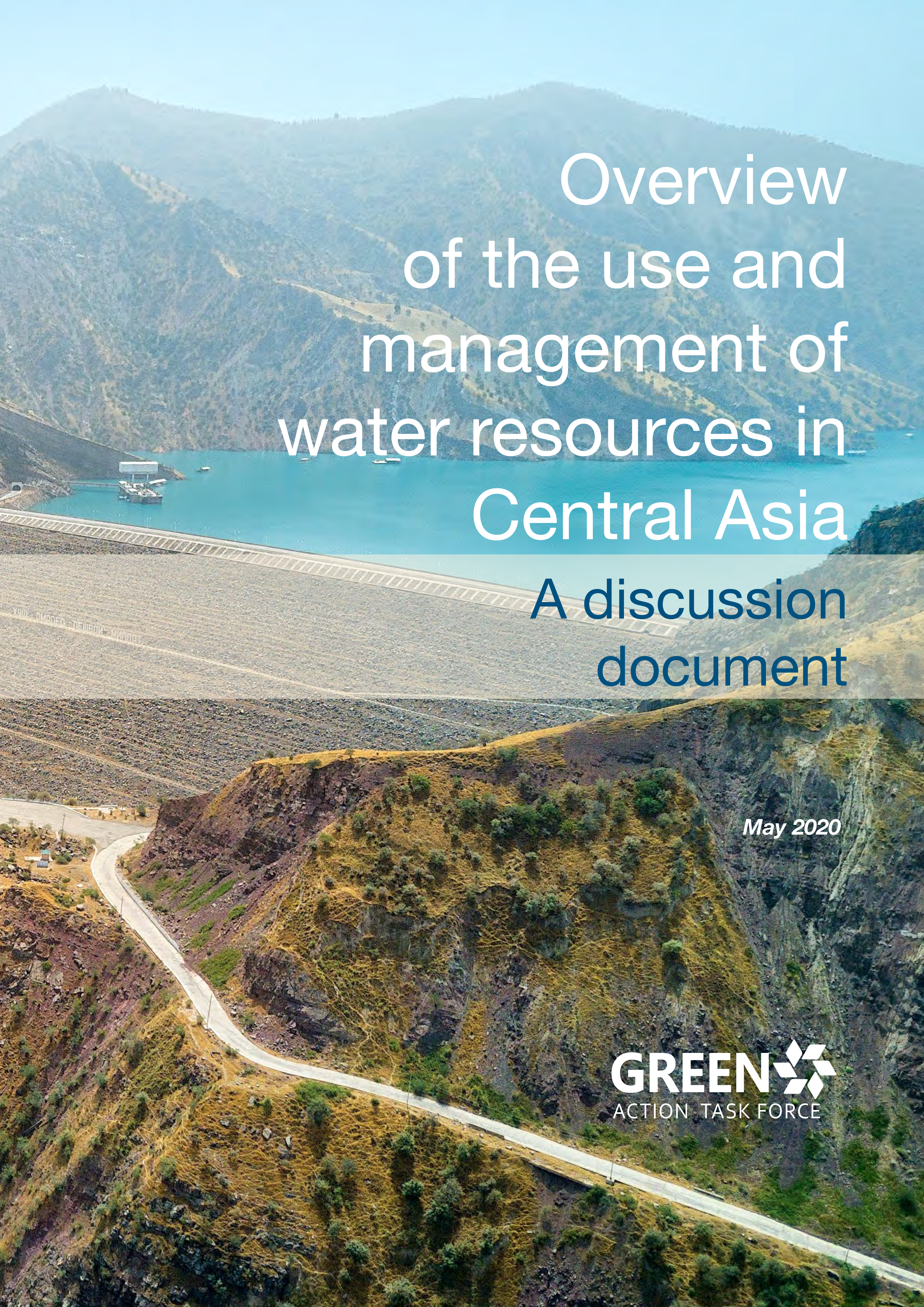

Overview of the use and management of water resources in Central Asia

A discussion document

May 2020

GREEN
ACTION TASK FORCE

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OECD

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Abbreviations and acronyms

ADB	Asian Development Bank
ASB	Aral Sea Basin
ASBP	Aral Sea Basin Program
BISA	Basin Irrigation System Authority
BWO	Basin Water Organization
CA	Central Asia
CAREC	Regional Environmental Centre for Central Asia
CAREC Program	Central Asia Regional Economic Cooperation Program
CIS	Commonwealth of Independent States
CSTO	Collective Security Treaty Organization
CWPI	Complex Water Pollution Index
CWUC	Comprehensive Water Use and Conservation
EU	European Union
EurAzEC	EuroAsian Economic Community
FAO	UN Food and Agricultural Organization
GDP	Gross Domestic Product
GIS	Geographic Information System
GIZ	German Society for International Cooperation
ICWC CA	Interstate Commission for Water Coordination in Central Asia
IFAS	International Fund for saving the Aral Sea
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
OECD	Organization of Economic Cooperation and Development
OSCE	Organization for Security and Cooperation in Europe
PEER	Partnerships for Enhanced Engagement in Research
SCO	Shanghai Cooperation Organization
SDC	Swiss Development and Cooperation
SIC ICWC	Scientific-Information Center of the Interstate Commission for Water Coordination
SPECA	Special Program for the Central Asian countries
UN	United Nations
UNDP	UN Development Program
UNECE	UN Economic Commission for Europe
UNESCAP	UN Economic and Social Commission for Asia and Pacific
UNESCO	UN Educational, Scientific and Cultural Organization
UNRCCA	United Nations Regional Center for Preventive Diplomacy for Central Asia
WB	World Bank
WUA/WCA	Water User/Consumer Association
WUEMoCA	Water Use Efficiency Monitor in Central Asia
XUAR	Xinjiang Uyghur Autonomous Region

Introduction

This diagnostic report provides an overview of the use and management of water resources in Central Asia over the period from 1998 to 2019. The previous diagnostic study was conducted within the framework of the United Nations Special Programme for the Economies of Central Asia (SPECA) in 2001, mainly building on materials provided by SIC ICWC and representatives of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The 2001 Diagnostic Report aimed at jointly developing a regional strategy for the rational and efficient use of water and energy resources.[1] Although the Executive Committee of the Interstate Council for the Aral Sea Problems (forbearer of IFAS) developed with the World Bank's support "Fundamental Provisions of Water Management Strategy in the Aral Sea Basin"[2] in 1998, and the Board of Interstate Fund of saving the Aral Sea (IFAS) have approved "Main objectives and focus areas of the rational water use strategy"[3] , UNECE and UNESCAP hoped that recommendations of that diagnostic study would contribute to a joint strategy of efficient water and energy use. However, attempts to find symbiosis between energy and water resources have largely failed. Only some steps towards this direction has been made, for example, by signing Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic and the Republic of Uzbekistan on the use of water and energy in the Syr Darya River Basin (Bishkek, March 1998), to which Tajikistan joined in 1999, by drafting recommendations for the improvement of water and energy regulation and management in the Syr Darya Basin under ADB RETA[4] and by initiating discussions on establishing a water and energy consortium. It is evident from many analytical studies on regional water and energy issues that significantly better interactions between the region's countries on multisectoral water use are paramount, especially in the context of climate change, peacebuilding in Afghanistan, and demographic and economic changes in the region.

Against this background, **the specific objectives** of this report include:

- to assess changes in water and land use and management in Central Asia over the past 20 years;
- to identify future water challenges, development trends and needs for the long-term rational use of water resources and irrigated land;
- to assess the progress made with implementation of the "Fundamental Provisions of Water Management Strategy in the Aral Sea Basin" and recommendations of the 2001 Diagnostic Report;
- to prepare a database of key information and indicators to support of the Diagnostic Report.

