SUMMARY
REVIEW OF THE CURRENT SITUATION AND PRELIMINARY RECOMMENDATIONS FOR ACTIONS TO ADAPT TO CLIMATE CHANGE IN THE CHU-TALAS BASIN

"Promoting Cooperation to Adapt to Climate Change in the Chu-Talas Basin" (Kazakhstan and Kyrgyzstan)

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Introduction

The growing shortage of fresh water and the realistic prospects of adverse impact of the ongoing global climate change on the population and economy of Central Asian countries bring forward the need to assess the impact of climate change on water resources in the region.

In Central Asia, the vast majority of water resources and practically all the renewable resources of freshwater are formed in the mountains, mainly from the melt water of seasonal snowpack and glaciers. Caused by the global warming, changes in glaciers and snow cover in the runoff areas can significantly affect the hydrology and water resources of the Central Asian region and trigger a sharp aggravation of the problem of water supply for the population and economy of the region.

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Draft of this report was presented at the 10th anniversary session of the Chu-Talas Rivers Commission and widely discussed with the stakeholders. Comments and suggestions received during the discussions were integrated into this version of the review. Full version of the review consists of four parts plus the Introduction, and Conclusions and Recommendations, and also contains 10 appendixes (hydrography and hydrology of the basin, water resources use, the main climatic and economic characteristics, etc.). The report examines the climatic and water characteristics of the basin and their possible changes, analyzes the modern system of water management, on-going projects and programs, as well as the use of water resources. Based on the provided materials, we have developed recommendations for further action in the basin, aimed at studying the influence of climate change in the basin, as well as adapting to these changes.

Overall description

Basins of the Chu and Talas rivers are located in two neighboring countries - Kyrgyzstan and Kazakhstan. The mountainous regions of Kyrgyzstan produce the majority of the runoff and in Kazakhstan the runoff basically spreads out in the river system. The studied area is featured with various forms of river network: permanent watercourses, drying rivers – sai, the dry beds of alluvial plains and water bodies of artificial origin (channels), which acquired the features of natural streams.

The territory of the Chu basin contains 5244 small rivers and 506 lakes with a total area of 39 km^2, and the basin of the Talas River – 3632 rivers and 1405 lakes with the total area of 23 km^2.

The total length of the rivers in Chu and Talas Basin comprises 38,500 km, the river network density on average is 0.45 km/km^2, and the gradients vary widely (2 - 200 ‰). The main river of the basin is Chu, with the basin area (including undrained areas in the lowlands) of 67 500 km^2.

The rivers within the territory belong to the river system associated with the Aral Sea basin (the basins of Chu, Talas and Assa rivers, and adjacent rivers running down the northern slopes of the Karatau Range). The plain areas and the estuaries of the rivers contain a multitude of floodplain lakes. An essential element in the hydrography are irrigation canals, ponds, reservoirs, and "karasu" – outcrops of ground and return water.

At present, 17 reservoirs with a storage capacity of more than 1 million m^3 operate in the Kyrgyz territory of Chu river basin. 14 reservoirs, large and small, with a total effective capacity of 587 million m^3 function in the territory of Kazakhstan. There are many small natural reservoirs in Talas river basin, including 30 artificial ponds and reservoirs. Currently, in Kazakhstan the entire flow of Chu and Talas rivers is regulated, and represents the water discharges from the Tashutkulskoye and Chon-Kapkinskoye reservoirs, respectively.

Monitoring - overview of existing data

The National Hydrometeorological Service (NMHS) in **the Republic of Kazakhstan** is represented by the Republican State Enterprise (RSE) "Kazhydromet", functioning within the structure of the Ministry of Environment. The flow regime of rivers and intermittent streams was studied by the Office of the Hydrometeorological Service of Kazakhstan (Kazhydromet), which owns the local network of hydrological stations, the Kazakh SSR Ministry of Water Resources, and the Office of Water Resources.

First observations of water levels on Chu (Shu) river began in the southern suburbs of Blagoveshchenskoye town in 1909. During the entire period of observations, the Kazakh part of the Chu and Talas rivers' basin and their interstream area was monitored by about 220 stations in 155 rivers, channels and intermittent streams. Development of the hydrological network was extremely erratic. Sharp reduction in the number of observation stations in the 1980 – 1990 was associated with the abandonment of hydrological stations of the Kazakh SSR Ministry of Water Resources and Office of Water Management, as well as some departmental stations. Over the years of establishing independence of the Republic of Kazakhstan (the 1990s), the number of hydrological stations in Chu-Talas basin decreased almost four-fold.

