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Article

Econometric Model of Increasing Agricultural Water Productivity in Khorezm Region

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Abstract: Water productivity is one of the most important indicator of measuring agricultural water use efficiency. To find factors affecting water poductivity and evaluate their effects on water productivity are very crucial. In the article correlation and regression analysis are carried out between agricultural water productivity and its affecting factors. Our findings show that level of laser-aligned area impact higher on agricultural water productivity than level of water-saving technologies and level of concreting of channels in Khorezm region.

Keywords: agricultural water productivity, level of using water-saving technologies, level of concreting of channels, level of laser-aligned area, correlation matrix, regression analysis

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1. Introduction

Nowadays, due to the global climate change, the glaciers that supply water to rivers are melting faster than expected, which threatens to lead to water shortages in Central Asian countries in the future. In particular, this situation shows that the effective use of water resources is of great importance in the agricultural sector, which is the main user of water resources in the Republic of Uzbekistan. Water resources are crucial for Uzbekistan, which is located in an arid region, far from the oceans and large seas. About 80 percent of the water resources used in our country (about 41.5 km3 / year) are formed due to glaciers in neighboring republics. Due to global climate change, 30 percent of the area of more than 8 thousand glaciers in Tajikistan and 16 percent of the area of about 10 thousand glaciers in Kyrgyzstan have melted. It is predicted that another 15-20 percent of glaciers will disappear by 2030. At the same time, the number of years with water shortages in our region has been increasing recently. If until the 2000s, water shortages occurred every 6-8 years, then recently this situation has been observed every 3-4 years.

Khorezm region's agriculture is dependent to transboundary river , Amudaryo river. The region is located in the Lower Amu Darya natural-geographical region, and the agricultural land of the Khorezm region alone accounts for 5% of the republic's agricultural land. That is why the proper organization and regulation of water resources and irrigation systems is closely related not only to the ecological state of the oasis, but also to the social and economic lifestyle[1]. It is clear from this that the rational and productive use of every drop of water is becoming one of the most urgent tasks today, not only in our country, but throughout the world.

Agricultural Water productivity is an important indicator to evaluate the efficiency of agricultural water use. According to Cai and Rosegrant (2003) "Water productivity describes the physical or economic output per unit of water"[2]; further, Clemmens and Molden (2007) emphasized that "Water productivity deals with the amount of production from either an area of land or based on an amount of water input. Production can be mass of product or economic value" [3].

This paper is organized as follows. First, we describe authors studies that belongs to the topic, then we identify the methodology and data used. Following that, we analyze the factors affecting the water productivity based on correlation-regression analysis in Khorezm region.

LITERATURE REVIEW.

A. Ahmedov used an inter-sectoral balance model for water consumption in agriculture and other sectors of Khorezm region [4]. Furthermore, R. Muradov developed an "economic-mathematical model for rapid adjustment of water use plans in the event of a shortage of water resources" in agriculture [5].

M.M. Al-Kaisi and H. Yin, calculated that concreting water channels allows to increase the efficiency of the channels and reduce water loss by up to 95%[6].

Y.Kang et.al (2009) describes that "climate change will impact to the temperature and rainfall, so it will influence to crop water productivity" [7].

Cai and Rosegrant (2003) emphasizes that water productivity dependent on many factors, for instance, "crop patterns, climate patterns, irrigation technology and field water management, land and infrastructure, and input, including labor, fertilizer and machinery". Besides, Lei Zhang et.al (2013) also tests cultivated land size, labor input, machines value, irrigation water use and fertilizer and seed use factors to measure water productivity [8].

2. Materials and Methods

We use statistical data on agriculture at the district and farm category levels of Samarkand Province from 2011-2024. We collected long time period data from state statistic committee of Khorezm province and Chapqirgak-Amudarya basin irrigation system department. Water productivity is determined by used water and the amount of production.

