"ISSUES TO IMPROVE WATER USE EFFICIENCY"

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ABSTRACT:

This article evaluates the efficiency of water use in the Republic of Karakalpakstan by districts on the basis of specific coefficients. Optimal solutions to increase water use efficiency across regions have been developed on the basis of the intersectoral balance model. Based on the results of the analysis, conclusions and recommendations are provided.

Keywords:

water, main channel, auxiliary channel, efficiency, limit, water use efficiency, intersectoral balance model.

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INTRODUCTION

Currently, 70% of global water consumption is in agriculture. In most developed countries, the organization, financing and management of water supply are identified as one of the priority areas of socio-economic development.

World population growth and the development of economic sectors increases the demand for water. In many regions of the world there is a shortage of water. As scientists note, "in 2030, 47 percent of the world's population will live in conditions of water shortage" [1].

The main sources of surface runoff formation in the Republic of Uzbekistan are the Amu Darya and Syr Darya rivers, the total long-term average flow of which is 116.48 km3.Of these, 79.28 km3 are formed in the Amu Darya basin, and 37.2 km3 in the Syr Darya. At the same time, water resources formed in Uzbekistan are part of the total water resources available to the Aral Sea basin. Their share is about 10.9% of the total runoff of the two main rivers, in particular, 4.74 km3 (or 6.0%) in the Amu Darya basin and 6.17 km3 (16.6%) in the Syr Darya basin. This makes up about 20% of the total water demand, and the remaining 80% is covered by the resources of the transboundary rivers Amu Darya and Syr Darya and is formed in the mountainous regions of neighboring countries.

The Republic of Karakalpakstan is one of the least developed regions of Uzbekistan in terms of water supply and ranks 13th in this regard [2]. The districts of Karakalpakstan on the right bank of the Amu Darya (Turtkul, Beruni, Ellikkala, Nukus, Kegeyli, Chimbay, Karaozak and Takhtakor) are supplied with water from the regional Tuyamoyin-Nukus-Chimbay-Takhtakor bridge and local surface and underground sources.

The districts on the left bank (Khojayli, Kanlikul, Shumanay and Kungrad) are supplied with water from the Takhiatash-Kungrad water network, local canals Erkin, Shumanay, Kharitabay and others.

The lands of the Republic of Karakalpakstan are irrigated through the irrigation systems of Pakhtaarna-Naiman, Mangit-Nazarhan, Kattagar-Bozatau, Kizketken-Kegaili, Kuvanish-Jarma and Suenli. The source of all irrigation systems is a river valley, and irrigation ditches are located along the Amu Darya River. The main area of irrigated land is reserved for the cultivation of rice, cotton, cereals and other crops.

RESEARCH METHODOLOGY

In the research process, an interindustry balance model, an optimization model, and logical thinking methods were used.

STUDY DEVELOPMENT PROBLEMS.

Issues related to the potential of resources, water resources management and reclamation processes in agriculture were considered in the works of a number of foreign and domestic authors. The problems of managing the use of water resources and systemic approaches to it are reflected in the studies of such scientists as V. Dukhovny, V. Sokolov [2].

The problem of assessing and improving the effectiveness of land reclamation measures in agriculture is a complex and multifaceted one. In this regard, in the framework of this problem, large-scale studies have been carried out by scientists from foreign countries. In particular, on methodological and scientific-theoretical solutions to this problem, special attention deserves the results of studies of such scientists as E.V. Kuznetsov and A.E. Khadzhidi [3].

In addition, we can cite a number of works related to the Lower Amu Darya and Aral regions, studied by such scientists as F.Bequette, G.J.A. Veldwisch, and many foreign as well as domestic scientists [4, 5]. In the works of Zh. Medetullaev, N. Tukhliev, U. P. Umurzakov [6-8], issues of using the potential of resources in the agricultural sector and improving economic relations between participants in the agro-industrial complex are considered.

In addition, you can cite a number of works related to the Lower Amu Darya and Aral region, studied by such scientists as F. Bequette, G.J.A. Veldwisch, and many foreign and domestic scientists [9-10]

Water availability in the Aral Sea region, including the Republic of Karakalpakstan, is the lowest in the republic (60-70%), which is due not only to limited water resources, but also to their inefficient use. Only 30% of the water taken at the borders of the region reaches the plants, and the rest of it is lost in the irrigation network (40%) and during irrigation (30%). For information, in Europe, 80-85% of water reaches plants, and on average around the world - 60-65% of water. The inefficient use of water resources in the region is also due to large filtration losses of irrigation systems and the poor technical condition of hydraulic structures (GTS). Significant losses of water resources occur in the fields, due to the use of inefficient irrigation methods, in particular, furrow irrigation. During furrow irrigation, water losses occur due to evaporation (2-5%), depth filtration (10-20%), surface discharge (10-15%), and reach 25-30%.