In recent years, "KazHydroMet" RSE resumed observations at the following hydrological monitoring stations: Talas river – Solnechniy town, Shokpak river – Zykovskoye village, Tamdy river - Karatau town, Tashutkul (Tasotekl) reservoir - Tashutkul town and Biylyukol lake, a recreation area. In addition, new hydroposts were established in 2006 on Aksu river – in Aksu village, and in 2008 on Karabalty river – Balasugun village, on Talas river - Zhasorken town and Talas river – duct to Zhasorken town. Observations of water quality were resumed on Shu – Blagoveshchenskoye section, on Talas river at the border with Kyrgyzstan and in Taraz town, at Assa river – Maimak railway station, Karabalta river - at the border with Kyrgyzstan, and at Tashutkolskoye reservoir – at Tashutkol town.

The meteorological monitoring is carried out at 18 meteorological and upper air observation stations and along one snow measuring route. The meteorological stations monitor and register air temperature and humidity, the soil surface temperature, wind speed and direction, quantity, type and intensity of precipitation, snowpack, cloudiness and other elements.

The first meteorological stations in the territory of **modern Kyrgyzstan** were established in the late XIX century (1883). The biggest development of the meteorological stations and hydrological monitoring stations network occurred in 1985, when 79 meteorological stations (including specialized) operated at the same time.

The period of growth of the monitoring network gave way in 1990 to the consistent decrease in the number of observations, which in 1999 ended with a sharp drop to the levels of the 1930s, due to the budget cuts. Further on, the amount of observations did not change significantly. To date, the observation meteorological network is significantly reduced and less than three dozen weather stations (including 6 automatic) are still in service.

There is practically no monitoring of the snowpack (except for measurements of the snowpack features with the permanently placed rods at meteorological stations and hydrological monitoring stations) at present.

Monitoring of the glaciers: detailed glaciological observations (measuring the mass balance for at least 5 consecutive years) on 4 glaciers used to be carried out **in Kyrgyzstan**. The Golubin Glacier was monitored by the Kirghiz Office of the Hydrometeorological Service of USSR, the Kara Batkak Glacier – by the Academy of Sciences of the Kirghiz SSR, the Abramov Glacier – by the Central Asian Research Hydrometeorological Institute, and the Sara-Tor Glacier – by the Institute of Geography of the Academy of Sciences of the USSR (5 years).

The systematic monitoring of river runoff in Kyrgyzstan begun in 1911. In the 60s, the monitoring network consisted of 470 hydrological stations, and in 70s, there were 155 monitoring stations in the Chu, Talas, and Tarim river basins and Issyk-Kul Lake. To date, only 76 of them are still in service, of those, 13 function in the Chu basin and 9 function in Talas basin. Only one station operates in the Chu River basin in Kyrgyzstan today, and the number of wells to monitor groundwater in comparison with the 1980s had dropped by more than 50%. Consequently, the accuracy of forecasting the runoff and water balance calculations is reduced. Fortunately, a number of measuring stations to control the discharge in irrigation canals is still in service. There are four hydrometric stations in Kazakhstan part of the Chu River basin, including one station located downstream from the border with Kyrgyzstan, in Blagoveshchenskoye.

Collection and exchange of data is difficult - particularly due to the lack of budget funding. Monitoring and forecasting functions are divided among numerous agencies, which often lack coordination. Early warning networks in general do not function, and those that do are not adapted to the needs of the new economic and local government agencies. The population has no access to the early warning systems (and often is not aware of them).

Since 2004, and particularly in 2005-2007, the activities to restore water resources monitoring system at the expense of Kazakhstan and Kyrgyzstan, as well as various international investment projects, had been significantly intensified in both basins.

Water regime

The entire area of flow generation is located within the territory of Kyrgyzstan; it is a mountainous part of the territory. Water balance here is featured with predominance of water inflow over its consumption, which determines the relatively high water content and a good branching of the river network. The main feeding source for most rivers is the seasonal snowpack in the mountains, but rather an essential role, and for some rivers – a prevailing one, is played by the glaciers.

