Montenegrin Journal of Economics

Vol. 14, No. 4 (2018), 057-068

Regional Development in Conditions of Limitation of Water Resources: Correlation Interconnections

SVITLANA FEDULOVA[1], VITALINA KOMIRNA[2], NATALIIA NAUMENKO[3] and OKSANA VASYLIUK[4]

[1] Associate Professor, Head of the department of Theoretical and Applied Economics, State Higher Educational Institution "Ukrainian State University of Chemical Technology", Dnipro, Ukraine, e-mail: sveta_fedulova@ukr.net
[2] Associate Professor, Professor of the department of Theoretical and Applied Economics, State Higher Educational Institution "Ukrainian State University of Chemical Technology", Dnipro, Ukraine, e-mail: v.komirna@gmail.com
[3] Associate Professor, Department of Theoretical and Applied Economics, State Higher Educational Institution "Ukrainian State University of Chemical Technology", Dnipro, Ukraine, e-mail: nata.yu.naumenko@gmail.com
[4] Postgraduate of the department of Theoretical and Applied Economics, State Higher Educational Institution "Ukrainian State University of Chemical Technology", Dnipro, Ukraine, e-mail: name8397@gmail.com

ARTICLE INFO

Received August 10, 2018
Revised from September 03, 2018
Accepted November 17, 2018
Available online December 15, 2018

JEL classification:

P11, P25, Q56, Q57, Q58, G18.

DOI: 10.14254/1800-5845/2018.14-4.4

Keywords:

regional development,
water resources,
virtual water,
biserial correlation.

ABSTRACT

The *main idea* of the article is to study the problem of regional development in the conditions of limited water resources. The *subject* of the study is theoretical and methodological provisions and applied practical recommendations for the regulation of regional development in the conditions of limited water resources. The *purpose* of the article is to determine the connection between water supply (water potential) of Ukrainian regions and their specialization in production and trade in the conditions of water resource constraints and determine the further prospects for regional development. In the study have been used traditional and special *methods* of research, including: historical and logical method, method of abstraction and analogy, system analysis methods and the method of correlation analysis. For calculations was used the biserial correlation method based on the point of biserial relation coefficient of Pearson. The article presents a *hypothesis* about the need to change the paradigm of regulation of regional development regulation on the basis of water-efficient water use and identified the territories of Ukraine with the general water risk. It is determined that Ukraine is the world's largest exporter of food products, along with the USA, Australia and Russia, that requires significant water resources. It has been proved that there is no link between the water supply (water potential) of the regions and production and trade with grain and leguminous plants. It is possible to assume that such conditions have arisen due to the existence of land resources (black earth) on the territory of the country, and also that in Ukraine there are other more important problems of effective regional water use.

INTRODUCTION

Over the past decades, the concepts of food security, energy security and access to natural resources have been widely discussed. However, for the moment, more researchers are recognizing that the environment and security are interconnected. In particular, on the example of water resources, it can be argued that the deficit of fresh water represents both a direct and an indirect threat to safety, since, on the one hand, this deficit creates a dangerous situation, and on the other hand, it is fraught with potential conflicts. The most serious security threat is associated with water deficit and it is not wars for water resources, but rather an aspect of human security that could endanger both state security and international security. However, it has to be taken into account that not only a water deficit generates a conflict, but the conflict itself can lead to a lack of water. Conflicts have direct consequences for water resources, for example, in the form of water pollution. So, the waters of the Danube river were polluted during the conflict in the former Yugoslavia, in Bosnia and even more so during the war in Kosovo. Also, dams and barrages, pumping stations and sewers can be damaged during war actions. In today's conditions it is necessary not to compete with each other, trying to provide ourselves with water resources but to cooperate.

With the growth of water deficit in a number of countries, recently due to global warming, a number of strategies have been developed to overcome it, which include savings on water consumption, salt removal of saltish or salty sea water. Another alternative to minimize water consumption is to import wet industry products for agriculture, industry and energy. This thesis is explained with the concept of “virtual water”, which was developed in 1993. The creator of the "virtual water" concept which is related to measuring the volume of water embodied in the products and trade of food and other commodities is the professor of London University John Antony Allan (1998). He proposed a formula for calculating the amount of water which is required for production of a particular product. This concept helps to understand how much water is needed in order to create different goods and services.