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1 Diagnostic Report for the preparation of the regional strategy for rational and efficient use of water resources in Central Asia. www.cawater-info.net/library/rus/water-rus.pdf

2 IFAS (1998) "Fundamental Provisions of Water Management Strategy in the Aral Sea Basin". www.cawater-info.net/library/rus/hist/regstr/pages/002.htm

3 Decision of the Board of Interstate Fund of saving the Aral Sea "On main objectives and focus areas of the rational water use strategy", 12 March 1998

4 ADB RETA 6163: Improvement of Shared Water Resources Management in Central Asia. http://www.cawater-info.net/reta/index.htm

The diagnostic report was prepared by the Scientific-Information Center of the Interstate Commission for Water Coordination (SIC ICWC) under the leadership of Prof. V. Dukhovniy, D. Ziganshina (PhD) and V. Sokolov (candidate of technical sciences), with contributions from country representatives: Prof. S. Ibatullin (Kazakhstan), Ch. Uzakbaev (Kyrgyzstan), Prof. Ya. Pulatov (Tajikistan), and a representative of Turkmenistan. Following experts have been leading work on the thematic sections of the report: A. Sorokin, N. Mirzaev and O. Eshtchanov (water resources); Sh. Muminov (economic aspects); V. Dukhovniy and O. Eshtchanov (environmental aspects, analysis of water management and future outlook). V. Sokolov made an assessment of implementation of the “Fundamental Provisions of Water Management Strategy in the Aral Sea Basin” and of recommendations of the 2001 Diagnostic Report. A database was prepared by D. Sorokin.

The team of authors appreciates comments and remarks submitted on the draft report version by water agencies, research institutes, universities and regional organizations in CA countries: (1) Republic of Kazakhstan - Ministry of Ecology, Geology and Natural Resources (Vice Minister S.Gromov); Ministry of Agriculture (Head of Hydrogeological meliorative field office K. Anzelm); International Training Center for the Safety of Hydrotechnical Constructions (Prof. S. Ibatullin); Eurasian National University named by L. Gumilyov (Dr. Prof. A. Zauirbek); (2) Kyrgyz Republic – Agency for Water Resources at the Government of KR (Director K. Tashtanaliev); (3) Republic of Tajikistan – Institute of Water Problems, Hydropower and Ecology at Academy of Sciences RT (Director Prof. Z. Kobuliev); (4) Republic of Uzbekistan – Ministry of Water Management (First Deputy Minister B. Ruzibaev); Ministry of Housing and Communal Services (First Deputy Minister S. Saifnazarov); 5) Regional Mountain Center of CA (Executive Director I. Dairov) In May 2020, the report was revised accordingly.

Scope of work

The Report views Central Asia as the region covering five post-Soviet states – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Relations of Central Asia with the Chinese Xinjiang Uygur Autonomous Region, Russian Siberia and, particularly, Afghanistan will be addressed to a certain extent as well. The Report pays close attention to and provide detailed analysis of the Aral Sea basin. Given territorial, historical and hydrological ties with the region, the Report also include analysis of Afghanistan, especially its northern part which is located in the basin of the Amu Darya River and its former tributaries.

The Report analyzes development dynamics since 1980 till 2018. Moreover, the period before gaining independence is shown for comparison with subsequent changes. Rough forecasts of regional development, particularly in the water sector are given till 2035-2040.

1 Central Asia

General description

Central Asia is a vast region stretching from the Caspian Sea in the west to China in the east, and from Russia in the north to Afghanistan and Iran in the south. Covering an area of more than 4 000 000 km^2, the region consists of five states, such as Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

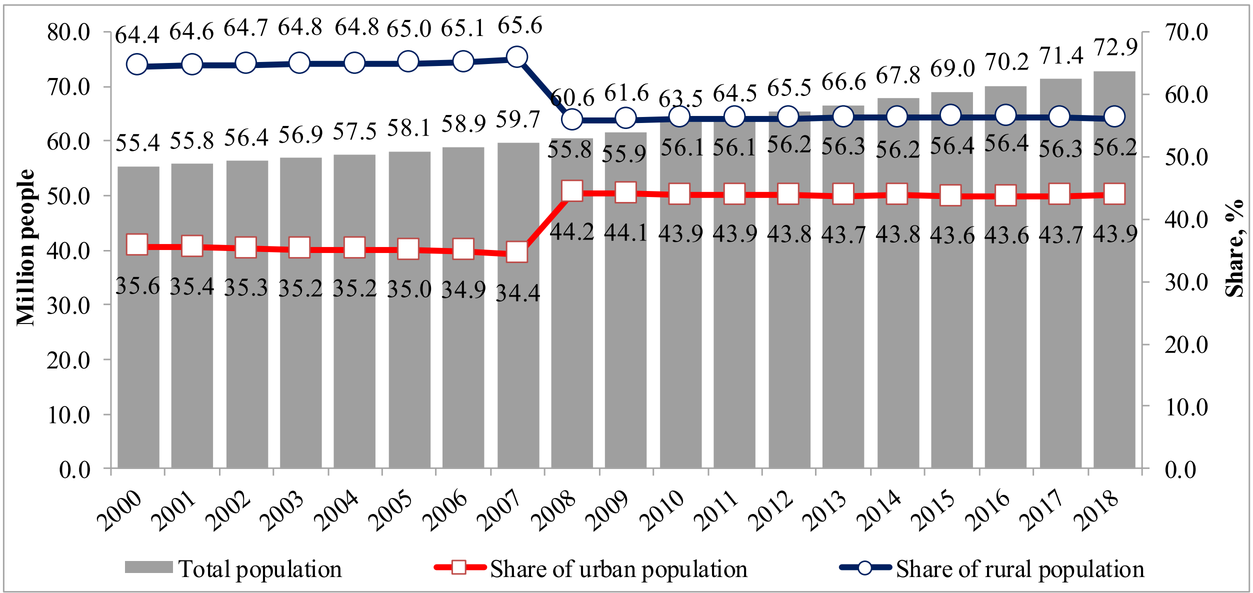
Socio-economic characteristics

Population and employment

Till 1990, the region's population was growing fast at the rate of more than 3% a year. Starting from the independence, demographic pressure has been lessened and the **growth rate has stabilized** at 2% a year in all countries, except for Afghanistan, where population growth exceeds 3%. Also, control over employment has been lost after the collapse of Soviet Union due to breakdown of economic relations and, consequently, decline in all economic and social indicators in all the countries, except Turkmenistan.

In recent years, the demographic situation in CA countries was characterized by higher birth rates, variations in crude death rates and an increase in external migration. In the period of economic restructuring in the Soviet Union, the average rates of population growth were more than 2.8% (3.1% in Uzbekistan). However, since independence, average annual population growth has fallen to 0.9% in Kyrgyzstan, 1.7% in Uzbekistan and 1.8% in Tajikistan. An increase in external migration is the main cause of lower population growth. In the meantime, in Kazakhstan the average annual population growth increased from 1.1% to 1.8%. At present, the total population in Central Asia is 72.9 million as compared to 55.4 million in 2000 and 63.5 million in 2010 (Figure 1.1).