Kazakhstan is the territory of flow dispersion. Many of the streams are largely used for irrigation and even in the flood times do not bring the water to the main river. Due to evaporation, the surface runoff is only possible through the inflow from the mountain region and the melting of the local snowpack in early spring and winter, as well as during intense rains in the spring.

The natural river regime in the flow dispersion area is strongly distorted by the intensive water withdrawals, the entire surface runoff is diverted into the irrigation system, and many riverbeds have dried up. However, the rivers receive extra feeding in form of so-called “secondary water”, totaling at appr. 3.0 km^3 per year, in the zone where groundwater discharges or from return water from irrigated fields.

The annual flow distribution is different for various months and seasons – in the glacier-and-snow and snow-and-glacier fed rivers with high-lying watersheds and significant glaciation, the July-September runoff comprises 30 - 60%, sometimes peaking at 80%, and never falling below 30%. In snow and snow-and-rain fed rivers with low-lying watersheds, the runoff during the spring flood and March-June comprises more than 60% of the total annual flow, and during July-September is less than 30% (at times falling to 20%).

A special dynamics of water flow features the delta of the Shu river - at the end of the vegetation period (September - October) the flow at the bottom of the river increases due to cessation of water withdrawals for irrigation systems and the inflow of return water from irrigated areas into the river. With the increase of runoff in winter, the water mainly accumulates as ice on the vast territory of the deltas, and only a small part of that water enters the downstream overflow ponds. Its further progress down the chain of overflow ponds slows down dramatically.

The predominant accumulation of winter runoff in the upper echelons of overflow ponds chain (deltas) leads to the gradual desertification of the lower parts of the delta region, degradation of soil, vegetation, wildlife depletion. In the delta areas, the entire flow of the river is gradually consumed mainly by evaporation and transpiration by the hydrophilous vegetation.

Rivers carry fresh water with a relatively low salinity, which does not prevent its use for the irrigation of agricultural lands and is suitable for drinking. Water in most rivers belongs to the hydrocarbonate-calcium class, poorly mineralized, low and moderately hard, rich in dissolved oxygen and meets the basic requirements of the domestic and industrial water use.

Water resources

Water resources of Chu and Talas basins are formed by surface water, groundwater and return water. According to the studies carried out in the 1960s and 80s, the average annual water reserves of the Chu river basin make up 6.64 km^3, and the Talas river basin- 1.62 km^3. More recent calculations confirm the validity of these estimates, with annual deviations not exceeding ± 6%.

Total resources of groundwater feeding sources of "Karasu" type in the territory of Kyrgyzstan make up for the Chu river basin about 1.29 km^3 per year, and for Talas river basin - about 0.1 km^3. The average annual amount of return water in the territory of Kyrgyzstan for the Chu river basin makes up about 0.81 km^3, and for Talas river basin - 0.26 km^3. The volume of return water for the Kazakhstan part of Talas river are estimated at about 1-1.2 km^3/year, and were not accurately calculated and subject to clarification for the Chu river basin.

In spring and summer, during the snowmelt and at times of torrential rains, the mountain rivers of Shu-Talas basin may form dangerously high snowmelt-and-rain-fed floods and mudflows.

The Shu-Talas River Basin flow is subject to long-term variability. Analysis of changes in river flows over a long period of Shu observations demonstrated constant flow fluctuations from year to year, alternate sequences of high-water and low-water-year-periods of different duration. 1969 may come as an outstanding example of a high-water year, which occurs once in a hundred years (except for Merke river), as well as the period of 2002-2005, when the water content was exceptionally high. We may also remark the high-water years of 1958 and 1994.

Groundwater

The fresh groundwater reserves within both basins have not been studied too well. The exploitable resources of such water in the four fields of the Talas region are about 228 thousand m^3 per day, although the predicted resources may exceed 925 thousand m^3/day. Similar reserves of Talas-Assinsky field in Zhambylskaya province are estimated at 320 thousand m^3/day. The exploitable resources of fresh groundwater in artesian Chu basin in Kyrgyzstan are 3255 m^3/day, and the possible resources are estimated at about 5900 m^3/day. The Kazakhstan part of the Chu basin was confirmed to have less significant groundwater resources, which make up only 323 thousand m^3/day. The current use does not exceed 15% of the predicted exploitable reserves of the underground water deposits.