According to this concept, all virtual water can be divided into “blue” it is surface water, or groundwater, which is evaporated in the production of products, "green" it is rain water, which is usually evaporated in production and "grey" which is the volume water contaminated during the production process, that is determined by calculating the volume of water required for the dilution of pollutants entering to natural water systems during the production process up to obtaining water quality that meets the standards (based on the Official site of water footprint, 2017). The concept of virtual water set a start for additional research and development in this area. Later, the Professor of University of Twente in the Netherlands, Arjen Y. Hoekstra proposed the concept of a "water footprint" in 2002. According to this theory, the water footprint represents the entire water consumed by the region, including the virtual one.

The amount of virtual water can be calculated not only for individual products, but also for the person, enterprise, region and country as a whole. Since not all the products are consumed and produced in the same country, the concept of "water footprint" is used in the research. The water footprint consists of two parts: the use of inland water resources and the use of water resources from sources located outside of the country. The water footprint includes water intake from surface and underground water sources and the use of ground water in agricultural production. The concept of "virtual water" allowed to have a new look at issues of effective water use and water policy. Among the Ukrainian researchers who develop virtual water issues, the following scientists from the Institute of Natural Resources and Sustainable Development of the National Academy of Sciences of Ukraine can be mentioned: M. Khvesyk (2014), A. Sunduk (2014), L. Levkovska (2014), O. Melnik (2011), O. Matsenko (2011) and M. Khizhnyak (2011). Also such Ukrainian scholars as A. Yakymchuk and P. Skrypchuk are dealing with this issue.

By definition of M. Khvesyk ("*Virtual water: a myth or reality*?"), stored in the product and its value, the water moves from the place of production to the final consumer. In the conditions of the global economy, the distances that goods overcome are thousands of kilometers. If to take into account the trade turnover between countries and continents, trade performance will be very high. No less significant are the volumes of water components, as well as their monetary expression. Virtual water flows are formed on the basis of export-import operations.

It should be noted that a large number of reports on the state of the environment and assessment of the state of water resources, which contain various materials and rich statistical information are published in Ukraine. At the same time, the analysis of all national and regional publications highlights the efficiency of water use shows that today there is not enough information available, and its relevance for effective political decisions is still low. The purpose of the article is to determine the connection between water supply (water potential) of regions of Ukraine and their specialization in production and trade in the conditions of water resource constraints and determine the further prospects for regional development.

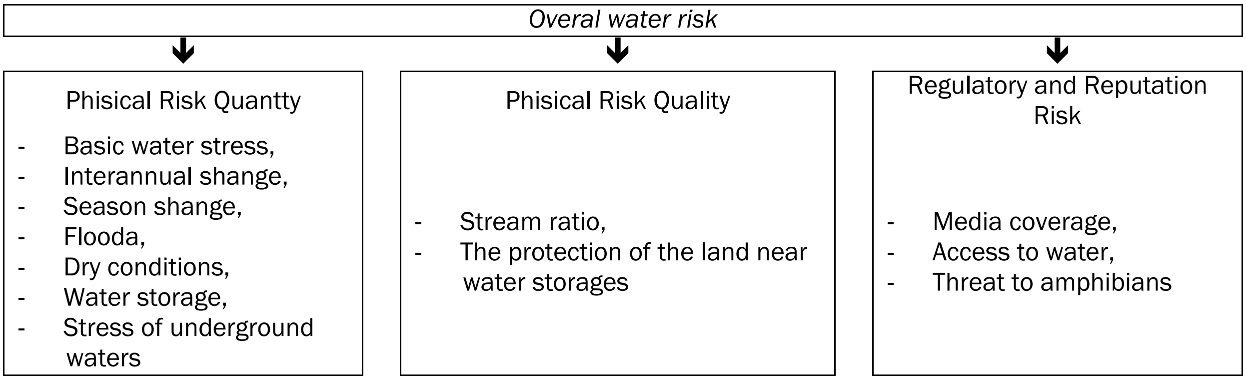
1. BACKGROUND OFREGULATION PARADIGM CHANGE OF REGIONAL DEVELOPMENT FOR EFFICIENT REGIONAL WATER USE IN REGIONS

Due to the non-homogenous geographical distribution of natural resources, demand for water and crude oil may not always be satisfied with the local supply. Water is usually not transported directly over long distances. Despite the fact that some cases of direct export of water are already fixed, there is neither a world market nor a standard global water price. Instead, the international trade in water-based goods, the so-called virtual water market, already exists (Oki, Yano and Hanasaki, 2017; Wichelns, 2010; Perelyot, 2010 and data of the Report of the High Level Panel on Financing Infrastructure for a Water-Secure World, 2015). As a rule, it is considered that trade with "real water" between territories without moisture is impossible due to long distances and associated costs, also because water as a production resource is required in a considerable volume (Oki, Yano and Hanasaki, 2017). International water trade through the construction of channels and the redistribution of river flows is very limited due to huge capital expenditures.