Figure 1.1. Population dynamics in Central Asia



Source: estimations based on the data from www.cawater-info.net/

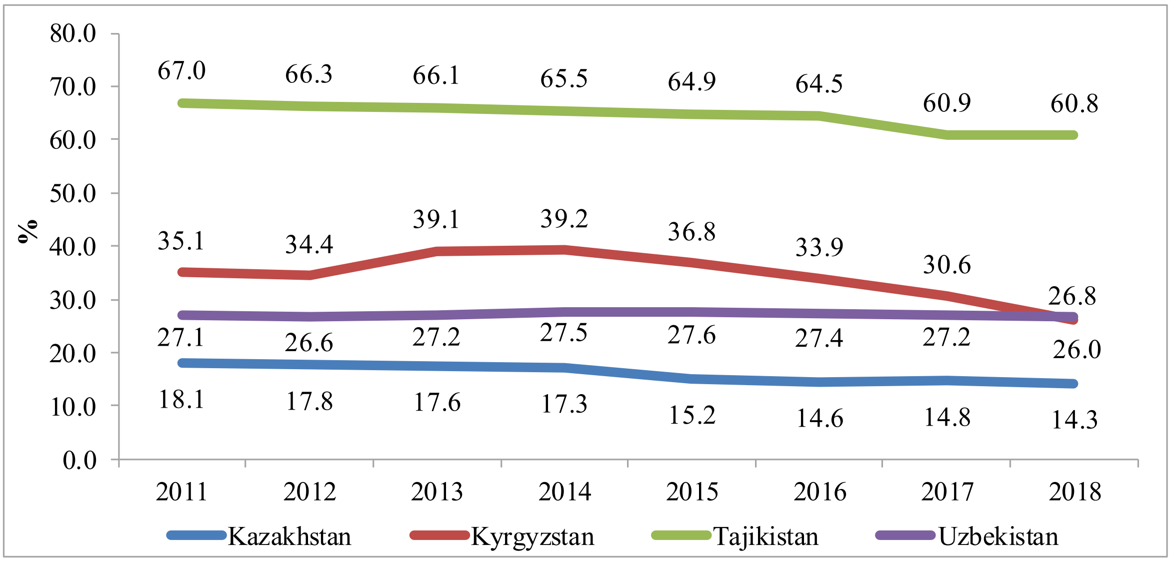
The share of rural population is still high in Central Asia. In 2000, rural population averaged 64.4%. By present, this indicator has decreased slightly (56.2%). It should be noted that most visible changes in the shares of rural and urban population in Central Asia has been witnessed in 2008 due to administrative-territorial restructuring in Uzbekistan.[5] That year the rate of decline in rural population was 13% on average.

The period since independence is characterized by growing labor migration, the key reasons of which will be shown below. Most migrants from Tajikistan, Kyrgyzstan and Uzbekistan work in Russia or Kazakhstan. As a result, remittances have become increasingly important in the region's economy, equivalent to 48% of GDP in Tajikistan (which was the highest coefficient globally), 31% in Kyrgyzstan, and about 5% in Uzbekistan in 2013. In 2013, the final year preceding the economic crisis in Russia, their value was nearly US$ 13.6 billion, of which US$ 6.7 billion was sent to Uzbekistan, US$ 4.2 billion to Tajikistan and US$ 2.1 billion to Kyrgyzstan. Due to the economic crisis in Russia and the devaluation of the rouble, in 2016 remittances from labor migrants stemming from Central Asia declined by 48%, with the biggest decline in the case of Uzbekistan (around 59%) and Tajikistan (54%) and less significant in the case of Kyrgyzstan (17%). This data shows an important role that remittances play in the region's economy and their high vulnerability to external economic shocks or policy changes in Russia.

The share of economically active population employed in agriculture is still very high in the riparian countries of the Aral Sea basin. At present, more than 60% of economically active population in Tajikistan is occupied in agriculture. This indicator is about 30% in Kyrgyzstan and Uzbekistan and 14.3% in Kazakhstan. For the period under consideration, the significant decline in employment in the agricultural sector is observed in Kyrgyz provinces that belong to the Aral Sea basin (23.7%). At the same time, ongoing reforms and industrial and service sector development strategies act as drivers of growing employment in these sectors.

5 Resolution of the President of Uzbekistan on Measures for Further Improvement of Administrative-Territorial Patterns in the Republic of Uzbekistan (PP-120 of 14 July 2005).

Figure 1.2. Dynamics of agricultural employment in the Aral Sea Basin



Source: author's calculations based on official national statistics (Committee on Statistics of the Kazakhstan's Ministry of National Economy www.stat.gov.kz, National Statistical Committee of the Kyrgyz Republic http://www.stat.kg, Agency on Statistics at the President of Tajikistan www.stat.tj, State Committee of Uzbekistan on Statistics https://stat.uz)

Economy

After a sharp drop in production due to the collapse of the Soviet Union, economies have started to grow since 2000: this was reflected in an increase in GDP, as a whole and per capita, and in increased agricultural production, especially that of irrigated agriculture. Meanwhile, production in rainfed agriculture, for example in Kazakhstan (outside the Aral basin) has remained at quite low level. GDP in all the countries, except for Tajikistan, exceeded the level that was before independence: 2.77 times in Kazakhstan; 4.7 times in Kyrgyzstan; 8 times in Turkmenistan; and, 2.93 times in Uzbekistan. At the same time, agricultural production has grown at well lower rates, twofold on average. This indicates to priority development of non-agricultural sectors, first of all, oil and gas industries, which particularly contributed to explosive growth in Turkmenistan's GDP. Turkmenistan is also the exception in the agricultural production volume, which grew substantially through the development of new land and expansion of the agrarian sector, mainly because of processing. **All the countries**, but Kazakhstan and Turkmenistan, **has kept irrigated land areas unchanged** by focusing on the improvement of agricultural productivity and diversification. In Kazakhstan, the irrigated area has been reduced by more than 1 million ha, mainly outside the Aral Sea basin – in Pavlodar, Karaganda and Kustanay provinces and in other northern provinces. This was caused by failure of sprinkler systems that needed substantial funds for maintenance. Moreover, productivity of one irrigated hectare has doubled, while productivity of irrigation water has increased 2.5 times. Although the average water productivity is about $0.2 per cubic meter, Kyrgyzstan, Tajikistan and Uzbekistan demonstrated the possibility of reaching 1.5 times higher figures in some of years.

Major changes took place in the structure of national income (GDP) in the countries of the Aral Sea basin since independence. The share of agriculture has dropped in national incomes of the riparian countries, particularly in Uzbekistan (by 26.8% in 2017 as compared to 1990) and Kazakhstan (by 12.6 pct). Concurrently, the share of industry increased moderately in Uzbekistan (+4.0 pct) and in Kyrgyzstan (+4.4 pct), grew significantly in Kazakhstan (+45.5 pct) and dropped in Tajikistan (-33.8 pct). At the same time, the services sector has shown dramatic growth in all the countries of the Aral Sea basin.

Income of the population and GDP. Until 2000, national economies in the basin were characterized by the average income of $500 per capita, but later on the countries started to become sharply divided by economic growth rates, depending on fuel and energy capacity, structure and orientation of economy and political situation in each of the countries. Kazakhstan and Turkmenistan have got ahead of others by increasing GDP per capita 6 and 10 times, respectively, over almost last 20 years, while Uzbekistan has increased its GDP almost 4 times by exceeding $2,000 per capita in 2014. The drop in GDP per capita in Uzbekistan after 2017 is related to liberalization of exchange rate, which changed on 5 September 2017 from 4210 soums to 8100 soums per $1.[6] Kyrgyzstan and Tajikistan were lagging behind. This caused disproportionate development and became the driver of centrifugal tendencies in the region.