The main resources of fresh transboundary groundwaters in Kyrgyzstan are located in 300 - 500 meter-thick Quaternary sediments. In the Chu basin, up to 10 m^3/sec of groundwater flows into the territory of Kazakhstan through a 115 km section of the border (the most intense flow of occurs over a 80 km northern section of the border), and in the Talas basin, through two sites with a total length of 51 km – at about 5 m^3/sec.

The main problems that can be anticipated with regard to the transboundary groundwater are the cross-border flow of anthropogenically polluted groundwater, and complete or partial capture of renewable natural groundwater resources by the upstream party, as well as drawdown of groundwater resources in the border zone decreasing the stock in the adjacent side. For Kyrgyzstan, a conflict on the grounds of the first two issues is a possibility, whereas the third problem may be caused by both parties. At present, these problems are not acute, but there are prerequisites for aggravation, which may develop into problems in future.

Climatic resources of the basin

The solar radiation reaching the earth's surface in the Chu-Talas water basin in **Kazakhstan** is fairly high not only due to the geographical latitude, but also due to the long average duration of sunshine, as well as the large number of sunny days per year. In general, the amount of total sun radiation per year ranges from 6000 up to 7500 MJ/m^2 depending on cloudiness.

The annual dynamics of relative humidity, both in the plains and the mountainous terrain, are featured with the following pattern: from September to March the relative humidity increases, peaking in December and January at 72-80%, and then from March until September it gradually decreases.

Since the 1980s, positive anomalies of the surface air temperature dominate the area, and the warming is faster. The average temperature increased in different regions of Kazakhstan at different rates, but all trends were statistically significant for the 95% confidence interval, and the contribution of the trend to the total variance of the average annual temperature exceeds 20%. Growth of the average annual air temperatures for the territory of the Chu-Talas basin on average for the period of 1941-2009 reached at least 0.30°C/10 years. In the last thirty years, the growth in average annual air temperature was most significant – at least 0.43°C/10 years, with the most significant increase rate seen in spring temperatures, and the lowest - in the summer.

The following trends were observed in the Chu-Talas rivers basin in 1936-2005:

- data from the majority meteorological stations show a significant increase in the number of extremely hot days and extremely warm nights;
- in plains, the number of extremely cold days and extremely cold nights had significantly decreased;
- the number of days with frost, when the minimum daily temperature comprised <0°C, significantly reduced;
- at the same time but at a slower pace, the number of hot days, when the maximum daily temperatures comprised >25°C, had increased;
- the duration of heat waves had increased, while the duration of cold waves had significantly reduced;
- for the most of the territory, the vegetation period has increased by 1-2 days every 10 years.

Changes in the rainfall in the basin in 1936-2005 have the following pattern:

- in some areas, the intensity of rainfall has increased;
- at some weather stations, the proportion of annual precipitation that falls as the extreme daily rainfall have significantly increased. However, these areas receive minimum atmospheric moisture;
- the maximum length of rainless period had decreased in almost the entire basin;
- the maximum duration of rainfall period has not changed.

The average amount of annual precipitation in the Northwest region, which includes the **Kyrgyz part of the Chu-Talas transboundary basin** is 456 mm. The total annual precipitation does not show any significant sustainable relationship with the height above the sea level. But there is a trend in the North West region which shows an increase in the amount of precipitation with increasing altitude.

According to the estimate obtained for the entire period of instrumental observations from 1883 to 2005, the average temperature trend as a whole throughout the Kyrgyz Republic is 0.78 ° C per 100 years. Annual changes in precipitation, in contrast to the temperature, vary considerably.

The mountain glaciation plays an important role in the formation of Chu-Talas basins' water reserves. According to the available sources, the total number of glaciers in Kyrgyzstan was 8208, with the total area of glaciers of 8076.9 km^2, and the total volume of 494.7 km^3. The glaciation had significantly changed in 2000 towards decrease.

