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PROBLEMS OF WATER SUPPLY OPTIMIZATION OF THE POPULATION IN KARAKALPAKSTAN

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Annotation. *The purpose of this work was to assess the conditions of drinking water use, calculate the necessary funding to provide the population of the Republic of Karakalpakstan with high-quality drinking water in the conditions of climate change.*

In Karakalpakstan, 51.2% of the population is provided with centralized water supply, 27.9% of the population is provided with non-centralized water supply, 18% of the rural population uses surface polluted water bodies for drinking needs. Over the retrospective period there has been a deterioration dynamics in the chemical and microbiological indicators of drinking water quality.The proportion of drinking water samples that do not meet hygienic requirements is 24.8-43.4% for chemical indicators and 3.6-7.2% for microbiological indicators.The highest rates of mineralization of tap and well water are observed in Khodzheli, Muynak, Kungrad and Takhtakupyr districts, where their values are 2.5-3.5 times higher than the normative levels.The proportion of water samples from surface water bodies that do not meet hygienic requirements for Karakalpakstan is 65.5%. The mineralization of water reaches 1600-2800 mg/l, the total hardness of water is 8-19 mg-eq/l, the concentrations of ammonium nitrogen, nitrites and nitrates exceed the established MPC by 5-8 times.The conducted studies showed that for the base period, the amount of financial costs for improving the conditions of drinking water use of the population and protecting drinking water bodies will amount to 3497.2 billion soums and for the adaptation period - 6219.8 billion soums

Key words: *surface water bodies, drinking water, wastewater, water use, population, financial flows, water quality, baseline scenario, adaptation scenario, climate change, water supply optimization*

Introduction. The Amudarya River, which is the only source of water supply and fresh water in Karakalpakstan, is subjected to pollution throughout [1, 2]. Surface waters within the Republic of Karakalpakstan are polluted due to the return to the Amudarya River from irrigated lands of waters with increased mineralization, contaminated with pesticides, inorganic fertilizers, as well as due to discharges of untreated and insufficiently purified industrial and domestic wastewater from the upper and middle reaches of the Amudarya River [3.4].

Groundwater in the Republic of Karakalpakstan over the past 5 years due to an increase in mineralization and general water hardness has stopped to meet the requirements of the standard for drinking water supply sources [5].

It has been established that in recent years there has been a downward trend in drinking water quality indicators in the Republic of Karakalpakstan in terms of mineralization concentrations and general hardness [6,7].

In the Amudarya basin 16–19 km^3 of return water is formed annually, of which 95% of the total flow volume is drainage water and 5% is unpurified industrial and domestic wastewater [8, 9].

Karakalpakstan is located in the Turan lowland. From the southwest the Karakum desert closely adjoins it, in the northwest is the Ustyurt plateau and in the northeast is the Kyzylkum desert. The territory of Karakalpakstan also includes the southern half of the former Aral Sea, on the dried bottom of which the new Aralkum saline desert is now being formed, and the drying lower reaches of the Amudarya River [10,15].

It should be noted that, to date isolated studies have been carried out on the study of the water quality of the Amudarya River and problems related to the calculation of the necessary funding for optimizing water supply systems in Karakalpakstan have not been studied [11, 12, 13, 14].

The purpose of the research was to assess the quality of drinking water and the state of water bodies over a long period to determine the limits of the necessary funding aimed at optimizing the water supply of the population and protecting water bodies in Karakalpakstan in the conditions of climate change.

Material and methods of research Methods of research included the collection of stock materials on the quality of drinking water and sources of water supply for the population in Karakalpakstan for a retrospective period. The assessment of the quality of drinking water and water supply sources was carried out in accordance with GOST 950:2011 “Drinking water. Hygienic requirements and quality control” and GOST 951:2011 “Sources of centralized household and drinking water supply. Hygienic, technical requirements and selection rules.”

Research results.

It was established that in 2017 compared to 2007 the dynamics of non-centralized water consumption of the population from springs and boreholes in the Republic of Karakalpakstan practically did not change. So, if in 2007 the coverage of the population was 28.2%, then in 2017 this figure was 27.9% (Table 1). The highest consumption of water for drinking needs is noted in the Karauzyak district - 34.1%, the smallest - in the Takhiatash district - 17.2%. It should be noted that the rural population of Karakalpakstan uses water from boreholes at a depth of 2.0-2.5 meters from the surface for drinking and domestic needs.