Independence has also contributed to changes in human development level in the region. The period of economic decline was accompanied by drop in the human development index (HDI), while economic recovery promoted a notable increase in this index. For instance, HDI increased from 0.685 to 0.800 in Kazakhstan, from 0.618 to 0.672 in Kyrgyzstan, from 0.623 to 0.650 in Tajikistan, from 0.595 to 0.706 in Turkmenistan, and from 0.595 to 0.710 in Uzbekistan.

Table 1.1. Comparative indicators of the Central Asian countries and Afghanistan (2018)

Country	Country area, Mha	Irrigated area, thousand ha	Population, million	GDP, billion $	Water resources formed within the country, km^3	Total water withdrawal of the country, km^3
Kazakhstan	272.50	1480.00	18.40	170.50	56.50	18.73
Kyrgyzstan	19.99	1024.50	6.26	7.95	47.30	5.53
Tajikistan	14.23	760.00	9.13	7.52	64.00	12.31
Turkmenistan	48.81	1553.10	5.85	40.76	1.40	25.38
Uzbekistan	44.90	4302.60	33.26	50.50	12.40	50.95
Total in CA	**400.42**	**9120.20**	**72.89**	**277.23**	**181.60**	**112.89**
Afghanistan	65.24	378.37*	8.2*	20.51	21.23*	3.50*

Note: The data on irrigated area, population, water formation and water withdrawal of Afghanistan are shown for Northern Afghanistan only (Amu Darya, Harirud and Murghab River basins).
Source: "Water Resources Management in Afghanistan", presentation by Nasim Nuri at the International Economic Forum in Astana (2018) (Nuri, 2018[1]).

Country	Energy production total, billion kWh	Hydroenergy production, billion kWh
Kazakhstan	107.10	10.40
Kyrgyzstan	15.60	13.47
Tajikistan	19.70	18.40
Turkmenistan	21.20	0.00
Uzbekistan	62.80	6.50
Total in CA	**226.40**	**48.77**
Afghanistan	0.98	0.83

Note: Afghanistan, though not being a part of Central Asia, is included in this Table because of its considerable impact on the Amu Darya basin, especially in the future
Source: The data on population and GDP (excluding Turkmenistan) are derived from national statistics (www.stat.gov.kz, www.stat.kg, www.stat.tj, https://stat.uz). Those data on Turkmenistan are taken from the World Bank's database (https://data.worldbank.org/)..

[6] Decree of the President of Uzbekistan of 2 September 2017 No.UP-5177 "On first-priority measures for liberalization of the foreign exchange policy" https://president.uz/ru/lists/view?id=991

Table 1.2. Specific indicators of water, land, and energy use in CA and Afghanistan, Mm3 (2018)

Country	Irrigated area per capita, ha/pers	GDP per capita, $/pers	Water use per capita, m3/pers	Water withdrawals for municipal water supply, m3/pers	Electricity production per capita, kWh/pers
Kazakhstan	0.080	9268.54	1018.27	48.63	5822.1
Kyrgyzstan	0.164	1270.11	883.21	32.60	2493.3
Tajikistan	0.083	823.97	1348.79	83.27	2158.5
Turkmenistan	0.265	6966.64	4337.77	95.43	3623.4
Uzbekistan	0.129	1518.47	1531.99	86.30	1888.4
Total in CA	**0.14**	**3969.54**	**1824.01**	**69.25**	**3197.1**
Afghanistan	0.010	551.83	426*	-	26.3

Note: *The data on per capita water use in Afghanistan are shown for Northern Afghanistan only (Amu Darya, Harirud and Murghab River basins).

Source: The data of CA experts involved in the work on the Diagnostic Report and from the Regional Information System CAWater-IS.

The above differences were manifested in 'per unit' indicators of water, land and energy use as shown in Table 1.2.

As Table 1.2 shows, the CA countries have relatively equal conditions in terms of unit water supply, except for Turkmenistan, which went far ahead, and Kyrgyzstan dramatically lagged behind. Similar situation is observed regarding irrigated land areas, given that Kazakhstan does not use about 1 Mha of land, which is equipped with irrigation network. As to energy supply, Kazakhstan and Turkmenistan are far ahead against relatively similar situation in other countries. Afghanistan well lags behind in all positions, including water, irrigated land and electricity.

Poverty. As of 2018, the poverty rate varies widely among CA countries. The poverty rate is 29.7% and 25.4% in Tajikistan and Kyrgyzstan, respectively. Poverty in Tajikistan has a seasonal character, which varies for several reasons. In rural areas, crop yields determine household income to a larger extent. During harvest, there is more work and income for those who produce and sell agricultural products. Work and income outside the agricultural sector also vary seasonally; for example, remittances significantly increase in summer and autumn. The poverty level in Kyrgyzstan varied with the economic crisis and political disturbances – from 32% in 2009 up to 38% in 2012, and down to 25.4% by 2016 (ADB, 2018). The poverty level in Kazakhstan is 2.6%. In Uzbekistan, 20 years ago poverty levels were at 27% and then fell down to 12.6% (2016). According to World Bank (2018), more than 16 million people in Afghanistan, which constitutes half of the population, live below the poverty line. Between 2011-12 and 2016-17, the national poverty rate increased from 38.3 to 54.5%. Mirroring the increase in poverty, food insecurity has climbed from 30 percent in 2011-2012 to 45 percent in 2016-2017.

Strategic priorities of country development

Prospective strategic priorities of CA countries development are based on natural and socio-economic characteristics of each country. There are also common development tendencies that, in the context of the water sector, can be formulated as follows:

- enhancement of market relations and support of innovation-based entrepreneurship;
- improvement of agricultural productivity and increase of crop processing, revival of cooperation and organization of clusters, achievement of food security;
- development of hydropower and renewables;
- widespread digitization;
- regional security.

Geopolitics and integration processes

Central Asia is a region at the crossroads of interests of the world's major powers. While being in the heart of the continent, the region can be considered as a 'gateway' among the Eurasian strategically important regions. It can be characterized as the easternmost end of Europe or western boundary of Asia. China and Asia-Pacific countries border the region in the east, Afghanistan, Middle East and a number of other Islamic states are neighbors in the south, and Caucasus, Turkey, Europe and Russia are located in the west and the north of the region.

With globalization of the world economy, the region is transformed into a linking chain between Europe and Asia. Undoubtedly, nowadays the region is an important part of the Eurasian continent not only for its fuel-energy resources (oil, natural gas and hydroresources) but also because of huge contribution to the world history and civilization and for its unique nations that gave birth to genius scientists, grand generals and politicians, gifted poets and sages.

To understand the geopolitical and geo-economic value of the region, a number of key factors should be taken into account:

- common cultural, historical and economic interests between the Central Asian and neighboring states; location at the interface of eastern and western cultures; and, development of Turkic-Islamic culture as a result of the Great Silk Road crossing the region;
- availability of huge reserves of oil and gas (second place in the world), explored and unexplored mineral resources, including gold, uranium, copper; control over the extraction of resources;
- lack of territorial access to the sea and dependence on transit ways;
- transit and communication ways, as well as energy routes crossing the region;
- strategic and geo-economic importance of the Caspian Sea;
- substantial differences that have become visual since independence in economic development and natural potential of the countries give rise to attempts to influence on both country development and internal crises from the side of major geopolitical powers.

The CA countries differ considerably from other Asian countries. The former cannot be treated as 'developing countries'. Almost 100% of population is literate, the well-developed infrastructure and modern health system are available, and the spiritual culture is very rich. Thus, the countries seek equal-foot cooperation with developed democratic countries.

As mentioned above, one of key factors influencing processes in CA is the external activity of the world leading states, particularly Russia, United States, China, as well as Turkey, Iran, Pakistan, India, and EU. Any key developments in the countries can be mirrored not only at the regional level but may cause changes in geopolitical balance of powers in Eurasia as a whole.