The recent **estimates of the expected climate change** over the territory of Kazakhstan - according to the R50 scenario - show the following average expected change in the mean annual temperature for Kazakhstan: +1.4 °C to 2030; +2.7 °C to 2050, and 4.6 °C to the 2085. The annual precipitation will slightly increase: by 2% to 2030, 4% to 2050 and 5% to 2085. Based on the R50 scenario, the winters to the end of this century are expected to see the increase in precipitation in all considered models: to 2030 by an average of 8% in all models, to 2050 - by 13%, and to 2085 - 24%. Based on the R50 scenario, the summer periods to 2030 will see 5% more precipitation, but from the middle of this century onwards, only two models predict increased precipitation, and the average for the models shows that by the 2050 the annual precipitation may return to the modern levels. By the end of the century, the average of the models forecasts the reduction in the amount of precipitation by 11%.

The results demonstrated the existing uncertainty in climate change scenarios, arising from the uncertainty of concentration change scenarios and imperfectness of the models. The greatest uncertainty concerns precipitation.

By 2050, the mean annual temperature, as well as the summer and winter temperature in the Chu-Talas basin may increase by 1.5-3.0°C, depending on the scenario of the GHG concentration changes. As for precipitation, the increase to a maximum of 15-20% is likely in winter, and the summer may, in some places, see an increase of 10-15%, and on the contrary, in some places there may be a decrease of 10-15%. Annual precipitation may increase, but only slightly.

Assessment of the impact of the likely regional climate change on water resources of the Kazakh part of the Chu-Talas basin was never performed.

Kyrgyz Republic - two options of a possible climate change were considered for different regions of Kyrgyzstan, both show rise in average seasonal temperatures (in the range from 3.6 to 7.8°C up to 2100), and the precipitation varied widely.

It should be noted that in all scenarios maintaining the current level of precipitation (average for 1961-1990), the glaciers in the Talas river basin will disappear by the 2050. The corresponding runoff calculations yield a slight increase in water content, followed by a significant decrease.

This paper leaves the questions about the effects of climate change on groundwater resources unaddressed. At present, this question has not been sufficiently developed, besides, the current status of monitoring of underground water resources is also not sufficient to allow a sound analysis.

When forecasting the surface water situation, some other questions pertaining to climate change impact on climatic emergencies related to water resources, for example, such as droughts, high mountain lakes overflows, mudflows, etc. have also remained unaddressed.

Analysis of water demand

Kazakhstan - the region is located in the arid zone, where water scarcity and inefficient use of available water resources limit the development of industries. Groundwater is mainly used to satisfy the domestic and drinking water needs of the population and industry. Wastewater discharged into the ponds at present is not used to cover the needs of the economy.

The main water users in the Talas river basin are the industry, municipal and community services, and agriculture, represented by agricultural water consumption, flooding of pastures and irrigated agriculture. Analysis of existing water resources and their consumption over the past 15 years indicates a significant reduction in water consumption both as drinking water, as well as process water. This happened due to a fairly significant population decrease, a sharp decline in industrial and agricultural production, abandonment and liquidation of enterprises. One of the main reasons for the sharp decrease in water intake is the reduction of artificially and flood irrigated lands. In recent years, the industrial wastewater generation increases annually due to the resumption of the industrial and agricultural sector operations.

Much of the Chu river basin's water reserves are consumed for agricultural purposes, mainly for irrigation. Due to the lack of funds for ongoing repairs of irrigation systems and agricultural machinery, as well due to other organizational issues in the basin, the current situation is as follows:

- actual use of the irrigated lands is 58.4% of the available stock;
- rehabilitation of the irrigation network is required on the 41.6% of the of the available irrigated land stock, or on 28.92 hectares;
- reconstruction of the irrigation network is required on the 79.5% of the of the available irrigated land stock, or on 55.26 hectares;
- the need for reclamation of irrigated lands in this region and the amount of reclamation needed within the existing volume was derived based on the expert opinion.

The amount of Talas river water consumed for regular and flood irrigation based on the reported data of BWOs as of 2006 constitutes 228.07 million m^3, while the actual irrigation rates are only 70-80% of the calculated norm. In the future, it is planned to restore the lands listed in the state balance as the regularly irrigated, and to rehabilitate the lands currently used to the modern level, as well as to meliorate lands prone to salinity. The water resources are used commercially not only to cover the needs of the regular and flood irrigation, but also to meet the needs of industrial, municipal and domestic water supply, as well as for pasture irrigation purposes.