It should be noted that the problems of export-import of "virtual water" are extremely worried by the Food and Agriculture Organization of the United Nations (FAO) (data of the Official site of Food and Agriculture Organization of the United Nations, 2018), the World Water Institute (SIWI) (data of the Official site of World Water Institute, 2018), the World Resources Institute (WRI) (data of the Official site of Institute of World Resources, 2018) and many European researchers. More we refresh on our memory the statement of the World Bank Vice-President I. Seragildina: "Wars of the XXI century will be wars for water," which he pronounced in 1995 (Dinar, 2007). For arid countries, the import of virtual water (first of all, in the form of agricultural products, which accounts up to 70-90% of water consumption, can be a good means of reducing domestic demand for water and, thus, mitigating the internal water shortage.

It should be noted that there are many factors that affect the flow of water-based products, which are many times more important than water supply itself. Thus, the question becomes more important the issue about water availability determines the specialization of the region in the export or import of water-based products in the actual practice of international trade (Chuprov, 2016). A study conducted in 2003 by H. Yang and co-authors (Yang et al., 2003), who, after analyzing the data for countries in Africa and Asia, confirms that for most countries, the degree of water availability is not a significant factor affecting international trade. However, after reaching a certain threshold for a shortage of water, the country begins to demand the import of cereals, exponentially increasing with the reduction of water resources. Later, researchers conclude that reducing water availability is an important factor in the growth of net imports of virtual water by countries in the region (Yang et al., 2007). A study of H. Young with co-authors allows us to trace the dynamics of the relationship between water resources supply and its trade specialization. Regarding the Ukrainian territories, in the light of the problems of development in the conditions of limited water resources, the riskiness of the Ukrainian territories notes the Institute of World Resources (WRI) (Table 1). According to the terminology of this Institute, the overall water risk determines areas where there is an increased risk associated with the use of water resources and represents the aggregate measure of all selected indicators by categories of physical, qualitative, regulatory and reputational risk (the explanation of these risks is given in Figure 1).

Figure 1. Components of general water risk according to the methodology of the World Resources Institute (WRI)*



*Source: Official site of Institute of World Resources: http://www.wri.org, 2018.

Table 1. Overall Water Risk for Ukrainian Regions according to the data of Institute of World Resources

Level of risk to methodology of WRI	Region of Ukraine
Low risk (0-1)	---
Low to medium risk (1-2)	Kyiv, Chernivtsi, Zakarpattya, Lutsk, Zhytomyr, Chernihiv, Cherkasy, Dnipropetrovsk (mostly), Zaporizhzhya (half)
Medium to high risk (2-3)	Kharkiv, Poltava, Luhansk (most), Sumy, Kirovograd, Vinnytsya, Khmelnytsky, Ternopil, Ivano-Frankivsk, Lviv, Rivne, Odessa (mostly), Zaporizhzhya (half)
High risk (3-4)	Crimea, Kherson, Nikolaev, Donetsk, Lugansk (small part), Dnipropetrovsk (small part), Odesa (small part)
Extremely high risk (4-5)	---

Source: Official site of Institute of World Resources: http://www.wri.org, 2018.

As can be seen from Table 1, the World Resources Institute (WRI) defines the territory of Ukraine with high water risk (3-4), including the temporarily occupied territory of the Autonomous Republic of Crimea, Kherson, Nikolaev, Donetsk, Lugansk (small part), Dnipropetrovsk (small part) and Odesa (small part) areas. At the same time, the researchers of the Institute for the Economy of Natural Resources and Sustainable Development of the National Academy of Sciences of Ukraine indicate that Ukraine, according to expert estimates, is distinguished by significant volumes of virtual water formation. In particular, the overall figure for exports is fixed at 19.5 billion m^3, which exceeds the baseline volumes of water use in the country as a whole (Table 2). By import, the rate of virtual water is no longer so high and is limited to 1.84 billion m^3 (Khvesyk, Levkovska and Sunduk, 2014).

Table 2 clearly demonstrates the predominance of virtual water exports over imports in Ukraine. 81.5% of this export is for agroindustrial complex, and only 18.5% refers to industry.