Therefore, it is not coincidence that since the first years of independence, the CA countries have been actively searching for an acceptable form of integration, also to share water resources in interstate sources. Among the first regional organizations established in the first years of independence was the **Interstate Commission for Water Coordination** (ICWC), which gave birth to the **International Fund for saving the Aral Sea** (IFAS). IFAS was established in 1993 by the Heads of five CA Republics to attract funds for projects related to the Aral Sea and encourage sustainable use, protection and control of interstate water. This was the first post-Soviet regional institute that involved all the countries in the region and that has been functioning with varying degrees of success till present. This priority area of regional coordination is quite understandable, given the role of water in the region and its influence on natural and socio-economic conditions.

Besides, a number of other unions arose and included or were formed under umbrella of external actors to form target societies oriented to group interests. Those include, for instance, the Commonwealth of

Independent States **(CIS),** the Collective Security Treaty Organization **(CSTO)[7],** the EuroAsian Economic Community **(EurAsEC)** (2001-2014), the Shanghai Cooperation Organization **(SCO)[8],** the Central Asia Regional Economic Cooperation Program[9], and the Economic Cooperation Organization (**ECO**)[10]. Those organizations at their summits or as part of their activities addressed regional water use issues. For example, EurAsEC made efforts to develop a mechanism of water collaboration in 2003-2007. The CAREC Program adopted in 2017 as "CAREC 2030: Connecting the Region for Shared and Sustainable Development" has an Agriculture and Water Cluster in its framework.

SCO, which, besides permanent members, involves more and more observers, is the most successful in the region. In opinion of Laruelle and Peyrouse (2012), this is because SCO reinforced political legitimacy of the CA regimes, officialised Russian and Chinese support, developed a common narrative concerning "the three evils" (san gu shili) of separatism, extremism, and fundamentalism and denounced pro-Western interference and forces. (Laruelle M., Pertouse S, 2012[2])

Most regional organizations in CA, in essence, represent platforms for communication. Resolutions adopted at summits or meetings are usually in form of declarations of intent that lack any enforcement mechanisms. Thus, the regional organizations play a socializing role, which is defined in international relations as the communication of rules and guidelines to states and their leaders on how they should behave themselves in international system.

However, the performance of regional integration organizations cannot be considered as productive, largely, because of diverging economic and geostrategic patterns of member-states. There is the lack of will towards regional identity and the desires to keep independence, while gaining the maximal effect from the image of community. Most regional integration organizations have difficulties with execution of reached agreements and lack effective enforcement mechanisms as implementation is in the sole discretion of member-states. Provisions of those agreements should be implemented in national legislations and this is often not the case. Collective actions are hampered by jurisdictional fragmentation and the lack of interdepartmental cooperation on key matters and mechanisms for conflict resolution. Besides, rivalries for leading position in the region, especially when it comes to water, have a big negative effect.

In this context, the question arises of whether the region will keep in the future its geographical and historical value only and lose its economic and political character under influence of national egoism and centrifugal forces of external "friends bearing gifts"? For this reason, many international financing institutions virtually gave up on regional projects and prefer bilateral agreements and loans. This again brings discord to regional integrity of organizations.

The optimism and understanding by national leaders and elite of their responsibility for the future of their people in more and more complex global situation gives hope that completion of states and nations building would be accompanied by the change of elites in the CA countries in favor of new leaders that are more inclined to regional integration. A number of initiatives of the President of Uzbekistan that were supported by his counterparts and put in place indicate to good chances for such development path. The common past and common customs and roots serve as the 'ground zero' for centripetal forces. The growing severity of the situation around Roghun gave place to the integration proposal from the side of Uzbekistan on a possibility of joint construction. As an initial step, currently the authorized agencies of Tajikistan and Uzbekistan hold discussions on a joint hydropower project along the Zaravshan River. One may assume also that the need for enhancement of regional cooperation would become ever more apparent in the future in light of internal and external threats. Besides, the CA economies need to become more competitive to attract more investments and get know-how. One country cannot succeed in its own in the face of such

[7] By December 2019, members from CA include Kazakhstan, Kyrgyzstan and Tajikistan

[8] By December 2019, members include Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. Afghanistan is an observer.

[9] By December 2019, members include all CA countries and Afghanistan.

[10] By December 2019, members include all CA countries and Afghanistan.

regional challenges as transportation and customs problems, climate change, migration, alternative development in Afghanistan related to its return to peaceful life and, major one, water supply and interstate water management. As Laruelle and Peyrouse (2012) rightly pointed out, “If they [regional organizations] are to become real agenda-setters in Central Asia, regional organizations must address the critical issue of separating issue-based dialogue from the grand narrative on integration. External actors have their share of responsibility in this. So far they have insisted on integration as a miracle solution for all the region’s ills, creating an unbridgeable gap between objectives and their fulfillment. Moreover, they have used integration as an argument to advance their own geopolitical agendas. To be effective, regional organizations must move away from a narrative of grand design and instead promote coordinated projects that are more modest, focused, controlled, transparent, sustainable and issue-based”. (Laruelle M., Pertouse S, 2012[2])

Global water initiatives by the President of Tajikistan also allow much room for more active regional cooperation. Thus, the initiated by E. Rahmon International Decade for Action “Water for Sustainable Development”, 2018-2028 may substantially contribute to the improvement of regional water cooperation and sustainable development.

Another important process that concerns all development aspects in CA, including water use, is the Chinese **Belt and Road Initiative (BRI)**. China launched this initiative to accelerate growth of its western provinces and to solve problems related to excess industrial capacities and environmental degradation. It also reflects the China’s intention for regional economic integration within the framework of the so called “new model of globalization”. By present, 261 BRI projects have been completed or are ongoing for a total amount of $136,25 billion in five countries in CA. (Roman Vakulchuk; Farkhod Aminjonov; Indra Overland; Bahtiyor Eshchanov; Alina Abylkasymova; Daniyar Moldokanov, 2019[3]) Most of investments were made in Kazakhstan ($90.86 billion or 66.7%) and Turkmenistan ($24.84 billion or 18.2%). Where it is possible, China is eager to participate in water projects under the banner of BRI. For instance, it was reported on construction of small hydropower along the Shelek River in Kazakhstan and 7 cement factories (for hydroprojects under construction) in Tajikistan, on partial Chinese financing of the national irrigation development program in Kyrgyzstan and on plans to invest in irrigation and hydropower projects in Uzbekistan. (Simonov, 2018[4])

The China's BRI Initiative offers huge economic potentials and a mechanism of advancement that feasibly could support the countries of the Great Silk Road institutionally, technically and financially, if its projects are based on interests of CA countries and are subject to regulation and oversight of investments in line with the norms and principles of international law (Simonov, 2018[4]). To this end, preparedness and understanding of potentials and risks in the CA countries are needed.

Finally, this review of geopolitical situation in CA will be incomplete if the key role of Afghanistan in preservation of regional peace and security is not taken into account. Afghanistan is increasingly considered as a strategic partner, which can give new impetus to development of inter-regional connections in the Eurasian space, rather than the source of regional problems, threats and challenges. Such strategic and mutually beneficial partnership with Afghanistan is crucial for water relations.