Wesseling and Feddes (2006) state that water productivity is dependent on the stakeholders involved and explain four examples:

(1) an agronomist will define water productivity as harvested yield/evapotranspiration;
(2) a farmer usually considers water productivity as harvested yield/irrigation water supply;
(3) at the scale of an irrigation network water productivity is usually expressed as yield/canal water supply;
(4) policy makers at the scale of a river basin, are interested in water productivity as US $/amount of water used"[9].

Level of concreting of channels is expressed as length of concreting channels/ total length of channels. Level of use of water saving technologies is share of area of using water technologies in total irrigated area. Level of laser aligned area is expressed as laser aligned area/ total irrigated area.

Table 1. Summary Statistics, using the observations 1 – 14

Variable	Mean	Median	S.D.	Min	Max
Agricultural Water productivity (in Uzs)	1.38e+03	1.29e+03	401.	803.	2.03e+03
Level of concreting of channels	0.0101	0.00753	0.00671	0.00289	0.0236
Level of use of water saving technologies	0.0207	0.00744	0.0264	0.000352	0.0775
Level of laser aligned area	0.0804	0.0781	0.0545	0.0112	0.172

Table 1 shows correlation analysis is performed to determine the density of relationships between factors affecting water efficiency. Then, regression analysis is performed to determine the type of relationship between these factors.

3. Results and Discussion

We try to form correlation matrix to evaluate of the relationship between agricultural water productivity and it's affecting factors by using GRETLsoftware

Table 2. Correlation matrix, using the observations 1-14

	AgWP	LevCC	Lev WST	LevLAA
AgWP	1.0000			
LevCC	0.8079	1.0000		
LevWST	0.8821	0.7162	1.0000	
LevLAA	0.9520	0.8483	0.9033	1.0000

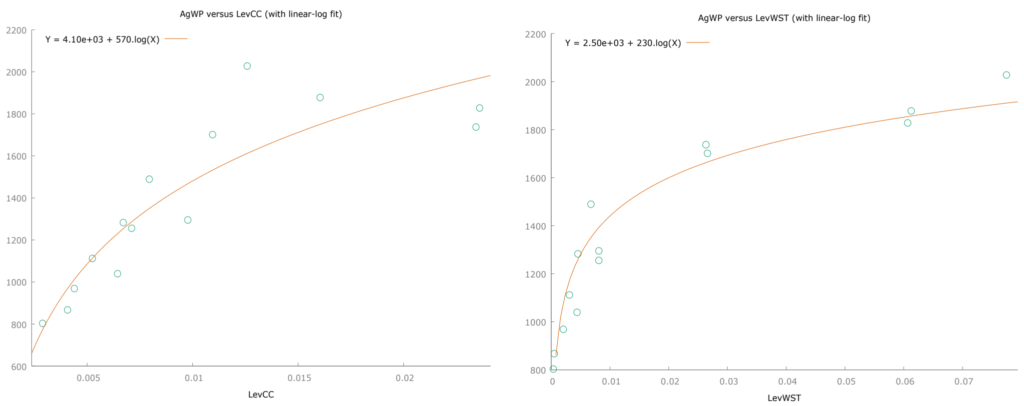
AgWP - Agricultural Water productivity

LevCC - Level of concreting of channels

Lev WST- Level of use of water saving technologies

LevLAA - Level of laser aligned area

As can be seen from the table 2, the relationship is considered strong, as the correlation coefficient between water productivity and the factors affecting it is above 0.8. We will perform regression analysis to determine the type of elationship between these factors, see Figure 1.



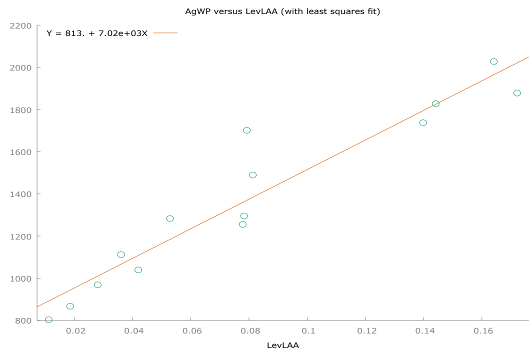


Fig 1. Regression model between agricultural water productivity and affecting factors.