Thus, Ukraine, supplying grain abroad, outputs significant volumes of virtual water over its borders, which is not so much in imported goods. According to the researches of the Institute of Natural Resources of Economics and Sustainable Development of the National Academy of Sciences of Ukraine, in the regional dimension, the main load on virtual water falls predominantly on the south-eastern regions of the country. The problem is the occupation of the territories of Donetsk and Luhansk regions and the annexation of the Crimea, as they created significant flows of virtual water. These leading regions serve as a kind of "global gate" for virtual water flows (Khvesyk, Levkovska and Sunduk, 2014).

Table 2. Export-import of virtual water and its characteristics for Ukraine (as of January 1, 2013)

Sphere of virtual water formation		*Million m^3*	*Internal prices, million UAH*	*World prices, million USD*
Agricultural complex	Export	15900,4	6996,2	7950,2
	Import	119,7	359,1	59,9
Industry	Export	3604,3	1587,0	3604,3
	Import	1728,1	5184,3	1728,1
General index	Export	19504,7	8583,2	11554,5
	Import	1847,8	5543,4	1788,0

Source: According to the data of Institute for the Economy of Natural Resources and Sustainable Development of the National Academy of Sciences of Ukraine, 2014.

According to researchers from the University of Leiden (the Netherlands), as of 2017, Ukraine is the world's largest food exporter, along with the United States (mainly South America), Australia and Russia. But the main importers of food products are Western Europe, Asia and Africa and the Middle East (Bacon, 2017). The same opinion is shared by researchers at the Institute of Natural Resources and Sustainable Development of the National Academy of Sciences of Ukraine, who claim that Ukraine is now among the three world grain exporters (after the USA) and has a significant place in the export of metallurgical products.

Among the sectors of the economy of Ukraine, the largest consumers are energy, metallurgy, chemical and petrochemical industries, which simultaneously belong to the main polluting industries in the industrial sector of the economy. According to the State Agency of Water Resources and the State Committee of Statistics of Ukraine, Dnipropetrovsk, Zaporizhzhya, Donetsk, Kherson and Kyiv regions (Table 3) belong to the five largest consumers of water in Ukraine, which confirms the opinion that they are the main exporting regions of virtual water. The industrial need of these five regions (out of the 24 existing in Ukraine and the Autonomous Republic of Crimea) is almost 63.3% of the total use of fresh water by regions (Fedulova and Komirna, 2017).

It should be noted that in Dnipro basin is created a diversified economic complex, which includes industry, agriculture, hydropower, communal services, water transport, fisheries. Here is concentrated about 43% of industrial production of Ukraine (Fedulova, 2017).

Water content of gross national product is in 3-5 times higher than in industrialized countries of Europe, which testifies to inappropriate water use and low efficiency of existing production equipment. Today, the volumes of water use in river basins virtually reached the upper limit, resulting in a contradiction between the demand for water and the possibilities to meet it, not only in terms of quantity but also in quality (Khvesyk, 2013).

Table 3. Use of fresh water by regions of Ukraine, including freshwater and seawater, mln. m³*

Regions	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Ukraine	30201	20338	12991	10188	9817	10086	10507	10092	8710	7125	7169
Regions											
Dnipro	3599	2752	1756	1579	1361	1407	1429	1349	1359	881	1055
Donetsk	3419	2548	1751	1508	1467	1479	1445	1354	1135	936	926
Zapori-zhzhya	4598	2635	1702	1076	1099	944	1186	1237	1146	1150	1081
Kyiv	2131	1496	1132	812	902	925	1028	866	808	706	664
Kherson	2161	1131	639	610	770	963	1083	1074	1062	1037	990

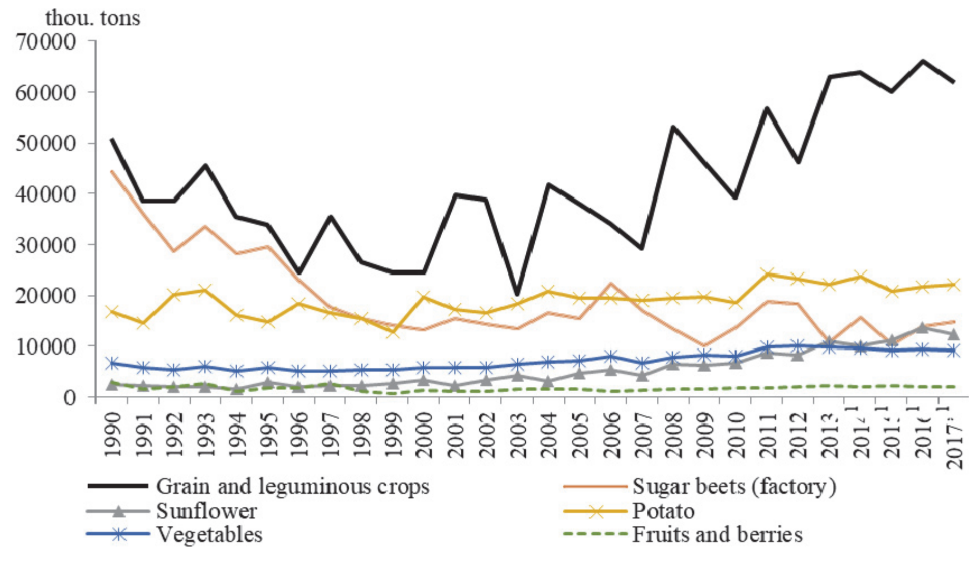
* Prepared by the authors based on the source of State Statistics Service of Ukraine, 2014–2017.