By 2017 in comparison with 2007 in Karakalpakstan it has been marked an increase in the dynamics of provision of the population in all districts, with the exception of the Khojeli district, where this indicator has decreased by 7.0%.

Table1 - Coverage of the population of Karakalpakstan with non-centralized water supply by regions in %

№	Cities and regions	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	Turtkul	22,3	24,6	23,7	23,7	24,1	21,2	20,7	21,8	21,8	25,8	33,8
2	Beruniy	29,8	30,4	31,8	28,2	27,5	25,7	25,5	24,9	29,2	25,9	32,3
3	Ellikkala	26,3	23,8	24,3	24,1	24,1	23,5	24,2	23,6	24,2	25,8	28,7
4	Amu Darya	28,7	29,5	31,2	32,2	32,5	32,5	32,8	31,9	32,5	30,7	31,2
5	Khodjeili	29,3	28,9	27,3	26,8	26,1	25,9	27,8	25,4	25,7	20,5	22,3
6	Shumanay	30,1	32,7	31,8	31,7	31,8	32,5	31,5	30,9	29,8	29,3	30,9
7	Kanlykul	23,9	22,7	22,5	21,1	21,6	22,2	21,8	22,6	20,7	21,2	26,4
8	Kungrad	15,8	16,1	14,8	17,1	14,5	16,8	16,3	15,8	17,6	18,9	20,2
9	Muynak	31,2	29,5	29,7	30,5	27,3	29,1	28,9	32,8	31,3	30,9	32,4
10	Nukus district	18,8	17,9	14,6	14,6	15,1	17,5	17,2	17,6	16,3	23,2	33,2
11	Kegeyli	31,5	29,7	28,4	28,3	28,9	26,7	27,1	27,3	29,4	30,3	31,5
12	Chimbay	24,4	25,8	26,3	27,1	25,4	25,8	25,4	26,1	26,6	26,4	32,7
13	Karauzyak	23,8	23,1	24,9	25,1	26,2	28,1	28,2	28,2	32,2	32,8	34,1
14	Takhtakupyr	16,1	18,8	15,7	15,5	14,9	11,6	11,6	10,2	15,8	17,9	27,4
15	Takhiatash	15,3	9,2	0,4	0,4	0,4	1,1	1,9	0,9	2,4	3,4	17,2
Total:		**28,2**	**29,5**	**27,3**	**26,4**	**25,2**	**24,3**	**24,1**	**24,3**	**25,3**	**26,2**	**27,9**

Analysis of long-term data on providing the population of Karakalpakstan with centralized drinking water supply systems for 2007-2017 showed that in the Khojeli, Takhiatash districts and the city of Nukus there is a positive dynamics (table 2). If in 2007 in the Khojeli district the percentage of population provided with centralized water supply systems was 50.5%, then in 2017 this figure was at the level of 81.7%, i.e. the increase was 31.2%. In the Takhiatash district the increase in water supply amounted to 7.6% and in the city of Nukus 16.8% relatively.

In all other districts of Karakalpakstan by 2017 compared with 2007 there is a decrease in the percentage of coverage of the population with centralized drinking water supply systems.

In the Republic of Karakalpakstan by 2017 compared to 2007 there was a decrease in the provision of the population with centralized domestic drinking water supply by 9.4% (Table 2).

Table 2 - Coverage of the population of Karakalpakstan with centralized domestic drinking water supply in %

№	Cities and regions	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	Nukus	75	73,9	75,4	75,4	74,6	75,6	75,1	74,8	66	92,8	91,8
2	Turtkul	64,7	58,2	60,9	60,9	65,3	73,2	76,7	73,7	73,7	53,6	37,8
3	Beruniy	40,9	39,4	36,5	42,3	44,7	48,6	48,5	48,1	42,5	48,3	32,8
4	Ellikkala	55,1	59,6	66,2	67,5	67,6	67,1	68	67,8	68	50,1	30,8
5	Amu Darya	41	35	31,4	32,4	35,1	33,7	35,4	36,5	34,2	37,3	28,6
6	Kegeyli	50,5	51	53,7	54	54,4	56,4	54	54,6	54,8	77,6	81,7
7	Shumanay	50,4	58,8	57,5	57,6	57,4	53,1	55	54,9	52,8	55,2	38,5
8	Kanlykul	67,5	68,5	68,9	74	73,8	72,9	73,7	73,4	75,2	74,1	58,4
9	Kungrad	80,9	80,5	85,7	58,1	84,5	83,2	83,5	83,8	72,9	69,7	63,1
10	Muynak	52,6	53,8	54,1	53,9	82,4	58	57,9	43,1	47,3	47,3	34,6
11	Nukus district	77,2	78,4	83,5	83,5	82,4	79,3	79,9	79,7	80	60,6	37,3
12	Kegeyli	57,8	59	58,8	58,9	58,4	61	61,4	61,1	55,5	56,8	40,7
13	Chimbay	60	59	58,2	57,2	59	59,2	59	58,7	58,5	58,4	41,4
14	Karauzyak	61,5	62,2	59,3	59,2	58,4	55,5	55,4	55,7	50	49	34,6
15	Takhtakupyr	79,4	70,1	81,9	81,5	82,4	82,1	82	85,2	78,1	71,3	47.0
16	Takhiatash	48,3	96	100	100	100	99,1	98,5	99,9	94,8	88,3	55,9
Total:		**60,6**	**59,8**	**61,2**	**62,3**	**63,4**	**64,1**	**64,6**	**64,1**	**60,6**	**63**	**51,2**