However, most of the above works were completed before the independence of our republic or in the transition period to market relations. In these studies, insufficient attention is paid to the problems of improving the economic efficiency of land reclamation measures and the issues of a comprehensive study of this problem. In this regard, insufficient knowledge of the problem of improving the effectiveness of land reclamation measures in the context of modernization and innovative development of the economy necessitated the choice of the topic of this study, which requires a new scientific approach to the problem.

ANALYSIS AND RESULTS

In our research in the Republic of Karakalpakstan, there are 232,143 hectares irrigated, and the amount of water used for these areas is 5,402.21 million.

The Ministry of Water Resources of the Republic of Uzbekistan has allocated 4968.75 million water for the cultivation of agricultural products during the growing season as a result of the distribution of water resources to the economy (limit). It is also planned to spend 2197.23 million soums for salinization and 433.46 million soums for winter wheat irrigation during the non-vegetation period.

The volume of water allocated during the autumn-winter period of 2018-2019 and the growing season of 2019 amounted to 6724 mln. 1,662 million gallons of water were used for saline leaching activities in strongly and moderately saline soils. 174.4 million less water was used to irrigate agricultural crops. During the novelization period, 26.7 million more water was used than planned [11-12].

In the Republic of Karakalpakstan, 11,622.25 hectares of irrigated land (the main crop) are cultivated with agricultural products. However, according to the Department of Water Resources, 11,832.25 hectares were cultivated and irrigated. The main reason for this is that the use of available reserve lands may expand depending on the wetness of the year or, conversely, the cultivation of secondary crops in areas cleared of crops may also be limited (Figure 1).

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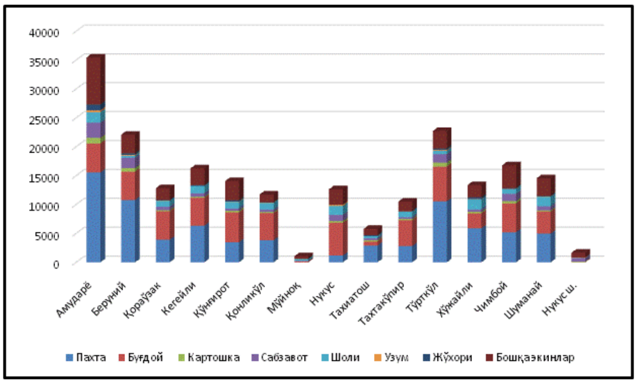

Source: Compiled by the author on the basis of data from the Department of Water Resources of the Republic of Karakalpakstan.

1-picture. Areas under agricultural crops in the Republic of Karakalpakstan, hectares (Kh_{ij})

In 2019, the total area under agricultural crops in Karakalpakstan will be 232,143 hectares, which is 6.4% of the total land area in Uzbekistan. The main crops grown in Karakalpakstan are cotton and wheat. In 2019, cotton was planted on 88,560 hectares (38.15% of all arable land), grain area was 62,987 hectares (27.13% of total arable land) and rice was 14,717 hectares, accounting for 6.34% of firewood cultivation land. In Karakalpakstan, cotton, wheat and rice account for more than 71.5% of the total harvest area.

According to the data of 2019, Amudarya district occupies 15,554 hectares of land, 17.56% of the total area of cotton in the country; Ellikkala district accounted for 11,220 hectares (12.67%), Beruni district for 10,784 hectares (12.18%), and Turtkul district for 10,533 hectares (11.83%). In the Republic of Karakalpakstan, 48091 hectares of land allocated for cotton cultivation, or 54.30%, accounted for the above four districts.

Cereals play an important role in meeting the food needs of the population. Cereal cultivation is the world's leading agricultural sector. In the Republic of Karakalpakstan, compared to previous periods, today it has a leading position in terms of grain area and gross yield.