Talas River basin contains nearly a dozen of lakes and reservoirs used for fishery. The water is fed to these reservoirs from the Talas river, spring snowmelt and precipitation. Due to the complete regulation of the Talas river flow, the bulk of the water is retained in upstream reservoirs, and only after those are filled up, the water of spring floods gets to the downstream ponds.

Predominance of urban population largely determines the development of recreation facilities in the region. At the same time, the territory contains a number of natural objects of great appeal and possessing the recreational potential as hunting sites, scientific and educational centers. As to the other elements of recreational potential of the Talas River basin, we should mention the efforts to improve transport accessibility of these areas, construction of hunting and fishing centers, seasonal recreation centers, hotels, construction of recreational facilities for adults and children, equipment of beaches, water sports facilities etc., which all will enable receiving several thousand (up to 100-200 per season) of domestic and foreign tourists.

Fresh water withdrawals by various sectors of the economy in the long-term prospective until 2020 were determined through calculation of water consumption per sectors of the economy within the basin, taking into account the introduction of the circulating water supply systems, water conservation, reduction of losses and improvement of network efficiency. According to the land stock data, Talas river basin has the potential for development. However, the economic situation in the basin holds back any large-scale development of irrigated agriculture. The pace and scope of rehabilitation and reconstruction of irrigation network in the basin are planned based on the requirement to meet the needs of both the basin and the republic population in food, taking into account the economic and material resources available.

In Kyrgyzstan, the water consumption for irrigated agriculture in both basins depends primarily on the annual rainfall and the use of irrigated land. Water use in the Talas province of Kyrgyzstan declined in terms of irrigation water supply from 0.82 to 0.61 km/year from 1990 to 1995, followed by a slight increase in the period from 1996 to 2005, and in the Chui province of Kyrgyzstan, the water supply for irrigation was reduced from 2.3 to 1.6 km/year in 1990-95. In Zhambyl province of Kazakhstan, which relates to both basins, the amount of irrigation water supply has also declined over this period from 2.00 to 1.79 km/year. In addition to these factors, the decrease in water consumption can be attributed to unreliability of official statistical reporting.

Based on various forecasts, taking into account national socio-economic development, the restoration of water consumption in the Chu and Talas river basins to the levels of 1990 is expected between 2010 and 2020. In future, a gradual increase in water scarcity due to increasing demand for water is forecasted. Therefore, even today, it is advisable to plan and implement preventive measures aimed at protecting and managing surface and groundwater resources in both basins.

Key conclusions and recommendations

General conclusions

The climate of the studied area has undergone significant changes since the last century, which resulted in a considerable increase in surface air temperature. Changes in precipitation at the territory are not consistent. Under the scenarios of climate change, further significant increase in air temperature is very likely. However, the precipitation change scenarios contain a great deal of uncertainty.

Water resources of the basin are limited, unevenly distributed in space and time, and to a significant degree contaminated. Taking into account the expected future changes in cross-border river resources flow, a significant shortage of water resources, and serious economic and environmental damage should be expected.

Water resources of the basin are needed to ensure drinking water supply for population, supply of water for agriculture and hydropower, as well as to maintain the biodiversity in Kazakhstan and Kyrgyzstan. It should be noted that the impact of the changes in water reserves on biodiversity in the region is currently not well understood and requires some research.

The issue of sustainable drinking water supply has now acquired particular urgency. Lack of, or contamination of, water are the main causes of deterioration of the socio-environmental and sanitary living conditions.

The projected increase in agricultural production will depend on solving a number of difficult tasks, which are aimed, in particular, at the more efficient use of water resources, better utilization of existing irrigated lands, improvement of reclamation, introduction of efficient irrigation systems that provide a maximum amount of product per hectare of land.