It was established by the study of water quality of water supply sources for 2007-2017 the dynamics of the deterioration of their condition in terms of chemical indicators. The percentage of water quality discrepancy in 2017 was 47.9% against 41.1% in 2007, i.e. the dynamics of deterioration in chemical indicators is 6.8 percent.

It was established that over a ten-year retrospective period there had been a significant deterioration in the indicators of microbiological water pollution in the Republic of Karakalpakstan.

So if in 2007 the average annual indicators of microbiological contamination of water supply sources in Karakalpakstan were 11.7%, then in 2017 the percentage of non-compliance with sanitary standards increased by 3.5 times and amounted to 40.8%.

In general in the Republic of Karakalpakstan over the past ten years there has been a deterioration in the quality of drinking water from urban water pipes in terms of chemical and microbiological indicators.

The results of analyzes of the quality of drinking water in Karakalpakstan testify a significant increase in the level of mineralization in recent years. The worst indicators of mineralization of tap and well water are observed in Khodzheli and Muynak. In Kungrad and Tahtakupyr districts where their values are 2.5-3.5 times higher than the normative levels. Tap water is the most favorable for drinking in the city of Nukus where the total mineralization is 871-989 mg/l, which does not go beyond the hygienic standards. However, in other areas the total mineralization is 1.5-2 times higher than the MPC. In the autumn and spring periods of the year the maximum values of total mineralization reach 2100-2500 mg/l.

In recent years the surface waters of the Aral Sea basin have long become unsuitable for the drinking needs of the population. Pollution of water resources of anthropogenic origin can be identified as the negative impact of agricultural activities, pollution as a result of industrial production and pollution of water bodies with domestic wastewater flows.

As a result of anthropogenic pollution of water bodies and desertification of the Aral Sea the proportion of samples that do not meet the requirements of hygienic standards in the surface watercourses of the Republic of Karakalpakstan is 65.5%.

The Amudarya River which is the only source of water supply and fresh water in Karakalpakstan is polluted throughout its length. The main source of pollution in the Amu Darya is return water, which makes up a significant proportion of the water resources in the basin. The return flow consists of drainage and waste water from irrigation, industry and municipal users.

In front of the Tuyamuyun reservoir, water in total mineralization, over the past 10 years has been steadily fluctuating in the range from 1600-2800 mg / l.

The total hardness of water is 8-18 mg-eq/l. Nitrogen ammonia, nitrites and nitrates entering the river water with agricultural flow are recorded in maximum quantities in May - June, the concentrations of which exceed the established RSM by 5-8 times.

Surface waters within the Republic of Karakalpakstan are polluted due to the return to the Amudarya River from irrigated lands of waters with increased mineralization, contaminated with pesticides, inorganic fertilizers, as well as due to insufficiently purified industrial and domestic wastewater coming from the upper reaches of the Amudarya River. The quality of water in water bodies throughout almost the entire territory of the Republic of Karakalpakstan does not meet hygienic standards and is not suitable for drinking water use.

The priority of issues solution of assessing investment and financial flows to improve the quality of drinking water and increase the efficiency of drinking water supply systems in the Republic of Karakalpakstan is due to the fact that the economic policy of the Government of Karakalpakstan planned for the near future provides for:

- providing the population of the Republic of Karakalpakstan with good quality and safe drinking water, especially in rural areas;
- prevention of further anthropogenic pollution of underground and surface natural sources of water supply;
- full coverage of the population of the Republic of Karakalpakstan with systems of centralized and non-centralized domestic and drinking water supply;
- radical renewal of the material and technical base of drinking water supply systems.