But, returning to the assessment of the overall water risk by the World Resources Institute (Table 1) raises the question of if such water export loading on the virtual water could be endured by Kherson, Donetsk, and Dnipropetrovsk regions and the temporarily occupied territory of the ARC. These territories are classified as "High risk (3-4)". It should be noted that agricultural products are low value added goods. In our view, it's necessary to have more balanced approach to the formation of strategic areas of economic activity and their forms. Thus, the conducted theoretical analysis of the functioning of regional socio-economic systems allows us to ascertain the change in the paradigm of regulation of regional development on the basis of water-efficient regional water use.

2. METHODIC APPROACH TO RESEARCH: CORRELATION INTERCONNECTIONS

It is known that the largest volumes of water use in the world forms the production of grain and agricultural products. Data from the State Statistics Committee indicate that Ukraine can indeed be considered one of the largest exporters of grain and sunflower in the world (Figure 2).

Figure 2. Production of basic crops in Ukraine for 1990–2017, thou. tons

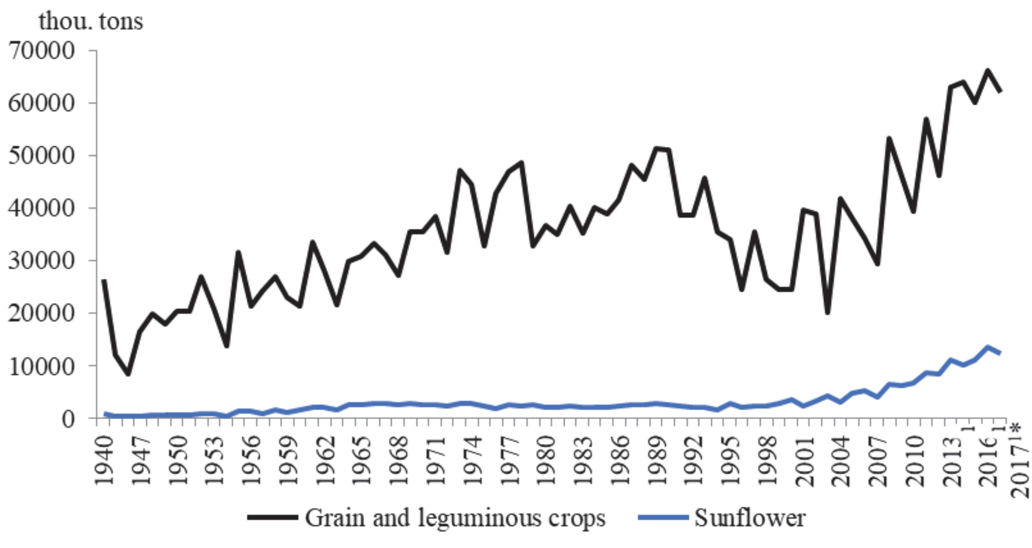


Source: prepared by the authors based on the source Agriculture of Ukraine. Statistical Collection, 2016.
*Plant Growing in Ukraine. Statistical Collection, 2017.
[1]The data are given without taking into account the temporarily occupied territory of the ARC, the city of Sevastopol and the temporarily occupied territories of Donetsk and Luhansk.