2 Water Resources in Central Asia

Formation of water

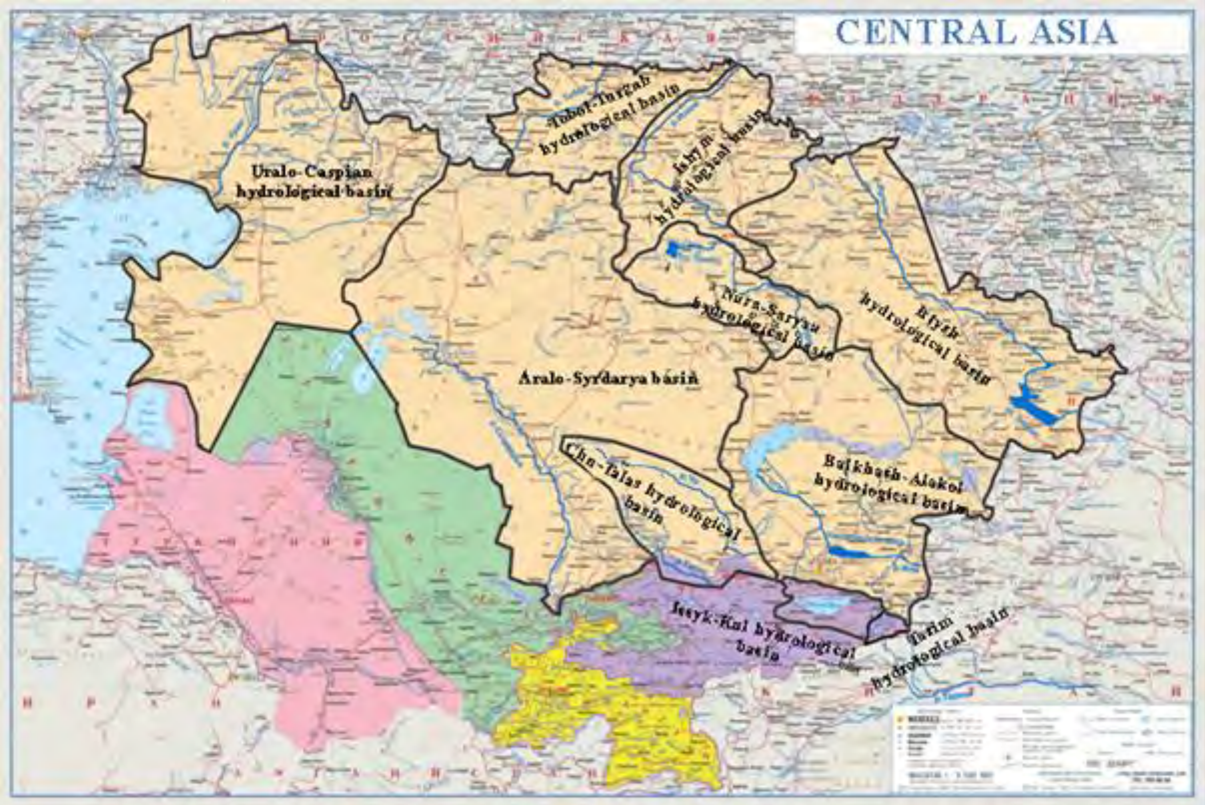
Central Asia has several hydrological basins, the largest of them being the Aral Sea basin (Figure 2.1). The area of the basin is 1,778,000 km^2. Additionally, there are number of interstate basins in Kazakhstan (Ural, Irtysh, Tobol, Yesil, Nura), Kyrgyzstan (Sary-Jaz, Issyk-Kul), as well as the Ily River and Chu-Talas basins in the territories of Kazakhstan and Kyrgyzstan. Besides, three interstate basins are located in the territory of Turkmenistan, the two of which belong to the Large Amu Darya basin – the Murgab and the Harirud (Tejen). The third basin of the Atrek River is small. Schematic map of hydrological basins located mainly in Kazakhstan and Kyrgyzstan outside the Aral Sea basin is shown in Figure 2.2.

Detailed analysis of all tributaries and water sources is made for the Aral Sea basin as the key subject of research.

Figure 2.1. Hydrographic scheme of the Aral Sea basin

Source: SIC ICWC, 2019. GIS layers (*.shp files of SIC ICWC*); Regional Information System CAWater-IS

Figure 2.2. Schematic map of interstate river basins located in the territories of Kazakhstan and Kyrgyzstan



Source: Base map: www.karty.ru/assets/images/centre-azia.jpg, Basins in Kazakhstan: https://ru.wikipedia.org/wiki/Водные_ресурсы_Казахстана, Basins in Kyrgyzstan: Regional Information System CAWater-IS

Surface water resources

Assessment of surface water resources. The comparison of current assessments and the data for 2001 indicates to lowering of runoff by 0.51 km3 in the Amu Darya basin and by 0.9 km3 in the Syr Darya basin. At the same time, river runoffs showed usual variations, with slight lowering in the last 12 years. For instance, in the Amu Darya basin over last thirty hydrological years, since 1989-1990, there was higher runoff than the average long-term one in 11 years, including 8 years in the first decade, 2 years in the second decade, and 1 year in the third five-year period. Accordingly, dry years with flow probability less than 80% in the long-term series occurred in decadal dimension 1 year in the first decade, 5 years in the second decade and 4 years in the third decade since the start of the analysis.

Table 2.1. Assessment of river runoff in ASB: changes occurred since 2000

Rivers in the Aral Sea basin	SPECA	2000-2018	Change W1 - W	
	W, km³	W1, km³	km³	%
Syr Darya River basin				
Naryn – inflow to Toktogul HPS	14.54	13.70	- 0.84	- 5.8
Karadarya – inflow to Andizhan reservoir	3.92	3.80	- 0.12	- 3.1
Chirchik – inflo to Charvak reservoir	7.95	6.90	- 1.05	- 13.2
Total interstate rivers	26.41	24.40	- 2.01	- 7.6
Fergana Valley's rivers	7.81	8.2	0.39	5.0
Rivers of Chirchik, Akhangaran and Keles basin (excl. Chirchik), middle and lower reaches	2.98	3.7	0.72	24.0
Total in the basin	37.2	36.3	- 0.9	- 2.4
Amu Darya River basin				
Vakhsh – inflow to Nurek HPS	20.0	21.3	1.3	6.5
Panj – Lower Panj section	34.29	33.5	- 0.79	- 2.3
Kunduz – Askarkhana section	4.5	4.4	- 0.1	- 2.2
Kafirnigan – accounted surface inflow	5.45	5.1	- 0.35	- 6.4
Surkhandarya – accounted surface inflow	3.32	3.3	- 0.02	- 0.6
Total for the Amu Darya River	67.56	67.6	0.04	- 0.06
Kashkadarya – accounted surface inflow	1.24	1.17	- 0.07	- 5.6
Zarafshan – Dupuli bridge + Magiandarya – Sudji station	5.14	5.0	- 0.14	- 2.7
Rivers in Turkmenistan	3.1	2.9	- 0.2	- 6.5
Rivers in Northern Afghanistan	2.24	2.1	- 0.14	- 6.3
Total in the basin	79.28	78.77	- 0.51	- 0.6
Grand total in the Aral Sea basin	116.48	115.07	- 1.41	- 1.2

Source: Data over 2000-2018 (W1) –estimation by SIC ICWC based on the Hydromet's data (Naryn, Karadarya, Chirchik, Vakhsh, Zaravshan rivers), and partial reconstruction from connections of main courses with tributaries (Panj, Kafirnigan, - from connection with the Amu Darya).

Table 2.2 shows changes in surface water runoff for other basins. The detailed analysis of Kazakhstan's hydrological basins is made by Kazakh experts. Such analysis on other basins is not available because of lack of data on runoff formation and dynamics. Even in basins, where relevant commissions exist, the above indicators were not the subject of in-depth analysis (Chu-Talas and Russian-Kazakhstan commissions).