The solution of the tasks set is largely determined by the state of water bodies and their predicted change in the future. Therefore, the study of the possible unfavorable impact of climate change on the

functioning of drinking water supply systems and the quality of drinking water in the Republic of Karakalpakstan is of great social and economic importance.

Baseline scenario. This stage includes a description of the conditions that are developing in the Republic of Karakalpakstan in the field of drinking water supply of the population without taking into account adaptation measures due to climate change. It takes into account the fact that surface and underground sources of water supply for the population are a national asset that plays a large role in the socio-economic development of the Republic of Karakalpakstan, which constantly lacks water resources. Due to changing conditions, such as the current economic situation, the state of the international food market, the state of agriculture, population growth, the development of free economic zones, the construction of agricultural and industrial enterprises, the base scenario should be corrected. When correcting the program of the baseline scenario priority measures are set, and usually, a plan is drawn up while maintaining the average level of development of the water industry of the republic. The realization of measures under the baseline scenario is fully 100% financed from the budget of the Republic of Karakalpakstan and is always carried out in full. This circumstance is the basis of the baseline scenario.

Therefore the methodological approach of the baseline scenario up to 2025 is based on average indicators of the development of drinking water supply systems. Thus, the scale and growth rate of investment, financial investments and operating expenses until 2025 will grow in the same dynamics as in the historical period of 2006-2014 without regard to adaptation measures.

The adaptation scenario takes into account the situation in which there is a change in the Earth's climate in the direction of its increase by 1.5-2 degrees of Celsius. At the same time the deficiency of water resources will increase. The number of population in Karakalpakstan is also increasing. The Republic of Karakalpakstan has no additional sources of surface water. Under such conditions providing the population with good-quality drinking water, optimizing water supply sources, and raising the efficiency of the functioning of water supply systems in this region to the required level is a vital problem, the solution of which requires significant efforts not only from the Government of the Republic of Karakalpakstan, but also from International financial organizations.

Calculations of financial and investment flows to optimize the drinking water supply of the population for the expected period were carried out in accordance with the "Methodological guide for assessing investment and financial flows to solve problems associated with climate change" (Rebecca K. Methodological guide to assessing investment and financial flows to solve problems related to climate change, (United Nations Development Program - 2009).

The methodological approach in the baseline scenario is based on the level of cost growth rates for the period from 2006 to 2014 and on their basis (in the same dynamics) the calculation was made until 2025. As mentioned above, a feature of the development of water supply systems in Karakalpakstan is the **implementation of the realization of all investments from the state budget.** This circumstance was the basis for the assumption that this situation will remain unchanged in the future.

However, calculations have shown that the planned investments until 2025 under the baseline scenario in the event of a predicted climate change of 1.5-2 degrees of Celsius in Karakalpakstan will not ensure the reliable work of centralized and non-centralized water supply systems.

The methodological approach of the adaptation scenario is based on the realization of a number of measures by 2025 to minimize the adverse impact of climate change on the efficiency of drinking water supply systems and the conditions of water use of the population in the Republic of

Karakalpakstan. This situation was the basis for calculating the required volumes of investments and financial flows for the adaptation scenario.

In the absence of data on the number of investment and financial flows for some indicator indices for 2022-2025, we used the methods of expert assessments and correlation-regression analysis allowing us to make calculations for 2025.

An analytical description of the dependencies between variables is performed at the stage of retrospection (historical period), assessment of the current state of the system (baseline period) and is further used to calculate investment flows for the period of the target scenario (adaptation period).