Compared to 1990 the highest rates of growth were observed in the production of grain and leguminous crops in Ukraine and sunflower, respectively, 121.38% and 475.94%, it means that over the years of independence, grain and legume production is increased in 1.2 times, while sunflower almost in 4.8 times

If to investigate in the context of the last 10 years, then from 2007 to 2017 grain and legume production has already increased in 2.1 times, that is, we have a tendency for increase of this production. The studied dynamics since 1940 indicates that over the years, Ukraine has only increased grain and legume production from 26419.7 thousand tons in 1940 up to 61916.7 thousand tons in 2017 (in 2.3 times) and sunflower from 946.5 thousand tons in 1940 and up to 12235.5 thousand tons in 2017 (in 13 times) (Figure 3). This production burden falls on arid southeastern regions of Ukraine. As it was already described, some of these areas are referred by the Institute of World Resources to high risk water regions (High risk (3-4), the Crimea (temporarily occupied), Kherson, Nikolaev, Donetsk (part of the territory is occupied), Luhansk a small part of the territory is occupied), Dnipropetrovsk (a small part), Odesa (a small part). The peculiarity is that these regions have a critically low value of river runoff per year per person, Kherson has 0.13 thousand m³/year; Mykolaiv 0.49 thousand m³/year; Donetsk 0.24 thousand m³/year; Luhansk 0.66 thousand m³/year; Dnipropetrovsk 0.27 thousand m³/year; Odesa 0.15 thousand m³/year. In general, all south-eastern regions have a low value of river runoff per one person per year (Dnipropetrovsk, Donetsk, Zaporizhzhya, Luhansk, Mykolaiv, Odesa, Poltava, Kharkiv, Kherson) (from 0.13 to 0.66 thousand m³/year).

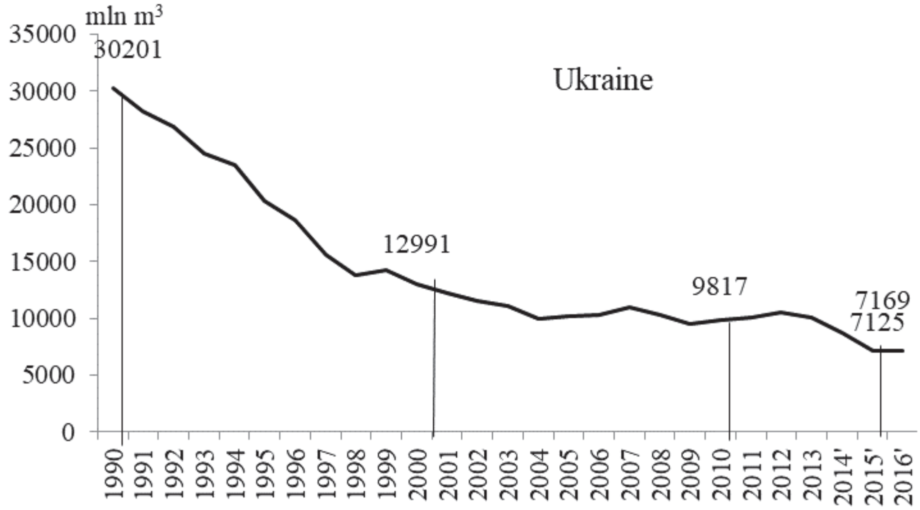
Figure 3. Production of grain and leguminous crops and sunflower in Ukraine for 1940–2017, thou. tons



Source: prepared by the authors based on the source Agriculture of Ukraine. Statistical Collection, 2008.
*Plant Growing in Ukraine. Statistical Collection, 2017.
[1]The data are given without taking into account the temporarily occupied territory of the ARC, the city of Sevastopol and the temporarily occupied territories of Donetsk and Luhansk.

So taking into account the increase of the agrarian potential described above, in Ukraine since 1990 and up to date there has been a significant reduction in water use (compared with 1990 almost in four times) and a corresponding reduction in the technogenic load on water objects (Figure 4).

Figure 4. Use of fresh water from 1990 to 2016 in Ukraine (including freshwater and seawater), mln. m³*



* prepared by the authors based on the source of State Statistics Service of Ukraine, 2010–2017.
[1]The data are given without taking into account the temporarily occupied territory of the ARC, the city of Sevastopol and the temporarily occupied territories of Donetsk and Luhansk.

There are several reasons for this: the one first is the reduction of national production, happened due to the reorientation of production to the domestic market during the crisis of 1991-1996, and the second one is moral and physical aging of wastewater treatment equipment and systems, which also led to a decline in national production, and, of course, the third one, the use of water-efficient technologies in recent years has to be taken into account (technology of consistent recycled water supply in productions, closed technologies). However, the ecological state of surface and underground sources of water supply is not improving. There is a significant geochemical pollution of water with heavy metals, products of oil refining, mineral fertilizer residues. Every year, large amounts of inadequately cleaned municipal and industrial sewage are discharged into surface water objects of the country, which is the result of significant volumes of such waste and inefficiency of water treatment systems.