Table 2.2. Characteristics of hydrological basins in Kazakhstan and Kyrgyzstan (outside ASB), km3/year

	Average long-term runoff		Transfers to other basins	Inside countries	Available runoff	Decrease in external inflow	Catchment area, thousand km²
	Total	External inflow					
Kazakhstan's water resources, excluding Aral-Syrdarya basin:							
Balkhash-Ili (Alakol)	27.8	11.4	7.0		3.3	-5.0	68.4 (131)*
Irtysh	33.5	9.8	7.9		5.6	-3.5	210 (1592)
Yesil	2.6				1.1		113 (156)
Nura-Sarysu	1.3			0.9	0.9		
Tobol-Turgai	2.0				0.6		130 (395)
Chu- Talas	4.2	3.1			2.5/2.79		77.9 (115.2)
Ural-Caspi	11.2	7.9			4.6	-3.6	72.5 (231)
Total	**82.6**	**32.2**	**14.9**	**0.9**	**18.6**	**-12.1**	

Kyrgyzstan's water resources:							
Chu-Talas	6.74	-	3.10		3.60		37.3 (115.2)
Ili	0.36	-			0.36		
Sary-Jaz	6.15	-	3.0	1.6	1.55		28.5
Issyk-Kul	4.65				4.65		21.89
Total	**17.9**		**3.10**		10.16		

Note: in brackets – total catchment area, without brackets – the area in the territory of countries

Source: Kazakhstan - S. Ibatullin (2019) Analytical materials for the diagnostic report on water sector development in the Republic of Kazakhstan. The data on Ural-Caspian basin is taken from "Ural (Zhaiyk) – Caspian Basin study results", Center for Water Initiatives, Summary report. Astana, 2016; Kyrgyzstan - the data provided by expert Ch. Uzakbayev. Catchment areas are based on UNECE (2011) Second assessment of transboundary rivers, lakes and groundwaters. New York & Geneva. The data on catchment area in the Chu-Talas basin is taken from the Strategic Action Program for the Chu and Talas River Basin. UNECE Project: Enhancing Climate Resilience and Adaptive Capacity in the Transboundary Chu-Talas Basin. 9.03 2019.

Generally, there was a decrease in inflow in the region outside the Aral Sea basin: by 16.2 km^3 in Kazakhstan, including by 12.1 km^3 along transboundary Black Irtysh, Ili and Ural rivers. Major 'disturbers' of runoff along those rivers are China, which increased its water withdrawals by 8.5 km^3 from upper reaches of the Ili and the Black Irtysh, and the Russian Federation, which recently increased its water withdrawals from the Ural River by 3.6 km^3. If the growing tendency of water intake from the Ili by China continues, the water balance in Lake Balkhash can be disturbed. As to the Irtysh, even in case if China withdraws almost the entire runoff formed in the territory of the country, free water resource will be available in the river. In this context, it was proposed in the "Plan of prospective water use projects in Kazakhstan" to transfer a share of runoff from the Irtysh River to the Syr Darya basin.

Groundwater

The regional evaluation of groundwater was made in 1997. The results of this evaluation are shown in the 2001 Diagnostic report. This report attempted to update these data based on hydrogeological services reports (Table 2.3).

Industrial and agricultural development over the last two decades negatively affected fresh groundwater in the Aral Sea basin's states, with a substantial decrease in groundwater reserves and exhaustion of some aquifers due to unauthorized construction of intake structures and unregulated water abstractions. Yet, the current groundwater monitoring system in the region does not allow assessing timely and reliably the negative factors that cause pollution of aquifers, exhaustion of groundwater stock, and waterlogging of settlements.

At the same time, overestimation of the regional stock is caused by the fact that boundaries of aquifers and 'connection' of their sources with these boundaries are determined very roughly. Given the present status of record-keeping on location, recharge and water stock of aquifers, such process becomes particularly complicated. Most governments very carefully set usable groundwater stock and allocate it mainly for drinking and household water supply purposes, except for groundwater abstraction through vertical drainage systems that are especially widespread in Kazakhstan, Tajikistan and Uzbekistan.

Table 2.3. Groundwater stock and its use by CA countries (Mm3/year) against 2000

Country	Evaluation of regional stock		Approved usable stock		Actual abstraction		Use for drinking water supply	
	2000	2018	2000	2018	2000	2018	2000	2018
Kazakhstan	1 846	8 410	1 270	1 052	963	859	200	367.6
Kyrgyzstan	1 595	14 212	632	622	548	545	304	340
Tajikistan	18 700	*na*	6 020	2 965	2 294	2300	485	461**
Turkmenistan	3 360	69 000	1 220	1 270	457	1 200	210	558
Uzbekistan	18 455	*na*	7 796	6 336	7 749	5 577	3 369	1825
Total	**43 956**	**91 622***	**16 938**	**12 245**	**12 011**	**10 481**	**4 568**	**3 552**

Note: *The data for 2000 was used in estimation of average values for the countries, on which the data for 2018 was not available. ** The data is different: according to “TajikGlavGeology”, 39.3% (903.3 Mm^3) are used for drinking needs.
Source: The data of CA experts involved in the work on the Diagnostic Report

Given the degradation of groundwater and the fact that this resource is of strategic importance for the countries, basic information and analytical assessments of groundwater are closed for public access. Nevertheless, the countries have started active inventory of groundwater stock and its use in the recent years.

A new assessment of aquifers made in 2015 in Kazakhstan revealed 2905 aquifers and groundwater abstraction sites. The results for southern provinces show 8.41 km^3 a year of regional stock in Southern Kazakhstan or 4 times increase and 1.05 km^3 of usable stock (slight decrease).

Same year, similar assessment on Kyrgyzstan was updated: explored 44 aquifers, of which 20 ones designated for drinking-household and industrial needs. The total usable groundwater amounted to 622.4 Mm^3 or slightly lower than in the previous assessment. The total abstraction of usable groundwater was 545 Mm^3.

According to the data of 2014, the forecast groundwater resources amount to 18,688 Mm^3/year in Tajikistan. At the same time, the developed usable stock of fresh groundwater in valley territories of the republic is 2,774 Mm^3/year. The number of operational water wells is more than 4600. Presumably, given that forecasts remained the same, the situation with groundwater in the republic has not been changed. Moreover, groundwater abstraction has slightly decreased to 793 Mm^3 a year.

By present, in Turkmenistan, the total groundwater stock is estimated in the amount of 69.0 km^3, of which 1270 Mm^3 are usable. Most of groundwater resources are brackish and unsuitable for drinking and household-domestic needs.

Uzbekistan has 97 aquifers, of which 19 aquifers are the protected natural areas of fresh groundwater formation. Groundwater resources are distributed unevenly throughout the republic; however, their total amount slightly increased 27.586 Mm^3 a year, comprising fresh and brackish groundwater. This is 9 km^3 more than the estimation in 1999. The total amount of the approved usable groundwater stock is 6336.4 Mm^3, of which the total annual abstraction is 5577.3 Mm^3. In February-March 2017, the inventory of more than 10,000 water wells was made and showed that the negative factors continue impacting groundwater. The inventory results indicate to uncontrolled abstraction of groundwater from more than 60% wells and further pollution and depletion; abstraction of 59% of groundwater from unapproved stock; real risk of irreversible losses of more than half of fresh groundwater in the coming decades. Given the need for urgent solution of the above-mentioned problems, the President’s decree was adopted on 4 May 2017 “On measures for the improvement of control and accounting of the use of groundwater stock in 2017-2021”.