In the Republic of Karakalpakstan, wheat currently dominates in the area of all cereals, followed by rice, oats and others. In 2019, of the total area of 80,932 hectares of grain crops in the Republic of Karakalpakstan, 62,987 hectares or 77.8% fell to wheat, 14,717 hectares (18.2%) to rice, 3,228 hectares (4.0%) to corn.

Amudarya district is the leader among the districts of the republic in terms of the area under agricultural crops, which accounts for a total of 35,440 hectares of land (15.27% of all arable land), Turtkul (9.79%), Beruni (9.51%). and Ellikkala (8.9%), in contrast, Moynak district (0.45%), Nukus city (0.71%) and Takhiatash (2.49%) districts.

Spring and autumn grain crops were grown on an average of 3,936.6875 hectares in the district. Reproduction carried out on an area of 2636.5 hectares, which was additionally allocated for spring grain and other crops.

District water consumption of agricultural crops is studied and represented as elements of the intersectoral balance model (Table 2).

Districts	Cotton (C)	Wheat (W)	Potato (П)	Vegetables (B)	Rice (P)	Grapes (Г)	Maize (M)	Others (O)
Amudarya	139,08	31,28	8,58	7,94	57,04	12,02	14,06	343,53
Beruniy	81,42	26,90	8,14	7,94	44,54	8,13	22,51	182,27
Korauzyak	44,10	34,40	2,31	2,86	96,72	1,55	9,88	250,89
Kegayli	63,81	35,80	2,16	2,45	51,21	1,91	17,78	334,25
Kungrad	30,24	40,40	2,64	3,34	101,20	1,43	40,89	146,98
Kanlikul	35,76	39,20	2,44	3,35	106,64	1,10	27,09	92,60
Muynak	0	2,18	0,22	0,64	9,18	0,16	8,87	19,82
Nukus	13,64	46,40	4,80	12,64	99,28	21,48	6,36	178,08
Takhiyatash	22,46	6,40	2,80	2,31	18,10	1,17	3,43	18,11
Takhtakupir	32,13	32,80	2,43	2,70	74,43	0,51	19,68	191,52
Turtkul	82,32	25,60	7,68	7,91	43,62	6,31	29,97	194,41
Khodjeyli	48,80	19,20	2,45	4,10	76,88	4,66	6,87	81,02
Shimbay	55,02	38,60	2,54	3,13	99,20	1,76	19,87	298,35
Shumanay	47,71	27,60	2,39	3,54	59,52	1,20	8,60	228,59
Ellikkala	95,37	26,70	8,42	7,98	45,61	20,73	18,81	161,69

(Table 2) Distribution of water resources in agriculture of the Republic of Karakalpakstan by districts, mln m^3 (m_{ij})

Source: Compiled by the author on the basis of data from the Department of Water Resources of the Republic of Karakalpakstan.

The 5 irrigation canals in the study area provide irrigated land with an area of 232,143 hectares. The data on water resources used for agriculture in the districts of the Republic of Karakalpakstan show that the distribution of water resources varied by district. Amudarya district is the leader among the districts of the republic in terms of water resources spent on agriculture, with a total of 619.18 million soums. m3 of water resources (11.36% of water resources spent on agriculture in the country, Chimbay district - 528.76 million m3 (9.60%), Kegeyli district - 516.31 million m3 (9.43%), Karauzak district spent 449.39 million m3 (8.19%) of water resources on agriculture, while Muynak district - 46.99 million m3 (0.76%), Takhiyatash district - 77.16 million m3 (1.38). %), Khojaly is the district with the lowest water resources for the cultivation of 248.59 million m3 (4.52%) of agricultural products.

The Kizketgan Grand Canal, the main water source of the five districts, was constructed at a rate of 400 m of water per second, but now the figure is 66%. To give another example, the rate of most major channels is in the range of 44% -71%. However, these indicators of most large and small canals do not cause any problems in water distribution, as the reason is that the limited water resources have led to a reduction in crop area. At present, there is no problem at the level of water distribution, but the problem arises only if the area of arable land is expanded as before.

The density of the internal channels is 34 m / ha and is sufficient or close to sufficient. The condition of the internal canals in the study area is very poor. Due to a shortage of equipment and funds, the Water Supply Association (STB) is unable to fully repair the canal and hydraulic structures. Therefore, we can say that water management is not enough, and water consumption is high.