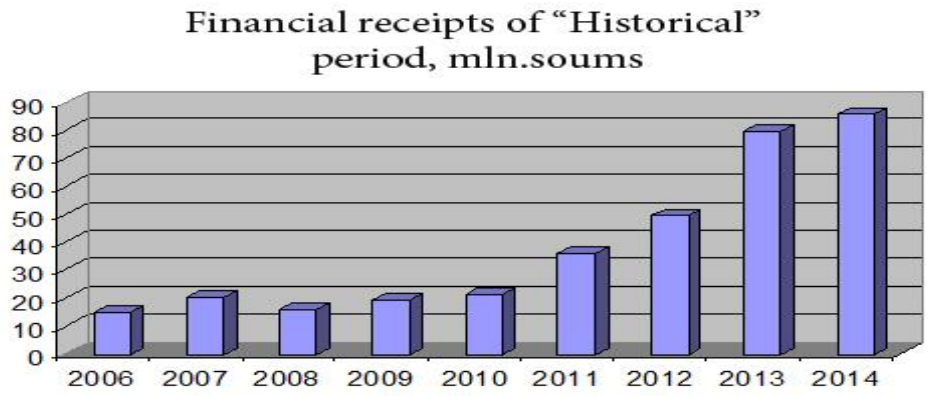
The methodical scheme was developed on the principle of calculations based on simple methods - extrapolation of historical indicators for the expected period and complex methods that involve the construction of regression models when the dependence of indicators of investment and financial flows of the adaptation period (2022-2025) on historical data is established.

Historical data on investment flows (2006-2014) are given according to the Ministry of Housing and Communal Services of the Republic of Karakalpakstan, the Karakalpak branch of the Research Institute of Irrigation and Water Problems of the Ministry of Agriculture of the Republic of Uzbekistan and the Center for State Sanitary and Epidemiological Welfare and Public Health of the Ministry of Health of the Republic of Karakalpakstan. In addition, the following financial flows and costs are taken into account:Over the "historical" period there has been a gradual increase in the volume of investment flows to improve the reliability of the drinking water supply systems (see graph) in 2014 in comparison with the costs for the previous period of time.

This situation can be explained by the desire of the government of the Republic of Karakalpakstan to improve the conditions for the population's water use and the efficiency of the water supply systems in the republic in all basic indicators.

It should be noted that for the **"historical period"** for the construction of water pipelines the amount of costs is 44.22 million soums; water supply networks - 37.2 million soums; boreholes - 49.9 million soums; water towers - 70.8 million soums; reservoirs - 44.6 million soums; pumping stations - 42.1 million soums and chlorate installations - 67.3 million soums.

The total amount of budget revenues for the "historical period" is **356.12 million soums**. **Of this amount** the percentage of costs for the construction of water conduits amounted to 12.41%, water supply networks - 10.44%, boreholes - 14.01%, water towers - 19.88%, reservoirs - 12.52%, pumping stations - 11.82 % and chlorination plants - 18.89%.



It should be noted that in the historical period of 2007-2014 the Asian Development Bank (ADB) choosed 3,723.0049 million US dollars for the reconstruction and construction of water conduits, water

supply networks, treatment facilities, water freshener plants, chlorination plants and fences in the sanitary protection zones of the Republic of Karakalpakstan.

Baseline Scenario

The analysis of financial receipts showed that the realization of the planned activities under the baseline scenario will allow to eliminate the problems associated with improving the functioning of drinking water supply systems and the quality of drinking water by 2025 by no more than 50%.

It has been established that the total amount of financial receipts for the period 2015-2025, calculated on the basis of the current real costs, will be equal to **3,497.2** billion soums, (table 3), including:

1.Construction, reconstruction and repair of water pipelines - 575.0 million soums.
2.Construction, reconstruction and repair of water supply networks - 474.4 million soums. 3. 3.
3.Construction and repair of boreholes - 527.5 million soums.
4.Construction of water towers - 470.5 million soums.
5.Construction of reservoirs - 453.3 million soums.
6.Construction, reconstruction and repair of pumping stations - 448.3 million soums.
7.Construction, reconstruction and repair of chlorination plants - 548.7 million soums.

Table 3 - Indicators of the baseline scenario, mln.soums

Indicators	Total cost	Percentage of costs of the total amount
1. Conduits	575,0	16,4
2. Water networks	474,4	13,6
3.Boreholes	527,5	15,0
4. Water towers	470,5	13,5
5. Reservoirs	453,3	13,0
6. Pumping stations	448,3	12,8
7. Chlorination plants	548,7	15,7
Total:	**3 497,2**	**100**

Analysis of the submitted materials showed that the Asian Development Bank (ADB) in the base period of 2016-2018 made investments in the Republic of Karakalpakstan in the amount of 180 million US dollars for the realization of the project “Development and modernization of water supply systems

in the Nukus, Beruni, Muynak, Kungrad and Karauzyak regions, as well as the modernization of the 2nd lift stations “Tuyamuyun” (table 4).

However, other international financial organizations: the World Development Bank (WDB), the Arab Coordination Group (ACG) and the International Development Association (IDA) for previous years and in the future do not provide for financial infusions into the development of water supply systems in Karakalpakstan.