Water reserves of Chu river in natural conditions comprised 4.5 km^3. In modern conditions, runoff of Chu depends not only on water abundance of a year and natural losses of runoff, but more on the mode of operation of reservoirs and varying water withdrawals from the basin's rivers and return water both in the territory of Kazakhstan, and Kyrgyzstan. The allocation of the Chu River flow between the Republic of Kazakhstan and the Kyrgyz Republic is based on the "Regulations on allocation of the flow in the basin of Chu river" (approved by the Ministry of Water Economy of USSR in 24.02.1983), and the Protocol of 18.02.1985. In dry and average water years, Kazakhstan loses the share, which it should receive based on the "Water Allocation Rules". The availability of water in these years does not exceed 90-92%, and in some dry years - 77%. Another factor not complied with is the distribution of the incoming flow to Kazakhstan by the seasons of the year: 55.2% - in the vegetation season and 44.8% - in non-vegetation period. In fact, the main stock is supplied to Kazakhstan in non-vegetation period (up to 60%).

The land stock of the basin concerned allows the increase (re-commissioning) of irrigated lands, but the limiting factor here is the adverse socio-economic situation in the region, preventing any significant investment in infrastructure development. There is also a technical aspect to the problem, which is the poor state of irrigation systems. All of this slows down and prevents timely and efficient addressing of urgent problems in the basin.

Based on the developed forecast and calculation of water consumption in Kazakhstan for the period up to 2020, the planned rate of development of the economy in the average water years will result in water shortages also in Talas river basin. In visible prospective, the Talas River basin will need, taking into account the real situation, a complex of organizational and technical measures obligatory to all stakeholders of the water complex. The main activities in the short and mid-term prospective should aim at introduction of resource saving, through the implementation of non-capital-intensive, institutional, administrative and technical measures.

The resulting estimates of surface runoff in rivers Chu and Talas in Kyrgyz part of the basin (no such assessments were done for the Kazakh part) show a significant change (growth in 2010-2015 followed by a subsequent decrease, in the most unfavorable scenarios - by several times) in almost all possible (at the time of calculation, the year of 2007) climate scenarios, developed by the Intergovernmental Panel on Climate Change, which defines the necessity of accounting for the climate change in the proposed efforts on water resources management. At the same time, a significant change in surface runoff during the main season is expected, first of all, due to reduction of the glacial component of the runoff. The accelerated change in the volumes of surface runoff of Chu and Talas rivers as compared with other water basins of Kyrgyz Republic is due to the specifics of glacier changes in these basins.

Estimates of surface runoff were obtained in studies conducted during the preparation of the Second National Communication of Kyrgyz Republic on climate change and correspond to the climate scenarios and global climate models that were available at the time of preparation of the national communication. The irregular calculation of the climatic profiles, only as part of preparation of the National Communications, does not satisfy the needs in sufficient information, appropriate for the tasks to meet.

The hydro-meteorological monitoring system had consistently deteriorated over the past decades in both countries, and currently does not correspond to modern requirements. A series of measures is needed to restore and improve the monitoring network in all directions, as reflected herein.

Data on water-and land-use and relevant trends, due to its limitations, did not allow a full assessment of the relationship between hydrological characteristics and the possible impact of climate change.

The existing challenges hindering the **successful development and implementation of strategies to adapt** the management of transboundary water resources to the changing climate:

- lack of the hydrological, meteorological and environmental monitoring network;
- not all required parameters are measured and evaluated (for example, there is no analysis of changes in water temperature resulting from its chemical composition);
- dominance of water-intensive production technologies in the region and imperfect schemes of water regulation and water allocation;
- imperfection of various aspects of Chu and Talas rivers water management, both at the local level and across borders.

In 2000, in Astana, Kazakhstan and Kyrgyzstan had signed an “Agreement between the Government of the Republic of Kazakhstan and the Government of Kyrgyz Republic on the use of interstate water structures in the Chu and Talas rivers”, which was later prolonged by both parties. The work of the Chu-Talas Commission on the use and allocation of water resources of the two basins must be strengthened. The following are recommendations for improving various aspects of transboundary water resources management to develop and implement strategies to adapt to changing climate.

Recommendations for hydro-meteorological and environmental monitoring

Monitoring of water bodies should be considered as a subsystem of a single automated system for monitoring the environment and natural resources, and shall include:

- monitoring of climatic parameters;
- monitoring of quality and quantity of surface water bodies;
- monitoring of groundwater bodies;
- monitoring of water systems and structures.