It is natural that the amount of water required for agricultural crops should be more or less according to the area under cultivation. When analyzing water use efficiency, the total water consumption shown in Figure 2 is 5402.21 million m^3. In terms of actual water consumption, 1577.448 million m^3 of water was lost or used inefficiently in irrigation networks.

In this article, it was found that the efficiency of the main and auxiliary water supply canals in the Republic of Karakalpakstan varies by district. However, scientific results have shown that it is relatively low in areas far from water sources.

In determining the efficiency of working canals in water management, scientists in the field of agriculture, economists also noted that it is expedient to calculate on the basis of one approach. However, in practice, given that the calculations go through several stages, there is a lot of confusion in the process of obtaining water from the source and delivering it to the consumer. In particular, water supply to the farm is not the shortest route. This is because water consumers are not provided with sufficient equipment (pumps and pumping units). Therefore, it intends to irrigate more areas, even if it delivers water from a longer distance. As a result, losses increase and water use efficiency decreases. Also, crop location, land reclamation, soil conditions, and climate change are also factors that directly affect irrigation patterns and water volume.

While the assessment of the internal condition of canals in the use of water resources is determined in relation to gross water, the volume of water lost due to the canal flowing through several canals and the district is unevenly distributed until it reaches the final consumer. Therefore, it would be expedient to calculate the volume of water required for farms consuming water resources, estimating the amount of water lost relative to the volume of water available. To do this, we calculate the volume of water required for cultivation in the districts by analysis for each type of agricultural products grown in each district. To do this, we analyze all the districts that receive water from the canals and the amount of water resources required for crop types using the inter-sectoral balance (IB) model.

$x(x_1, x_2, ..., x_n)$ – agricultural production areas and the amount of water used for the cultivation of agricultural products $m(m_1, m_2, ..., m_n)$ has a vector form.

In this case, the water consumption of the districts will be as follows:

$$m_i = \sum_{k=1}^{n} m_{ik} + m_i^k + m''_i$$
$$(i = 1, ..., n; k \in j, j = 1, ..., n) \quad (1)$$

it can be written in this form.

In this, m_i – the amount of water required for each district, m^3;

m_{ik} – the volume of water required for the cultivation of agricultural products, m_i' – the amount of water lost and discharged (sewage) in irrigation systems m^3; m_i'' – the amount of water that evaporates depending on the air temperature m^3;

Now, we perform the replacement as follows,

$$C_i = m'_i + m''_i \quad (2)$$

Then (1) the formula can be expressed in general terms as follows:

$$m_i = \sum_{k=1}^{n} x_{ij} \tilde{m}_j + m'_i + m''_i$$
$$(i = 1, ..., n; k \in j, j = 1, ..., n) \quad (3)$$

Hence, by substituting (2), we obtain the following expression.

$$m_i = \sum_{k=1}^{n} x_{ij} \tilde{m}_j + C_i$$
$$(i = 1, ..., n; k \in j, j = 1, ..., n) \quad (4)$$

In this, $\widetilde{m_J}$ – seasonal irrigation norm (m^3/ga). Through this expression (3) we can calculate the water use efficiency coefficient (γ) In this case, γ is equal to the following:

$$\gamma = 1 - \frac{m'_i + m''_i}{m_{ij}} \quad (5)$$

or

$$\gamma = 1 - \frac{C_i}{m_{ij}} \quad (6)$$

to count in percent,

$$\gamma = \left(1 - \frac{C_i}{m_{ij}}\right) \cdot 100\% \quad (7)$$

So, from the (6),(7)expressions we get the following:

$$\gamma = 1 - \frac{m'_i + m''_i}{\sum_{k=1}^{n} x_{ij}\tilde{m}_j + m'_i + m''_i} = $$
$$= \frac{\sum_{k=1}^{n} x_{ij}\tilde{m}_j + m'_i + m''_i - (m'_i + m''_i)}{\sum_{k=1}^{n} x_{ij}\tilde{m}_j + m'_i + m''_i} = \quad (8)$$
$$= \frac{\sum_{k=1}^{n} x_{ij}\tilde{m}_j}{\sum_{k=1}^{n} x_{ij}\tilde{m}_j + m'_i + m''_i} = \frac{\sum_{k=1}^{n} x_{ij}\tilde{m}_j}{\sum_{k=1}^{n} x_{ij}\tilde{m}_j + C_i} = \frac{\sum_{k=1}^{n} x_{ij}\tilde{m}_j}{m_{ij}}$$

Summarizing calculation methods stated above, it can be expressed in vector form as follows:

$$m_{ij} = (A - X)(m'_i + m''_i)$$

or,

$$m_{ij} = (A - X)(C_i)$$

Depending on the effluent and evaporated water, we give the equation as follows:

$$m'_i + m''_i = m_{ij}(A - X)^{-1}$$

or,

$$C_i = m_{ij}(A - X)^{-1}$$

Based on the formulas stated above, we found that the determination of water usage efficiency in the inter-sectoral balance method can also be calculated using a part of the balance equation (water consumption). Using this calculation method, we calculate the water usage efficiency across the districts.