Until the beginning of the armed conflict in 2014, there was another region in Ukraine that consumed water much more than other regions it was the Autonomous Republic of Crimea. By the end of 2013, the water consumption of the ARC was 7.62% of the total water use; at the same time, in Dnipropetrovsk region it was 13.37%; in Donetsk 13.42%; Zaporizhzhya 12.26%; Kiev 8.58%; Kherson 10.64%. For the rest of regions there was no more than 2-3% of the total water use, except Kyiv (5.76%). Thus, for 25 years, the most significant consumers in Ukraine are Dnipropetrovsk, Zaporozhzhya, Donetsk, Kherson and Kyiv regions and the Autonomous Republic of Crimea during when the territory was not occupied. From statistics it is clear that water consumption in Ukraine has decreased considerably, almost in 4 times. A marked increase in water use is observed in the Kherson region since 2003. Donetsk region consumes sea water as considerable part, it is almost the only area that uses seawater for production needs (practically 60% of regional water use). Sometimes seawater is still used by the Odesa region, they use 2-3% of the regional water use and Kherson region, that is 0.1%.According to statistical data Kyiv slightly behind for water use, but still consumes more than other regions.

The described tendencies suggest that, indeed, in the regions of Ukraine, the degree of water availability (the water potential of the region) is not a significant factor affecting the trade with grain and legumes, which production requires significant water resources. In the fact that Ukraine is the poorest country in water resources in Europe, such trends are embarrassing and require scientific substantiation of rational water use in regions. The proof of the author's assumption is the lack of a correlation between the average arithmetic values for 10 years of production of grain and leguminous crops by regions of Ukraine (thousand tons) and the value of average many years resources of river runoff in the regions (km³/year). The calculations were not used data on the Autonomous Republic of Crimea due to its temporary occupation and lack of data.

3. RESULTS

For calculations was used such a method of correlation analysis of biserial correlation using a point biserial correlation coefficient of Pearson (Table 4).

Table 4. Calculation of the point biserial correlation coefficient of Pearson

The value is the arithmetic mean for 10 years of production of grain and leguminous crops in the region, thou. tons/year, x_i		The value of medium-long-term river runoff resources, km³/y, Y	Dichotomic scale for Y		$(x_i - \bar{x})$	$(x_i - \bar{x})^2$	Y1	Y0
Vinntsya	4158,56	2,47	high	1	1884,780	3552401,931	4158,56	
Volyn	882,92	2,18	high	1	-1390,858	1934486,903	882,92	
Dnipro	3218,36	0,87	low	0	944,582	892234,525		3218,36
Donetsk	1959,21	1,02	high	0	-314,568	98953,236		1959,21
Zhytomyr	1619,15	3,15	high	1	-654,628	428538,253	1619,15	
Zakarpattya	332,11	7,92	high	1	-1941,668	3770075,917	332,11	
Zaporizhzhya	2299,39	0,62	low	0	25,612	655,957		2299,39
Ivano-Frankivsk	597,17	4,59	high	1	-1676,608	2811015,503	597,17	
Kyiv	2855,28	2,04	high	1	581,502	338144,188	2855,28	
Kyrovohrad	3086,4	0,95	low	0	812,622	660353,973		3086,4
Luhansk	1213,09	1,46	low	0	-1060,688	1125059,74		1213,09
Lviv	1112,98	4,92	high	1	-1160,798	1347452,771	1112,98	
Mykolaiv	2492,25	0,57	low	0	218,472	47729,869		2492,25
Odesa	3402,88	0,35	low	0	1129,102	1274870,574		3402,88
Poltava	4576,34	1,94	high	1	2302,562	5301790,229	4576,34	
Rivno	975,28	2,33	high	1	-1298,498	1686097,922	975,28	
Sumy	2965,02	2,45	high	1	691,242	477815,042	2965,02	
Ternopil	2062,97	1,81	high	1	-210,808	44440,153	2062,97	
Kharkiv	3483,41	1,66	high	1	1209,632	1463208,769	3483,41	
Kherson	1781,35	0,14	low	0	-492,428	242485,664		1781,35
Khmelnitsk	2578,05	2,14	high	1	304,272	92581,247	2578,05	
Cherkasy	3430,84	1,01	low	0	1157,062	1338791,7		3430,84
Chenivtsi	557,81	1,23	low	0	-1715,968	2944547,321		557,81
Chernihiv	2929,86	3,45	high	1	656,082	430443,153	2929,86	
Amount	**54570,68**					**32304174,54**	**31129,1**	**23441,58**