It should also be noted that due to the lack of data on foreign investment for 2017-2025 it is not possible to compare investment levels in US dollars for the base and adaptation periods.

Table 4 - Foreign investments in the drinking water supply system of the Republic of Karakalpakstan, in million US dollars

Years	International Development Association (IDA)	Asian Development Bank (ADB)	Arab Coordination Group (ACG)	World Development Bank (WDB)
2007		Contract B3 "Replacement of pumps for WTP Tuyamuyun" in the amount of 2.0666 million US dollars Contract B1 / Lot 3 "Construction of the water conduit-cofferdam Shumanai" in the amount of 2.576 million US dollars		
2008		Contract D21 "Construction and reconstruction of 7 WUAs and networks of Shumanay district" in the amount of 1659.310 million soums		
2009		Contract D22 "Beruni-construction of 2 water stations and networks" in the amount of 2049.9189 million soums. Contract D3 “5 WRT, Boreholes and Desalination Plants (Kegeily district)” in the amount of 2.391 million USD		
2010	-	-	-	-
2011		Contract B2 "Reconstruction of WTP Takhiatash" for the amount 8,809 US$		
2012	-	-	-	-
2013	-	-	-	-

2014	-	-	-	-
2015	-	-	-	-
2016		Contract No. 2825/CW/1.2 "Improving the drinking water supply system in the Republic of Karakalpakstan and Khorezm region" in the amount of 13.5779 million US dollars		
2017		Project under development: “Development and modernization of water supply systems in the Nukus, Beruni, Muynak, Kungrad and Karauzyak regions, as well as the modernization of the Tuyamuyun 2nd rise stations” for 180 million US dollars.		
2018				
2019				
2020				
2021				
2022				

The adaptation scenario provides for the realization of a number of additional, compared to the baseline scenario, water protection measures and investment infusions into the “Water Supply” sector in Karakalpakstan, which will significantly reduce the unfavorable influence on climate change. As mentioned above, an increase in the climate in Karakalpakstan by an average of 1.5 - 2 degrees of Celsius will lead to a deterioration in water use conditions by about 30 percent. This will lead to a failure in the work of systems of centralized and non-centralized domestic and drinking water supply, the quality of drinking water will significantly deteriorate in terms of organoleptic, chemical and microbiological indicators, pollution levels of drinking water sources will increase and intensive indicators of the incidence of the population, in conjunction with the water factor. In connection with the above, for specific activities provided for in the adaptation scenario, the volume of their implementation and the amount of funding was increased compared to the baseline scenario. The list of main adaptation measures, determined by experts, includes:

• introduction of recycling water supply at industrial facilities;

• use of domestic and collector-drainage wastewater in agricultural irrigation fields;

• improvement of monitoring of the quality of drinking water and water supply sources;

• development of measures to prohibit the discharge of industrial wastewater into water bodies for drinking purposes, if the flow contains chemicals for which hygienic standards are not established;

• possibilities of involving additional water resources (low-mineralized collector-drainage waters, underground waters and waste waters) and their quantitative potential;

• allocation of appropriate capital investments for the construction of water pipelines and sewerage systems in cities and regions, laying of water supply networks.

• provision of the material and technical base of rural water pipelines (acquisition of water desalination plants, chlorinators of various systems, bactericidal lamps on a centralized basis);

• development and improvement of existing regulatory and legal documents in the field of sanitary protection of water supply sources and assessment of drinking water quality in accordance with the requirements of international standards, sanitary rules and norms;

• involvement of foreign financial organizations such as MBR, IDA, ACG, ADB and others to finance the construction of priority projects for the construction of interregional water pipelines in the Republic of Karakalpakstan.

The above suggestions were incorporated into the adaptation scenario

Taking into account the practical realization of the developed measures to protect water sources and improve the state of work of drinking water supply systems, we calculated investment and financial flows until 2025.

The implementation of investment and financial flows according to the developed measures for the adaptation scenario by 2025 in the Republic of Karakalpakstan will allow:

- reduce the levels of anthropogenic pollution of natural sources
- provide the population with safe drinking water
- improve the conditions for water use by the population
- modernize the systems of centralized drinking water supply
- provide the reconstruction of non-centralized water supply systems
- reduce the cost of fresh water for irrigation
- to choose additional financial resources for the realization of investment and financial flows
- use non-drinking water resources for agriculture
- create sanitary protection zones for water bodies and water supply sources.

