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## **WATER USE EFFICIENCY ANALYSIS IN THE AGRICULTURE OF THE REPUBLIC OF KARAKALPAKSTAN**

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### **Abstract**

In the context of the growing deficit of water resources in the Republic of Karakalpakstan, the revision of agricultural specialization taking into account water-saving and adaptation approaches is becoming especially relevant. An analysis of the current state of agricultural production in the region showed a discrepancy between water availability and the structure of crop areas, which leads to a decrease in the productivity and sustainability of the agricultural sector.

The Republic of Karakalpakstan is an autonomous republic within Uzbekistan with an area of approximately 164,900 km<sup>2</sup>, located in the arid zone of the Aral Sea region. Historically, the region's agricultural sector was based on the irrigation capabilities of the Amu Darya and Aral Sea systems. However, due to the depletion of natural resources and the deterioration of water and resource conditions, agricultural specialization requires revision: from water-intensive crops to drought-resistant crops and livestock farming. The Republic of Karakalpakstan, located in the arid zone of Uzbekistan, faces serious challenges in terms of water availability. Agriculture, being a major economic activity in the region, heavily depends on irrigation. In recent years, declining water resources, climate change, and soil salinization have prompted the need to optimize the use of water in agriculture [1]. The only source of water resources for agricultural production in the Republic of Karakalpakstan is the Amu Darya. The only water source for agricultural land in the republic is the Amu Darya, which is considered the only river, i.e. there are no naturally irrigated fields. Therefore, it is necessary to use every drop of water resources efficiently. Below, we analyze the efficiency of water used for agricultural production in relation to gross agricultural output by district of the republic. According to the table, in total, 5,273.4 million m<sup>3</sup> of water was used in agriculture

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in Karakalpakstan, from which a gross agricultural output of 17,970.7 billion soums was obtained.

**Table 1. The relationship between the amount of water used in agriculture and gross yield in the Republic of Karakalpakstan.**

District	Water Used (mln m <sup>3</sup> )	Gross Output (bln UZS)	Efficiency (UZS/m <sup>3</sup> )
To'rtko'l	496.3	1791.5	3609.71
Beruniy	447.2	2290.4	5121.65
Ellikqal'a	465.1	1999.7	4299.51
Amudaryo	687.1	3274.5	4765.68
Taxiatosh	108.8	432.0	3970.59
Xo'jayli	221.3	852.8	3853.59
Sho'manoy	318.7	747.8	2346.41
Qonliko'l	219.2	950.7	4337.14
Qo'ng'iro't	438.7	964.9	2199.45
Nukus	272.9	572.3	2097.11
Kegeyli	360.9	586.7	1625.66
Bo'zatov	125.6	354.9	2825.64
Chimboy	343.6	1466.1	4266.88
Qorao'zak	368.4	660.3	1792.35
Taxtako'pir	286.0	666.1	2329.02
Mo'ynoq	91.0	231.5	2543.96
Nukus sh	22.7	128.5	5660.79

The relationship between the amount of water used in agriculture and gross yield in the Republic of Karakalpakstan.

As water consumption increases in individual districts, the gross crop volume also increases. For example, the Amudarya district consumed the most water - 687.1 million m<sup>3</sup>, and obtained the highest value of the crop among the regions - 3,274.5 billion soums. At the same time, small regions also have lower water consumption and, correspondingly, relatively low crop volumes (for example, in the city of Nukus, only 22.7 million m<sup>3</sup> of water was used, and 128.5 billion soums of crop were obtained).

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There is a close positive correlation between water consumption and gross product (correlation coefficient is approximately 0.87). This means that in general, districts that used more water produced more agricultural products in value [2].

This study evaluates the efficiency of water use by calculating the value of gross agricultural output per cubic meter of water consumed in each district of Karakalpakstan. Data on total water used (in million m<sup>3</sup>) and agricultural output (in billion UZS) for 17 districts were used to derive efficiency values.