We calculate the water usage coefficient for each crop type and district cross section. As a result, it is possible to analyze the volume of water consumed per hectare by district and the indicator of water consumption corresponding to the type of crop.

The analysis of water usage efficiency Yij by inter-sectional balance method by crop types and districts is presented. The coefficient of water consumption determined by the section can be taken as the general average for the Republic of Karakalpakstan using the average geometric method (Table 3).

Districts	Cotton (C)	Wheat (W)	Potato (P)	Vegetables (V)	Rice (R)	Grapes (G)	Maize (M)	Others (O)
Amudarya	71,20896	16,01536	4,39296	4,06528	29,20448	6,15424	7,19872	175,8874
Beruniy	41,68704	13,7728	4,16768	4,06528	22,80448	4,16256	11,52512	93,32224
Karauzek	22,5792	17,6128	1,18272	1,46432	49,52064	0,7936	5,05856	128,4557
Kegeyli	32,67072	18,3296	1,10592	1,2544	26,21952	0,97792	9,10336	171,136
Kungrad	15,48288	20,6848	1,35168	1,71008	51,8144	0,73216	20,93568	75,25376
Kanlikul	18,30912	20,0704	1,24928	1,7152	54,59968	0,5632	13,87008	47,4112
Muynak	0	1,11616	0,11264	0,32768	4,70016	0,08192	4,54144	10,14784
Nukus	6,98368	23,7568	2,4576	6,47168	50,83136	10,99776	3,25632	91,17696
Takhiyatash	11,49952	3,2768	1,4336	1,18272	9,2672	0,59904	1,75616	9,27232
Takhtakupir	16,45056	16,7936	1,24416	1,3824	38,10816	0,26112	10,07616	98,05824
Turtkul	42,14784	13,1072	3,93216	4,04992	22,33344	3,23072	15,34464	99,53792
Khodjeyli	24,9856	9,8304	1,2544	2,0992	39,36256	2,38592	3,51744	41,48224
Shimbay	28,17024	19,7632	1,30048	1,60256	50,7904	0,90112	10,17344	152,7552
Shumanay	24,42752	14,1312	1,22368	1,81248	30,47424	0,6144	4,4032	117,0381
Ellikkala	48,82944	13,6704	4,31104	4,08576	23,35232	10,61376	9,63072	82,78528

Table 3 Water consumption according to the coefficient of water consumption of crops by districts mln. m^3

Source: Calculated by the author on the basis of data from the Department of Water Resources of the Republic of Karakalpakstan.

As a result of the comparative analysis of the water required for agricultural production in the Republic of Karakalpakstan with the actual allocated water, the coefficient of water consumption by the TB method is 0.512. When we analyze on the basis of data from the lower Amudarya Irrigation Basin, the efficiency of irrigation systems is 0.512.

Hence, the efficiency calculation by the intersectional balance method is analyzed more accurately and in accordance with the crop types than the calculation relative to the total water received. It allows us to obtain and substantiate a clear result in relation to the existing theoretical calculations.

As we have seen above, the role of irrigation systems in the cultivation of agricultural and fodder products in the districts is very large. At the same time, timely saline washing and irrigation of arable lands leads to greater productivity and efficiency. To achieve such results, it is necessary to take into account the correct distribution of water in water storage basins and the level of resistance and evaporation in waterways. Without such parameters, the lack of normal water supply to the designated area can result in low levels of productivity and productivity. Therefore, it is necessary to correctly calculate the evaporation rate of the volume of water allocated to the districts (Table 4).

