

## Water availability and water use planning in the Aral Sea basin

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**Abstract.** According to the forecast of international, regional, and Republican research institutes and design and survey institutes, in the current water management situation in the Aral Sea basin, the shortage of water resources will increase over time and space. Currently, the water supply of the territories located in the middle and lower reaches of the Syr Darya and the Amu Darya rivers does not exceed 60-70% of the required volume, which causes significant damage to agriculture. The consequences of low water are quite noticeable in areas located in the middle and lower reaches of rivers.

There are different points of view in the Republic about the possibility of mitigating water scarcity through widespread water conservation, effective regulation of river flow, improvement of operation and technical equipment of irrigation systems, the introduction of water-saving technologies for irrigation, cultivation, and introduction of drought-resistant crops. Without detracting from the importance of these measures, first of all, it is necessary to forecast and quickly establish the water level of the main water flows in the near future, and widely introduce organizational and technological methods to increase the productivity of water entering irrigated fields into production practice.

Analysis of the results of long-term observations and expert assessments in various parts of the irrigated zone indicates the presence in a wide production practice of cases of irrational use by farms of water allocated by the limit, un-planned by agricultural technology surface discharge into the existing collector-drainage network. The article presents the results of calculations of water use planning taking into account the water availability of the territory on the example of the Republic of Karakalpakstan.

The purpose of the study is to develop organizational and technological bases for planning water use in their limited capacity, taking into account the water availability of territories on the example of the Republic of Karakalpakstan. When determining the area, composition, and structure of agricultural crops, the water availability coefficient (%) actual ( $m^3$ ) and required water intake ( $m^3$ ) to the territory are taken into account. As initial data, the results of long-term systematic observations, measurements, and expert assessments of operational and planning water use organizations of the Ministry of agriculture of the Republic of Karakalpakstan were used. The calculations were performed using a computer program compiled jointly with specialists of the Nukus State University and tested on the example of individual irrigation systems, channels, and administrative districts of the water users Association.

The recommended procedure for the rapid establishment of acreage and crop structure, depending on water availability conditions, does not harm the functioning infrastructure of agricultural production.



## 1. Introduction

The global demand for water has been increasing at a rate of about 1% per year as a function of population growth, economic development, and changing consumption patterns, among other factors, and it will continue to grow significantly over the next two decades. Industrial and domestic demand for water will increase much faster than agricultural demand, although agriculture will remain the largest overall user. The vast majority of the growing demand for water will occur in countries with developing or emerging economies.

At the same time, the global water cycle is intensifying due to climate change, with wetter regions generally becoming wetter and drier regions becoming even drier. At present, an estimated 3.6 billion people (nearly half the global population) live in areas that are potentially water-scarce at least one month per year, and this population could increase to some 4.8–5.7 billion by 2050.

The need to integrate green and blue water management is highlighted in a future scenario of water availability under climate change and population growth (HadCM2 A2). For 2050, the scenario indicates that 59% of the world population will face a blue water shortage, and 36% will face green and blue water shortages. Even under climate change, good options to build water resilience exist without further expansion of cropland, particularly through the management of local green water resources that reduce risks for dry spells and agricultural droughts [1,2,3].

Uzbekistan, as the country with the largest irrigated area and the largest population in the Central Asian region, is the most vulnerable in terms of water resources. Only about 20 % of the volume of water resources necessary for the country's needs is formed within the country when the main part is covered by the resources of the transboundary Rivers the Amu Darya and the Syr Darya. In recent years, the lack of water has become a limiting factor in the development of agriculture.

Currently, the total annual volume of water use in the Republic is about 55 km<sup>3</sup>, including about 50 km<sup>3</sup> for irrigated agriculture, and about 3.5 km<sup>3</sup> for drinking water for urban and rural populations.

The data obtained show that changes in air temperature and precipitation in the long term perspective, to 2050, may lead to a reduction in the flow of the Syr Darya and the Amu Darya rivers. The expected changes in the flow of this period for the Syr Darya will be in the range of 2-5 %, and for the Amu Darya – 10-15% of the average. However, given the current situation in irrigated agriculture, climate change will lead to increased water scarcity and additional risks for agriculture. Climate change is expected to increase the frequency and severity of droughts. In low-water years, when a hydrological drought is happening, the situation with water resources will become more critical." Despite the fact that the reduction of river water resources is possible by the middle of the XXI century, adaptation to the effects of climate change is already one of the most important tasks [4, 7, 8, 9].

The main objectives of water conservation are: saving irrigation water; increasing the efficiency of irrigation water use; improving the productivity of water and land use. Water-saving methods can be divided into hydrotechnical (water accounting, water circulation, irrigation regime, irrigation technique, washing, and water-charging irrigation, reuse of wastewater, flow regulation, etc.); agrotechnical (structure of irrigated areas, soil cultivation, increasing soil fertility, combating unproductive water losses, afforestation, etc.); organizational (paid water use, organization, and discipline of water use, etc.) [12].

The development of demographic trends and the extensive use of water and land resources admitted the disproportion in the pace of development of large areas without taking into account the opportunities located in the region of the water resources in the second half of the twentieth century was accompanied by - a fairly significant rate of population growth; - increasing deficit and deteriorating quality of river water; - sustainable in time and space, deterioration of ecological situation; - a decrease in the yield of cultivars of technical, grain, and fruit crops; - changes in the socio-economic situation in the context of the formation of new forms of land ownership and land use.