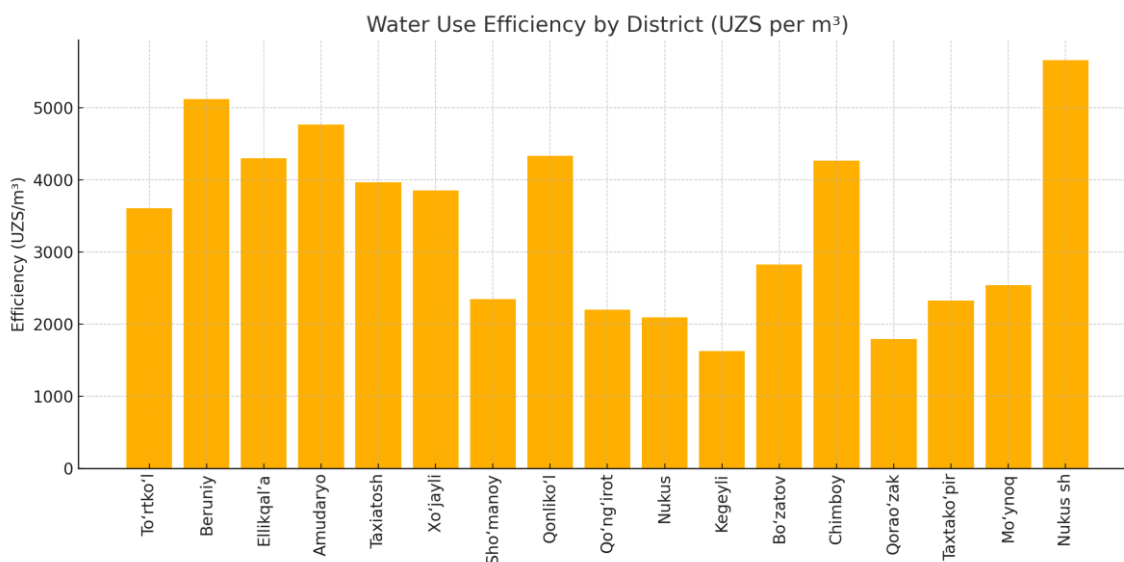
$$WUE = \frac{GO}{WU} \quad (1)$$

Here: WUE – Water Use Efficiency (UZS/m<sup>3</sup>)

GO – Gross Output (UZS)

WU – Water Used (m<sup>3</sup>)

The efficiency of water resources can be compared by calculating the gross crop value per 1 million m<sup>3</sup> of water in each district. The chart below illustrates the comparative efficiency of all districts:



**Fig – 1. Efficiency of water resources use by districts in the republic**

Based on the above water efficiency indicators, a ranking of water use efficiency by districts was compiled. Accordingly, the five most efficient and least efficient districts are listed below:

The 5 most efficient districts (product value per 1 million m<sup>3</sup> of water):

- Nukus city – 5.66 billion soums



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- Beruniy – 5.12 billion soums
  - Amudarya – 4.77 billion soums
  - Qonlikul – 4.34 billion soums
  - Ellikkal – 4.30 billion soums

These districts achieved the best results in water use. For example, although the share of Beruniy district accounted for only 8.5% of the total water, it provided 12.7% of the gross product value (i.e., the share of product is much higher than the share of water). Similarly, the Amudarya district, consuming 13% of the total water, provided 18.2% of the total crop value - these data indicate that the benefits returned from water in these districts are high.

The 5 most inefficient districts (crop value per 1 million m<sup>3</sup> of water):

- Kegeyli - 1.63 billion soums
- Karaozak - 1.79 billion soums
- Nukus district - 2.10 billion soums
- Kungirost - 2.20 billion soums
- Takhtkopir - 2.33 billion soums

In general, the trend of low efficiency is observed mainly in regions where the irrigation system is outdated, water-saving technologies have not been introduced, and crops are water-intensive. The trend of high efficiency is observed in regions where modern agrotechnologies are used, where attention is paid to water conservation and productivity [3].

As can be seen from the above analysis, the following measures are recommended to increase the efficiency of water resources use in Karakalpakstan:

- Improving irrigation technologies: By introducing modern methods of irrigation, such as drip irrigation and sprinkler irrigation, it is possible to significantly reduce water consumption and optimize the water standards per hectare of land. The analysis shows that these methods require 30-50% less water than traditional irrigation.
- Improving irrigation infrastructure: It is necessary to concretize canals and ditches, prevent water waste, and install modern pumping and control systems. By reducing losses in irrigation networks, the effective delivery of water to agriculture will increase.



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- Crop structure review: It is necessary to select crop types in accordance with water resources in each region. For example, instead of some crops with lower water requirements and value (some cereals or fodder crops, as well as crops such as rice), switching to more valuable, water-efficient crops will be effective. This will increase the possibility of obtaining “more value from a drop of water”.
  - Water accounting and management: It is necessary to accurately maintain water accounting in districts through automated systems, and to provide farmers with information about the volume of water used. In order to increase the culture of water use, measures should be taken to encourage efficient farmers and to put an end to cases of excessive water use.
  - Productivity improvement and innovation: To achieve higher yields with the same water consumption, it is important to update seeds, plant high-yielding varieties, and conduct timely and correct agrotechnical measures. Special technologies that work in water scarcity conditions (for example, low-soil methods) and the introduction of drought-resistant varieties will help to achieve higher yields per liter of water.
- By implementing the above proposals, the possibility of efficient use of water resources will increase, and as a result, the overall gross yield in Karakalpakstan agriculture will be increased. This will also serve to ensure food security and economic stability of the region.

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