For this, we used the OLS (Ordinary least squares) model. We performed the calculations in the Gretl program.

Table 3. OLS (model 1), using observations 1-14

Dependent variable: AgWP

	Coefficient	Std. Error	t-ratio	p-value	
const	4104.57	379.826	10.81	<0.0001	***
l_LevCC	569.761	78.7154	7.238	<0.0001	***

Mean dependent var	1377.534		S.D. dependent var	401.4508
Sum squared resid	390442.1		S.E. of regression	180.3797
R-squared	0.813642		Adjusted R-squared	0.798112
F(1, 12)	52.39210		P-value(F)	0.000010
Log-likelihood	−91.51698		Akaike criterion	187.0340
Schwarz criterion	188.3121		Hannan-Quinn	186.9157

Model 1 has the following form as shown in table 3, namely AgWP=4104.57+569.71 log(LevCC). Since the P value is less than 0.05, the coefficients are statistically significant, and the coefficient of determination is nearly 0.81, we can see that the model is adequate. In addition, we can see that the t value is also higher than the t table. From this model, it can be concluded that increasing the level of concreting of canals by 1% will increase the water productivity index in the Khorezm region by 56,9 Uzs.

Table 4. OLS (model 2), using observations 1-14

Dependent variable: AgWP

	Coefficient	Std. Error	t-ratio	p-value	
const	2497.64	97.1057	25.72	<0.0001	***
l_LevWST	229.567	18.8874	12.15	<0.0001	***

Mean dependent var	1377.534		S.D. dependent var	401.4508
Sum squared resid	157396.5		S.E. of regression	114.5267
R-squared	0.924875		Adjusted R-squared	0.918614

F(1, 12)	147.7328		P-value(F)	4.19e-08
Log-likelihood	−85.15740		Akaike criterion	174.3148
Schwarz criterion	175.5929		Hannan-Quinn	174.1965

Model 2 has the following form as shown in table 4, namely AgWP=2497,64+229,567 log(LevWST). Since the P value is less than 0.05, the coefficients are statistically significant, and the coefficient of determination is nearly 0.92, we can see that the model is adequate. In addition, we can see that the t value is also higher than the t table. From this model, it can be concluded that increasing the level of using water-saving technologies by 1% will increase the water productivity index in the Khorezm region by 22,9 Uzs.

Table 5: OLS, using observations 1-14

Dependent variable: AgWP

	Coefficient	Std. Error	t-ratio	p-value	
const	813.230	62.5400	13.00	<0.0001	***
LevLAA	7017.43	651.289	10.77	<0.0001	***

Mean dependent var	1377.534		S.D. dependent var	401.4508
Sum squared resid	196273.5		S.E. of regression	127.8911
R-squared	0.906319		Adjusted R-squared	0.898512
F(1, 12)	116.0936		P-value(F)	1.59e-07
Log-likelihood	−86.70259		Akaike criterion	177.4052
Schwarz criterion	178.6833		Hannan-Quinn	177.2869

Model 3 has the following form as shown in table 5, namely AgWP=813.2+7017,43LevLAA. Since the P value is less than 0.05, the coefficients are statistically significant, and the coefficient of determination is nearly 0.91, we can see that the model is adequate. In addition, we can see that the t value is also higher than the t table. From this model, it can be concluded that increasing the level of laser aligned area by 1% will increase the water productivity index in the Khorezm region by 70,1 Uzs.

4. Conclusion

In the article we try to find factors affecting agricultural water productivity of Khorezm region. Data collected among districts for long period. According to Fig 1. regression model is linear between AgWP and LevLAA, then the others are semi log models. These three models are adequate because coefficient of determination are 0.81,0.91 and 0.92 respectively.The most affectable regressor in the models is level of laser aligned area. By 1% Change of level laser-aligned area leads to increase of agricultural water productivity by 70,1 Uzs. By 1% Change of level water-saving technologies and level of concreting of channels lead to increase of agricultural water productivity by 22.9 Uzs and 56.9 Uzs respectively.

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