The total amount of financial receipts under the adaptation scenario to the Republic of Karakalpakstan will amount to **6,219.8 billion soums, of which:**

Construction, reconstruction and repair of water pipelines - 1,163.2 million soums.

Construction, reconstruction and repair of water supply networks - 608.1 million soums.

Construction and repair of boreholes - 999.5 million soums.

Construction of water towers - 889.1 million soums.

Construction of reservoirs - 869.2 million soums.

Construction, reconstruction and repair of pumping stations - 714.5 million soums.

Construction, reconstruction and repair of chlorination plants - 976.2 million soums.

The analysis of the obtained results showed that the realization of the adaptation scenario for the period from 2015 to 2025 provides for a significant increase in costs to improve the efficiency of the drinking water supply systems for all pointed indicator indices in the Republic of Karakalpakstan.

The costs of implementing measures to increase the coverage of the population with centralized and non-centralized water supply systems, improve the reliability of the work of water pipelines, provide the population of Karakalpakstan with good-quality, affordable drinking water and reduce the incidence of the population associated with the water factor, for the period from 2015 to 2025 may increase to 2 times.

Table 5 shows the cost amount of investment income for all indicator indices for the baseline and adaptation scenarios.

It has been established that during the adaptation period a significant increase (1.28-1.97 times) in the costs of implementing the planned measures in the Republic of Karakalpakstan is envisaged.

Table 5 shows that during the adaptation period the costs of water pipelines, compared with the baseline scenario, **will increase** by 1.97 times; water supply networks by 1.28 times; boreholes by 1.89 times; water towers 188 times; reservoirs by 1.91 times; pumping stations by 1.59 times; chlorination plants by 1.78 times.

Table 5 - Comparison of cost indicators of the baseline and adaptation scenarios, mln.soums.

№№ b/o	Indicators	Baseline scenario costs	Adaptation scenario costs	Added costs
1.	Water pipelines	575,0	1163,2	588,2 (1,97)
2.	Water supply networks	474,4	608,1	133,7 (1,28)
3.	Boreholes	527,5	999,5	4720 (1,89)
4.	Water towers	470,5	889,1	418,6 (1,88)
5.	Reservoirs	453,3	869,2	415,9 (1,91)
6.	Pumping stations	448,3	714,5	266,2 (1,59)
7.	Chlorination plants	548,7	976,2	427,5 (1,78)
	Total:	3497,2	6219,8	2722,6 (1,77)

Analytical analysis of the above results indicates that the realization of the developed measures under the adaptation scenario will allow to alleviate the unfavorable impact of climate temperature increase by 1.5-2 degrees of Celsius on water management activities in Karakalpakstan for the forecast period.

With a total investment and financial cost of more than 6 billion soums for the adaptation scenario, taking into account possible investments from foreign financial institutions, the reliable functioning of centralized and non-centralized drinking water supply systems in the Republic of Karakalpakstan by 2025 will be provided to the required level.

Calculations of investments have been made to improve the reliability of the functioning of water supply systems and complete coverage of the population of the Republic of Karakalpakstan with drinking water for the historical, basic and adaptation periods.

An increase in temperature by 1.5-2 degrees of Celsius, as mentioned above, will contribute to a deterioration in the quality of drinking water, a malfunction in the functioning of water supply systems, and a deficiency of water resources. This situation will lead to the spread of intestinal infectious and non-infectious morbidity of the population of aquatic etiology.

Such conditions will create social tension in the region, which conditioned the necessity of the development of a number of complex measures for the adaptation period, the realization of which will reduce the unfavorable impact of climate change on water bodies, improve the efficiency of water supply systems and the quality of drinking water.

The results of this work have shown that the realization of adaptation measures will significantly reduce the unfavorable impact of climate change in the sector. The value of investment and financial infusions under the adaptation scenario will exceed the costs by **1.28 - 1.97** times compared to the

baseline scenario.