In the current situation, the limiting factor for the sustainable functioning of the agricultural sector and other sectors of the national economy, the creation of food security, is the level of water availability of the territory.

## 2. Methods

In the world practice of water use planning the level of water availability of the territory is usually determined using an equation that has the form:

$$C_{wa} = \frac{W_a}{W_r} * 100$$

where  $C_{wa}$  is the coefficient of water availability, %;

$W_a$  is the actual water intake,  $m^3$ ;

$W_r$  is the required water intake,  $m^3$ .

Calculations performed using this formula using the materials of operating organizations indicate a wide range of changes in the level of water supply in the territories located in the middle and lower reaches of the main watercourses-PP. The Amu Darya and the Syr Darya in non-vegetative and vegetative periods [5, 6].

## 3. Result and Discussion

The observed periodic unstable level of water availability significantly affects the planning of the composition and structure of crop acreage for the current year's crop. In production practice, currently, there is a planning of acreage without taking into account the expected (projected) level of water availability, especially in low-water years. As a result, with extremely limited available water resources and crop acreage exceeding the allocated water limit, agricultural production suffers large losses. This can be clearly illustrated by the results of the consequences of the low-water years 2000-2001 in Karakalpakstan.

Unfortunately, the planning did not take into account the composition and structure of crop acreage and the possible scenario for the development of the situation with the level of water supply, which was noted in the projected calculations. The total area of arable land was 419 thousand hectares, including 113.5-80 thousand hectares for rice farming, 78-75 thousand hectares for forage crops, and 74.5-108 thousand hectares for other crops, respectively. So in 2000, with a planned sown area of 125 thousand hectares, 129.8 thousand hectares were allocated for cotton. Due to the lack of water in the area of 34.3 thousand hectares of plants died, and the harvest was not collected. It was planned to allocate 113.5 thousand hectares for rice, and the area was reduced to 60 thousand hectares due to the expected low water supply, however, due to the lack of water on the area of 52.1 thousand hectares, rice crops were lost. In 2001, with an actual acreage of 83.4 thousand hectares, cotton crops were lost by 7.3 thousand hectares. Although rice crops with a plan of 80 thousand hectares actually occupied only 4.74 thousand hectares, however, on an area of 3.81 thousand hectares were completely lost due to lack of water. According to calculations made on the basis of materials from the Ministry of agriculture and water management of the Republic, the total damage to the agricultural sector due to low water in 2000-2001 amounted to about 15 billion Uzbek sums.

From the above, it is obvious that there is a need to revise the existing procedure for planning the composition and structure of sown areas for the current year's harvest. At the same time, the expected level of water availability should be adopted as the main criterion, based on which the area of irrigated land allocated for crop rotation crops should be adjusted annually and promptly [10, 11, 13, 14, 15].

To streamline the use of available water resources in the Republic, and to differentiate their distribution among water users, the optimal areas of the main crop rotation crops and the required amount of water for sustainable agricultural production are set within the annually allocated limit, depending on water availability. This is taken into account:

- priority provision of water for areas under cotton and winter wheat crops that are of strategic importance and are cultivated by state order;

- differentiated determination of the required volume of water for the main crop rotation crops according to hydro module zoning;

- the need for proportional distribution of the established water limit between water users within the established limit.

Long-term data from operational and planning organizations of the Ministry of agriculture of the Republic of Karakalpakstan were used to determine the optimal areas and composition of agricultural crops, taking into account the level of water availability. The calculations were performed using a computer program developed and tested on the example of the Department of irrigation systems, canals, administrative districts, and the Association of water users.

The recommended procedure for reducing the acreage of cultivated crops, depending on the level of water availability, should be permanent in time and space, implemented promptly, without significant negative consequences for the functioning infrastructure of agricultural production (table 1).

**Table1.** Acreage and composition of agricultural crops, taking into account the level of water availability in the Republic of Karakalpakstan

The level of water availability, %	Cotton		Winter wheat		Rice		Alfalfa and forage crops		Other cultures		Total for the Republic	
	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>	cultivation area, thousand ha	Required volume of water, million m <sup>3</sup>
95												
-	145	1342.6	60	377.8	70	2903.7	65	601.8	40	333.3	380	5559.2
90												
-	140	1296.3	60	377.8	50	2074.1	55	509.2	40	333.3	345	4590.7
80												
-	120	1111.1	50	314.8	30	1244.4	50	462.9	50	416.6	300	3549.8
60												
-	110	1018.5	40	251.8	10	414.8	40	370.3	50	416.6	250	2472
50												
-	100	926.0	25	157.4	1	41.4	30	277.7	50	416.6	206	1819.3

#### 4. Conclusions

If there is a shortage of water use in areas with arid or subarid climate, it is advisable to place the main crop rotation crops in years of low water availability on land with relatively high productivity (bonus point) to mitigate the consequences of low water supply and maintain the existing level of crop production.

Land with a relatively low bonus score should be allocated for crops with drought and salt-resistant crops and used as natural pastures, plantations for the preparation of raw materials for the pharmaceutical industry.

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