface water through the rivers, lakes, reservoirs, channel, basin; from groundwater through springs or wells; or from other sources such as treated wastewater or desalinated water, etc.), the type of the soil, the energy source (motor pump, power generator, etc.), and financial implications (for initial investment and for maintenance).

The difference between profit and loss in irrigation practice is made by a proper timetable for irrigation and the economic use of water (regarding the consume of the two resources: water and energy).

IV. EU COUNTRIES COMPARATIVE ANALYSIS

In Romania, the development of big irrigation infrastructure (375 big systems of irrigation) started to the end of the year 1945, increasing a lot in the period 1970–1989, when it was built big irrigation system by pumping in crop of maize, wheat, and sunflower and of sugar beet, as well as vegetables and rice. In this period, it was endowed with irrigation systems a total area of almost 3.1 million hectares, meaning 20% of the used agricultural area (UAA) existing on national plan. The most of irrigation systems (2.7 million ha) had equipment of watering with manual movement, by aspersion [4].

Table 2. Share of irrigable areas in UAA by regions

GEO/TIME	2005	2007	2010	2013
Romania	5.8	4.5	3.1	1.8
North-West	0.1	0.0	0.0	0.0
Centre	0.1	0.0	0.1	0.0
North-East	2.5	2.4	0.3	0.2
South-East	16.6	12.8	12.6	8.1
South - Muntenia	8.7	7.6	3.8	1.7
Bucharest - Ilfov	13.2	5.3	0.4	0.7
South-West Oltenia	9.1	6.2	2.6	0.8
West	0.5	0.1	0.2	0.2

Source: Eurostat

The data available from Eurostat for the period 2005 and 2013 about irrigable and irrigated area are presented in Table 2 and 3, for the regions of Romania (NUTS 2 regions) regarding the share of irrigation (irrigable areas equipped for irrigation) and

irrigated areas (the land irrigated) in utilized agriculture area (UAA) expressed in percentage of total UAA (almost 14,000,000 ha according to available data 2003-2007). Romanian irrigation infrastructure right now corresponds to 700,000 hectares, but even half of it is not irrigated because of very high utility cost. World Bank report shows Romania can repair irrigation infrastructure for 800,000 hectares, but specialists advise small farmers to use small irrigation equipment because they are more efficient.

Table 3. Shares of irrigated areas in UAA by regions

GEO/TIME	2005	2007	2010	2013
Romania	0.6	1.3	1.0	1.2
North-West	0.0	0.0	0.0	0.0
Centre	0.0	0.0	0.1	0.0
North-East	0.1	1.5	0.1	0.1
South-East	2.0	4.0	4.3	5.8
South - Muntenia	1.0	1.8	1.2	1.0
Bucharest - Ilfov	1.2	0.2	0.2	0.2
South-West Oltenia	0.7	0.9	0.4	0.3
West	0.3	0.0	0.1	0.1

Source: Eurostat

Table 4. Share of irrigable areas in UAA for EU

GEO/TIME	2005	2007	2010	2013
Belgium	1.6	1.7	1.0	1.5
Bulgaria	4.1	3.4	3.1	2.5
Czechia	1.3	1.1	0.9	1.0
Denmark	16.6	16.4	18.2	16.8
Germany	:	:	3.8	4.1
Greece	40.0	38.2	25.1	31.2
Spain	15.1	14.7	15.1	29.0
France	9.8	9.7	8.4	10.1
Croatia	:	2.8	1.7	1.6
Italy	31.3	31.0	29.1	33.1
Cyprus	30.3	31.4	34.0	34.8
Hungary	3.6	3.3	5.0	5.6
Malta	29.5	31.0	27.5	38.6
Netherlands	20.8	23.9	26.0	27.0
Austria	3.7	3.6	3.2	4.4
Poland	0.8	0.7	0.6	0.5
Portugal	16.8	16.8	14.7	15.2
Romania	5.8	4.5	3.1	1.8
Slovenia	0.9	0.8	1.1	0.9
Slovakia	9.6	9.5	5.7	5.2
Finland	3.1	3.3	3.0	4.5
Sweden	5.2	5.1	5.4	5.1
United Kingdom	1.3	0.9	0.6	0.7

Source: Eurostat

It is noticed that for Romania the irrigation decreased constantly, and the irrigated area increased a little (Table 4 and 5). Bulgaria is a similarly case but with a little slow decreasing of irrigation area and the general trend is the same with few exceptions (Malta, Italy, Spain, and Austria).

Table 5. Shares of irrigated areas in UAA for EU

GEO/TIME	2005	2007	2010	2013
Belgium	0.2	0.4	0.3	0.4
Bulgaria	2.0	2.4	2.0	2.1
Czechia	0.5	0.6	0.6	0.5
Denmark	9.7	9.5	12.1	9.2
Germany	:	:	2.2	2.2
Greece	32.9	31.4	19.8	24.0
Spain	13.5	13.1	12.8	:
France	6.1	5.5	5.7	5.1
Croatia	:	0.9	1.1	0.9
Italy	20.6	20.9	18.7	23.7
Cyprus	22.0	21.4	23.9	22.6
Hungary	1.8	2.1	2.4	3.0
Malta	24.0	27.2	24.7	33.6
Netherlands	4.8	10.6	7.3	5.5
Austria	1.2	1.4	0.9	1.9
Poland	0.5	0.5	0.3	0.3
Portugal	12.3	12.1	12.7	13.1
Romania	0.6	1.3	1.0	1.2
Slovenia	0.5	0.3	0.3	0.5
Slovakia	2.4	2.0	0.8	1.3
Finland	0.0	0.0	0.6	0.4
Sweden	1.5	1.7	2.1	1.7
United Kingdom	1.3	0.9	0.4	0.3