Source: prepared by the authors

If the variable X is measured on a strong scale, and the variable Y is in the dichotomous, then the point biserial correlation coefficient is calculated by the formula

$$r_{pb} = \frac{\overline{x_1} - \overline{x_0}}{S_x} \cdot \sqrt{\frac{n_1 n_0}{n(n-1)}}, \quad (1)$$

where $\overline{x_1}$ – the average value for *X* objects with the value "unit" by *Y*;

$\overline{x_0}$ – the average value for *X* objects with a value of "zero" on *Y*;
s_x – average square deviation of all values by X;
n_1 – number of objects "unit" by *Y*, n2 - number of objects "zero" by *Y*;
$n = n_1 + n_0$–sample size.

The point biserial correlation coefficient can also be calculated using other equivalent expressions:

$$r_{pb} = \frac{\overline{x_1} - \overline{x}}{S_x} \cdot \sqrt{\frac{n_1 n}{n_0 (n-1)}}, \quad (2)$$

$$r_{pb} = \frac{\overline{x} - \overline{x_0}}{S_x} \cdot \sqrt{\frac{n_0 n}{n_1 (n-1)}}, \quad (3)$$

where $\overline{x}$ – total average value for variable *X*.

As per conditions of the task $n_1 = 14$, $n_0 = 10$. Sample size $n = 24$, $df = 22$.

We find the mean values for the variable X and the quadratic mean deviation s_x and the value of the point biserial correlation coefficient:

$\overline{x}$ = 2273,778; $\overline{x_1}$ = 2223,507; $\overline{x_0}$ = 2344,158; S_x =1160,176.

$$r_{pb} = \frac{\overline{x_1} - \overline{x_0}}{S_x} \cdot \sqrt{\frac{n_1 n_0}{n(n-1)}} = -0{,}0524$$

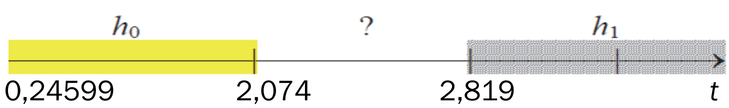
$$r_{pb} = \frac{\overline{x_1} - \overline{x}}{S_x} \cdot \sqrt{\frac{n_1 n}{n_0 (n-1)}} = -0{,}0524$$

$$r_{pb} = \frac{\overline{x} - \overline{x_0}}{S_x} \cdot \sqrt{\frac{n_0 n}{n_1 (n-1)}} = -0{,}0524$$

The hypothesis of the significance of the point biserial correlation coefficient is verified using Student's criterion. The empirical value is equal to

$$|t| = \frac{|r_{pb}|}{\sqrt{1 - r_{pb}^2}} \cdot \sqrt{n-2} = \frac{|-0{,}0524|}{\sqrt{1 - (-0{,}0524)^2}} \cdot \sqrt{24-2} = 0{,}24599$$

We find the critical values of Student's criterion $t_\alpha(df)$ in statistical tables for the number of degrees of freedom df = 22.



Empirical value | t | = 0,24599 does not fall into the critical region, which allows us to accept the null hypothesis ρ = 0. Consequently, there is no link between the water supply (water potential) of the regions and the production and trade with grain and legumes, the production of which requires significant water resources.

CONCLUSION

However, there is still a question that, after reaching the threshold for water scarcity, Ukraine will begin to demand the import of water-based technologies and goods exponentially increasing with the reduction of water resources. Ukraine, having a total only 5.1 km3/year of total domestic renewable water resources, in no way cannot be compared with Brazil which is 5661 km3/year, the USA is 2818 km3 /year, China is 2813 km3/year, although it is the largest exporter of cereals in the world after the USA and Russia. Brazil, Russia, Canada, Colombia and Australia have the largest water potential in the world, which in future can create the most favorable conditions for economic growth.

The analysis of the functioning of regional socioeconomic systems under the influence of global challenges for effective regional water use makes it possible to ascertain the existence of a problem of unbalanced regional development, and the country's economic complex is water unbalanced, and according to environmental parameters does not correspond to the possibilities of water resources restoration.

Water supply of the territories does not determine the specialization of the regions of Ukraine in the production and trade with grain and leguminous plants. It is possible to assume that such conditions have arisen due to the existence of land resources (black earth) in the country. It is also possible to assume based on the abovementioned facts that there are other more important problems of effective regional water use in Ukraine than the reduction of river runoff, namely, the infrastructure provision of water management in the regions, which causes large water losses and their repeated pollution, as well as unauthorized and unaccounted water discharges .

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