Districts	Volume of evaporated water							
Amudarya	40,61136	9,13376	2,50536	2,31848	16,65568	3,50984	4,10552	100,3108
Beruniy	23,77464	7,8548	2,37688	2,31848	13,00568	2,37396	6,57292	53,22284
Karauzek	12,8772	10,0448	0,67452	0,83512	28,24224	0,4526	2,88496	73,25988
Kegeyli	18,63252	10,4536	0,63072	0,7154	14,95332	0,55772	5,19176	97,601
Kungrad	8,83008	11,7968	0,77088	0,97528	29,5504	0,41756	11,93988	42,91816
Kanlikul	10,44192	11,4464	0,71248	0,9782	31,13888	0,3212	7,91028	27,0392
Muynak	0	0,63656	0,06424	0,18688	2,68056	0,04672	2,59004	5,78744
Nukus	3,98288	13,5488	1,4016	3,69088	28,98976	6,27216	1,85712	51,99936
Takhiyatash	6,55832	1,8688	0,8176	0,67452	5,2852	0,34164	1,00156	5,28812
Takhtakupir	9,38196	9,5776	0,70956	0,7884	21,73356	0,14892	5,74656	55,92384
Turtkul	24,03744	7,4752	2,24256	2,30972	12,73704	1,84252	8,75124	56,76772
Khodjeyli	14,2496	5,6064	0,7154	1,1972	22,44896	1,36072	2,00604	23,65784
Shimbay	16,06584	11,2712	0,74168	0,91396	28,9664	0,51392	5,80204	87,1182
Shumanay	13,93132	8,0592	0,69788	1,03368	17,37984	0,3504	2,5112	66,74828
Ellikkala	27,84804	7,7964	2,45864	2,33016	13,31812	6,05316	5,49252	47,21348

Table 4 the evaporation rate of the volume of water allocated to the districts is *mln m³*

Source: Calculated by the author on the basis of data from the Department of Water Resources of the Republic of Karakalpakstan.

Based on laboratory analyzes and experimental analyzes carried out in this district, losses relative to the channel level were also analyzed. As a result, losses in irrigation systems (subsoil absorption, surface evaporation, and water release through plants) are average 29.2 percent. If we take into account the water consumption during the non-vegetation period, the water usage efficiency was 51.2% and most of the lost water was discharged into drainage networks as sewage was also studied during the observations.

In the Republic of Karakalpakstan, the average water consumption per hectare is 9204,945 m^3, while due to the low efficiency of the system; water productivity is 18-21 thousand. Therefore, the rational use of water resources requires the rational use of water resources and changes in the water resources management system.

This can be achieved by changing the attitude of water consumers towards water, by

correctly explaining how much effort and expense comes to each cubic meter of water.

In particular, if we pay attention to the data in Table 3, it should be noted that the level of water usage is high in Turtkul, Beruniy, Ellikkala, Amudarya districts. The main reason for this can be explained by the fact that these districts are the main canals and rivers. In areas far from the main canals, Shumanay, Kungrad, Kanlikul and Moynak districts have lower water usage rates. The reason for this is the lack of water in these districts, i.e. the distance from the main canals.

Considering the introduction of water-saving technologies in a total of 1826.5 hectares in the Republic of Karakalpakstan in 2017-2019, according to estimates, 3,977thousand m^3 water savings were achieved. Taking into account the cost of delivering this saved water to consumers (operating costs per cubic meter of water), the cost of water saved in areas where water-saving technologies are applied amounted to an average of 60 million sum. Due to the saved water, depending on the crop, 290 hectares will be allocated for agricultural production.

CONCLUSION:

According to the results of our research, the rational use of water resources, finding optimal solutions for water distribution are among the most pressing problems in the agricultural sector of the Republic of Karakalpakstan, which is surrounded by environmental problems. Rational use of water in the region is an important factor in improving the reclamation situation, expanding arable land, reducing production costs and strengthening the guarantee of water supply in the region. Therefore, the quality implementation of the following water saving measures is important;

- the use of precise quantitative methods, econometric models in determining the optimal solutions for water distribution;
- interrelated implementation of reclamation and irrigation measures to prevent soil salinization;
- to consider water as the main limitation in solving the problem of optimal placement of agricultural products;
- it is necessary to take into account the experience of foreign countries in improving the efficiency of water-saving crops and water usage;
- keep the soil moist by enclosing the fields with protective crops. In particular, it is proposed as a solution to the existing problems of optimal water usage by reducing mulch water levels, reducing water evaporation in the fields and ensuring good crop development through mulberry planting, which is a tree suitable for the regional environment with salt resistance.

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