Source: Eurostat

In 2005-2013 the share of arable land in UAA for Romania (the ninth country by total area in EU-28) was almost 63% (the fourteenth country by arable land in EU-28), according to Eurostat, as the same figures (between 50% - 70%) with Austria (50%), Netherlands (57%), Latvia (64%), Italy (56%), Croatia (56%), France (67%), Estonia (66%), Belgium (62%). Countries with low values (between 20% - 50%) are: United Kingdom (37%), Slovenia (36%), Portugal (30%), Luxemburg (45%), Spain (48%), Greece (38%), Ireland (21%). Countries with high values (over 70%) are: Sweden (84%), Finland (99%), Poland (75%), Malta (80%), Hungary (81%), Lithuania (79%), Cyprus (73%), Germany (71%), Denmark (92%), Czechia (72%), Bulgaria (71%).
Cereal crop (including seeds) in Romania in 2013 (the final year the irrigation data are available) was 3,316 million euro (at basic price), on the seventh place in EU-27, after Germany (7,128 million euro), Spain (3,607 million euro), France (11,253 million euro),

Italy (4,233 million euro), Poland (3,545 million euro), United Kingdom (4,092 million euro).
Cereal crop (including seeds) in Romania in 2015 was 3,316 million euro (at basic price) with the main contribution of Macro-region II (North-West and South-East), staying on the same seventh place in EU-27, after Germany (7,400 million euro), Spain (3,607 million euro), France (10,766 million euro), Italy (3,995 million euro), Poland (3,546 million euro), United Kingdom (4,094 million euro). But in 2017 Romania jumped on the third place in EU-28 with a cereal crop by 4,203 million euro after France (9,676 million euro) and Germany (6,322 million euro).
A good indicator for this analysis is water use by agriculture (in million cubic meters), but unfortunately the Eurostat available data are shy (data for Romania include 2012 till 2015). According to these data, Romanian water consumption was 3.1 in 2012, 1.4 in 2013, 5.6 in 2014 and 1.6 in 2015. Data for Germany, France (first and second places in cereal crop), Italy, and Poland are not available. But Spain data released 34 in 2012, 23 in 2013, and 25 in 2014. United Kingdom only reported 120 water use in 2011. According to water productivity (how much economic output is produced per cubic meter of fresh water abstracted from any fresh water including mine water, drainage water [2], and precipitation, expressed in euro/cubic meter), Romania figures float around 20 value between 2005 and 2015, comparing with Germany (around 80 in 2007 and 2010), France (60-70), Spain (around 30), Poland (around 30) and Great Britain (between 175 and 275 value between 2005-2015 years), and Italy (no reported data). The best results of water productivity Luxembourg (1017 in 2015). Thus, we ca not conclude something about the relationship between water consuming, irrigation and cereal crop.
Regarding the total energy used in agriculture for all energy uses (expressed in KgOE, called kg of oil equivalent per capita), the figures from Eurostat show that in 2005 Romanian energy consumption for agriculture had the lowest level from EU (15) comparing with the highest level of energy consumption by Netherland (2016). France energy used was around 130 along the considered years (2005-2015), Italy around 200, Spain 100 and UK around 50. Germany has no reported data. In 2016 energy used in Romanian agriculture was 33.54 (the lowest from EU-28).
Finally, the paper concentrated over economy output, represented by the gross domestic product (GDP), expressed in euro per capita, for the considered years (2005, 2007, 2010, 2013), and the figures show Romania has the lowest level of GDP per capita (5,100) after Bulgaria (4,200) in 2005, competing just only with Bulgaria for all considered years (2007, 2010, 2013). The higher level is 76,500 in 2005 hold by Luxemburg, followed by Denmark, Ireland, Netherlands around 40,000; then Germany, France, Belgium, Italy, Austria, Finland, Sweden and UK around 30,000 euro per capita, and the EU-28 average being 24,800 euro per capita.
Nevertheless, the share of agriculture in GDP represents a small part in all EU-28 countries, under 4.5%, the greater level by Denmark in 2015 (Romania case being 4.2%), and less than 2.6% get by Spain in 2017. In Romania the share of agriculture in GDP was 3.9%. Romanian agriculture crop output at basic prices – the price received by the producer after deduction all taxes – (expressed in million euro) registered in 2013 the value of 12,185 million euro, on the sixth place in EU-28, after France (41,284), Italy (31,652), Germany (28,509), Spain (25,896), and Netherlands (13,489). The figures are almost the same for 2017 year.

V. RESULTS AND CONCLUSION

In conclusion, even if Romanian agriculture is not based on irrigation (table 1, 2, 3, 4) comparing with EU-28 countries, the agriculture crop is high, but the productivity is less. Furthermore, the relationship between GDP and irrigated agriculture is not so relevant, due to the small share of agriculture sector in GDP. We conclude that even if the empirical results are week, it is necessary to continue with water management reform [1] and European environmental policy. The responses of agricultural irrigated systems to horizontal policies are significantly different. The different results depend on economic context, environmental fragility they must face, water demand, socio-environmental performances, regional culture and environmental habit and education.

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