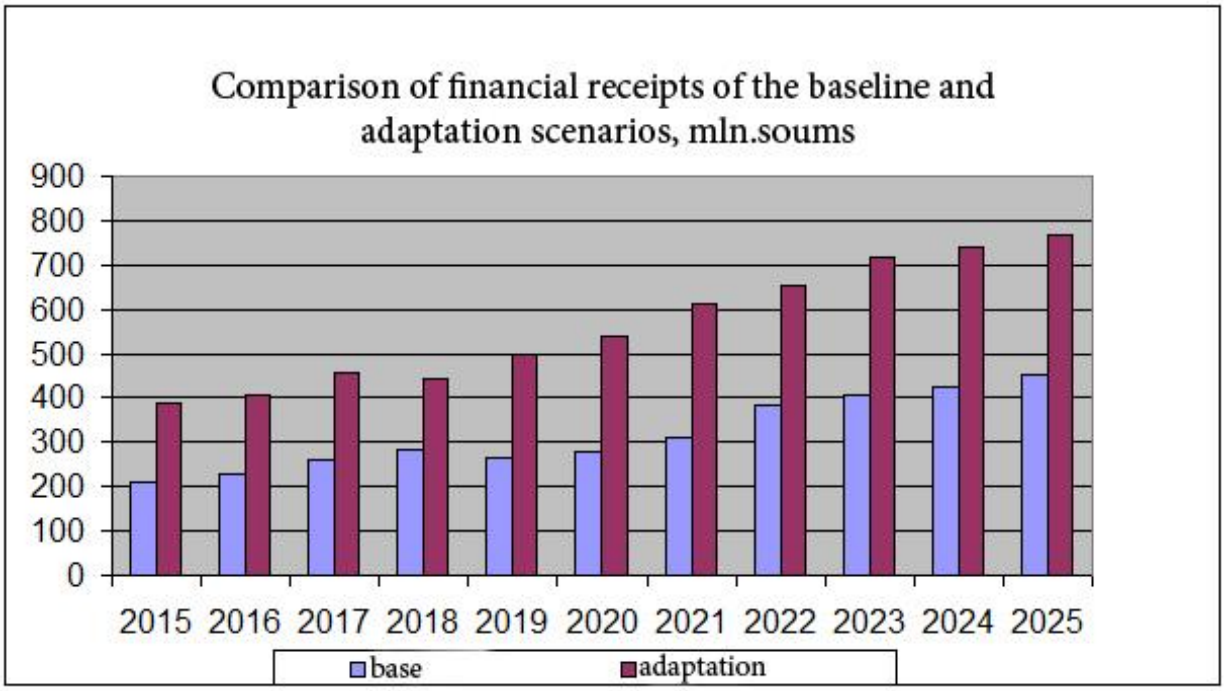
So, if in the base period the total amount of investment and financial receipts for the construction, repair and reconstruction of water pipelines amounted to **575.0** million soums, then in the adaptation period this figure was equal to **1163.2** million soums.

It is planned to invest **474.4** million in the base period and **608.1** million in the adaptation period for the repair, reconstruction and construction of water supply networks.

For the construction of boreholes **527.5** and **999.5** million respectively, water towers **470.5** and **889.1** million, reservoirs **453.3** and **869.2** million, pumping stations **448.3** and **714.5** million, chlorination installations **548.7** and **976.2** million respectively.

The baseline scenario provides for the realization of investments in the amount of **3 billion 497.2 million soums** and for the adaptation period - **6 billion 219.8 million soums**.

Thus, for the adaptation period it is planned to increase financial infusions **by 1.77 times** compared to the baseline scenario. The long-term dynamics of financial receipts for 2015-2025 in comparative terms for the baseline and adaptation scenarios is shown in the figure.



CONCLUSION:

1.In Karakalpakstan 51.2% of the population is provided with centralized water supply, 27.9% of the population is provided with non-centralized water supply, 18% of the rural population uses surface polluted water bodies for drinking needs.

2. Over the retrospective period there has been a dynamics of deterioration in the chemical and microbiological indicators of drinking water quality. The proportion of drinking water samples that do not meet hygienic requirements is 24.8-43.4% for chemical indicators and 3.6-7.2% for microbiological indicators.

3. The highest rates of mineralization of tap and well water are observed in Khodzheli and Muynak, Kungrad and Tahtakupyr districts, where their values are 2.5-3.5 times higher than the normative levels.

4. The proportion of water samples from surface water bodies that do not meet hygienic requirements in Karakalpakstan is 65.5%. The mineralization of water reaches 1600-2800 mg/l, the total hardness of water is 8-19 mg-eq/l and the concentrations of ammonium nitrogen, nitrites and nitrates exceed the established MPC by 5-8 times.

5. The conducted studies showed that for the base period, the amount of financial costs for improving the conditions of drinking water use of the population and protecting drinking water bodies will amount to 3497.2 billion soums and for the adaptation period - 6219.8 billion soums.

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