In order to create a system of regular monitoring observations of water bodies and water structures in the basin, a basin monitoring program must be developed, and targeted programs for hydro-meteorological and environmental monitoring must be implemented. The basin monitoring program shall:

- identify the features of existing stations monitoring the hydrologic situation, water quality, use of water resources, state of hydraulic structures, mode of operation of reservoirs and the harmful effects of water at all water bodies;
- identify the location of stations, their departmental affiliation, the observed parameters, the frequency of observation, collection and data processing points, completeness of the information provided;
- determine the adequacy and accuracy of the information obtained to resolve the target tasks for assessment and making forecasts of the situation at the water bodies, water structures and adjacent territory;
- assess the possibility of harmonizing the information received from various departments to arrive at comparative results (in terms of measurement, methodological approaches, units of measurement);
- determine the need for additional observations and a correspondent set of parameters, which should lay the basis for the systematic monitoring, and the prerequisite here shall be the respect of the river basin database requirements;
- develop an interagency and inter-state program of measures to improve the monitoring systems in the basin, including the use of remote observation devices;

- monitor the world's best practices in management of transboundary water resources in order to consider their possible introduction in the Chu-Talas river basin.

The following is the list of proposed high priority monitoring tasks to assess vulnerability and to develop strategies to adapt to changing climate:

- assess changes of recurrence and intensity of extreme weather events;
- assess changes in the snowpack;
- assess changes in temperature of river water, because it strongly influences the ecological systems of river basins;
- in order to take account of the Chu river transit water, the hydropost downstream of Chumysh dam should be restored;
- in order to take account of the lateral inflow, hydroposts must be put on tributaries and mountain springs;
- GIS technology shall be used to present the results of hydro-meteorological monitoring and socio-economic features of the basin.

Bearing in mind that the efforts to adapt to the climate change shall be based on reasonable estimates of climate changes and the consequent results of calculation of the expected water resources scenarios, the regular calculations of climatic profile both for Kazakh and for Kyrgyz part of the basin are necessary, with sufficient amount of detail for separate water basins, and with subsequent calculation of changes in the parameters of glaciers and the amount of surface runoff.

Recommendations on modeling:

- Increase resolution of climate models and use a consistent approach to the assessment of possible climate change. For example, use statistical methods for regionalization of global climate models, or regional climate models with a resolution of 10 ... 50 km (as compared to 250 km used at present). To this end, Kazhydromet RSE introduces, as part of its preparation of the Third National Communication, a system of regional climate modeling “PRECIS”, developed in the UK with a spatial resolution of 25 and 50 km. In addition, it is obvious that in current situation it is necessary to take into account new scenarios of greenhouse gas emissions, incorporating the scenarios with the active actions of the international community to reduce emissions, the so-called options “+2” and “+1.5” °C.
- Consider the possibilities of practical introduction of a medium-and long-term forecasting system, which would allow quick warning about the possible climatic anomalies that cause emergencies such as droughts, high mountain lakes overflows, mudflows, etc.
- Develop an integrated hydrological model and water-balance model for the basin. Based on the hydrological model, obtain the most reasonable estimates of the runoff and hydropower potential of the basin.

- Introduce into the practice of joint basin water management the regular reviews of expected climate scenarios and resulting assessments of water resources.
- Introduce a system of calculation and planning of water use, uniform for the entire transboundary basin. For example, the WEAP ("Water Evaluation And Planning") system, which consists of a software oriented on a wide range of users, and uses an integrated approach to water resources planning. Advantages: use of a unique integrated approach to the integrated activities on water resources management; the database provides water-balance calculations while supporting the mass balance in the calculation of water transferred from the source to consumers through the arcs linkages in the architecture of river network; the full range of capabilities in the management of water is taken into account; the multi-purpose use of water is considered; friendly graphical interface; performance of a series of calculations, such as demands for water, the flow of water into the river network, water movement, water filtration, reclamation standards for specific crops, consumption of water and its accumulation, contamination, treatment, changes in water quality under various hydrological scenarios and policies of water management.
- Assess the vulnerability of the basin to climate change in relation to the management of transboundary water resources using the advanced schemes of complex use and protection of water resources of river basins.

The resulting vulnerability assessment will enable development of measures to adapt to climate change, and the adaptation issues shall be considered as part of the overall strategy for the management of shared water resources of the basin.