In the Aral Sea basin as a whole, one may say, based on available information, that the estimated regional usable groundwater stock – about 400 aquifers – has decreased by 2018 as compared to 1998, through deterioration of aquifer quality in some places. Annual abstractions from the approved resources have decreased by 25-30% in Uzbekistan only. Water deficit faced by those who use groundwater is compensated through surface sources. This increases the risk of deterioration of water quality for some water uses. Groundwater resources are maintained at the same level or even increased in other countries; however, water intake from groundwater decreased in all the countries.

Return water

Return water is an additional source of water; however, because of relatively high salinity, this water is a source of pollution also. Today, about 88% of return water is comprised of collector-drainage water, while the rest is formed by agricultural and industrial wastewater. It is well-known that irrigation development increases the amount of return water, and the most intensive growth in return water was observed in 1970-1990.

According to SIC's data (regional database, PEER Project), in 2000-2017, 35.78 km3 of collector-drainage water and wastewater were generated in the Amu Darya and the Syr Darya basins. 15.26 km3 were generated in the Syr Darya basin and 20.51 km3 were formed in the Amu Darya basin. Over this period of time, on average 17.67 km3/year were discharged to rivers and 14.43 km3 – to lakes and natural depressions.

As compared to 1990, the amount of return water decreased by 0.6 km3 (1.7 %). However, the comparison with 1990–1999 [SPECA 2001 Diagnostic Report] shows that the amount of return water increased by 3.3 km3 (11%). In 2000-2017, the amount of return water discharged into rivers increased by 8% as compared to 1990-1999.

Distribution of return water over 2000-2017 by country and by their generation and use is shown in Table 2.4.

Table 2.4. Distribution of return water in ASB over 2000-2017

Country	Generation, Mm^3			Distribution, Mm^3			
	Total	of which:		Total discharge	of which:		
		Domestic and industrial wastewater	Collector-drainage water from irrigation		to rivers	to lakes and natural depressions	Re-use for irrigation
Kazakhstan	1478	138	1340	1478	847	104	527
Kyrgyzstan	414	56	358	414	229	47	138
Tajikistan	2699	188	2510	2699	2581	0	118
- Syr Darya	426	18	409	426	310	0	117
- Amu Darya	2272	170	2102	2272	2271	0	2
Turkmenistan	6141	234	5906	6141	955	4926	260
Uzbekistan	25045	5936	19974	25045	13061	9355	2628
- Syr Darya	12945	3919	9548	12945	8868	2090	1987
- Amu Darya	12100	2017	10425	12100	4193	7265	642
Total	**35776**	**6553**	**30088**	**35776**	**17672**	**14432**	**3672**
Syr Darya	15263	4131	11654	15263	10253	2241	2769
Amu Darya	20513	2422	18433	20513	7419	12191	903

Note: Based on the data of the Institute of Water Problems, Hydropower and Ecology at the Academy of Sciences of Tajikistan, the current volume of collector-drainage water is estimated at 4.64 km^3, of which 4.31 km^3 are discharged to rivers.
Source: SIC ICWC, reconstructed from incomplete data on return water in SIC's database www.cawater-info.net/

The amounts of return flow in Kyrgyzstan and Tajikistan are underestimated, approximately by 1.5 km3 and 0.5 km3, respectively – by those amounts of return water that are accounted in the territory of

Uzbekistan but flow from the above countries to Uzbekistan. Therefore, the return flow generated in Uzbekistan will be 25.05 – 2 = 23.05 km3.

The largest amount of return water was generated in the years of maximal water diversions. For instance, in 2003-2005, given the water diversion of 113-121 km3, 36-37 km3 of return water were generated. The minimal return flow was observed in the dry year 2001 - 32.1 km3.

Similar accounting of return water is not made in other basins.

Climate change and water resources

According to “Outlook on Climate Change Adaptation in the Central Asian Mountains”, Central Asia is already experiencing an overall warming in climate. The comparison of surface temperatures for 1942-1972 and 1973-2003 shows that the annual average temperature increased by 0.5° C.[11]

The Intergovernmental Panel on Climate Change (IPCC) underlines that the average surface temperature in the Central Asian region grew from 1°C to 2°C over a century (Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li and N. Huu Ninh,, 2007[5]) Based on national communications on climate change, in the most part of the region an increase in temperature was stronger in winter than in summer, forming an overall temperature growth pattern. However, as IPCC notes (IPCC, 2013[6]), the data on observed climate change and its effects in CA is not sufficient and additional research is needed to have a more accurate picture of climate change in CA and its mountains.

According to hydrometeorological centers in the CA countries, the **air temperature tends to increase** from 1971 to 2015. The average annual air temperature increased every 10 years by: 0.29°C in Uzbekistan (1950–2005); 0.26°C in Kazakhstan (1936–2005); 0.18°C in Turkmenistan (1961–1995); 0.10°C in Tajikistan (1940–2005); and, 0.08°C in Kyrgyzstan (1883–2005). Temperature growth had not a uniform pattern throughout the Central Asia. Higher rates of growth in average annual air temperature were observed in plains, while in mountains these rates are lower and even a decrease in temperature was noted in some cases. Increases in air temperature have more negative than positive aspects, and the latter should be addressed in a comprehensive manner in the context of different ecosystems – mountains, steppes, deserts and their constituent soils. In other words, one should clearly identify how much the temperature would rise in the above ecosystem by 2030-2050 and which fundamental studies should be carried out to develop various adaptation options (A, B, C) depending on temperature rise trends: 1-2 degrees; 3-4 degrees; and, probably, even 5-6 degrees.

Variability and intensity of precipitation increase in many areas in Central Asia. Amount of precipitation increased in most of Kazakhstan’s regions. In other CA areas wide variations in annual precipitation (decrease in winter and increase in spring) was observed, with slight tendency to an increase on average over the CA territory.

Positive temperature anomalies become stronger and are observed more frequently throughout all seasons in the region. Moreover, more days with heat waves are recorded in the Aral region (the so-called Prearalie) and in the lower reaches of the Amu Darya River.

River runoff did not undergo substantial transformations in this period of time. There is certain downward tendency for small rivers’ runoff, whereas in large river basins a decrease in runoff was minor (see Table 2.1). At the same time, the frequency and amplitude of extreme floods and water shortages have increased sharply. This necessitates closer attention to multiyear runoff regulation.

[11] Outlook on Climate Change Adaptation in the Central Asian Mountains, UN Environment, Regional Mountain Center of Central Asia in cooperation with the Central Asian experts and GRID-Arendal, with the financial support of the Government of Austria. 2017.

3 Water Use and Flow Regulation

This chapter provides information on water use in key sectors in the CA countries: drinking and household water supply, irrigated agriculture, hydropower and aquatic ecosystems. The information on total water withdrawal and available water supply in the countries is given beforehand.

Total water withdrawal and available water supply

Since the 2000s, the total water withdrawal did not change considerably, although some changes were observed in water uses (see Table 3.1). In the region as a whole, water withdrawal for drinking and household needs increased by 6.3% and that for industrial needs grew by 25.5%. However, in Turkmenistan and Uzbekistan water withdrawal for drinking and household needs decreased. In Tajikistan and Turkmenistan water withdrawal for industrial needs also decreased. Over the 20-year period, irrigation water use virtually did not change in the region as a whole. There is some dissonance in overall water withdrawal data due to information from Kazakhstan. The country keeps detailed accounting of water withdrawals using so-called 2 TP-Vodhoz (2-ТП Водхоз) form. This helps to keep records of even water circulation through turbines of power stations that show non-consumptive water use by the stations. This gives the impression of almost full usage of surface water by the state. As to other states, accounting of water used for energy generation is made through thermal power plants only, though not everywhere.

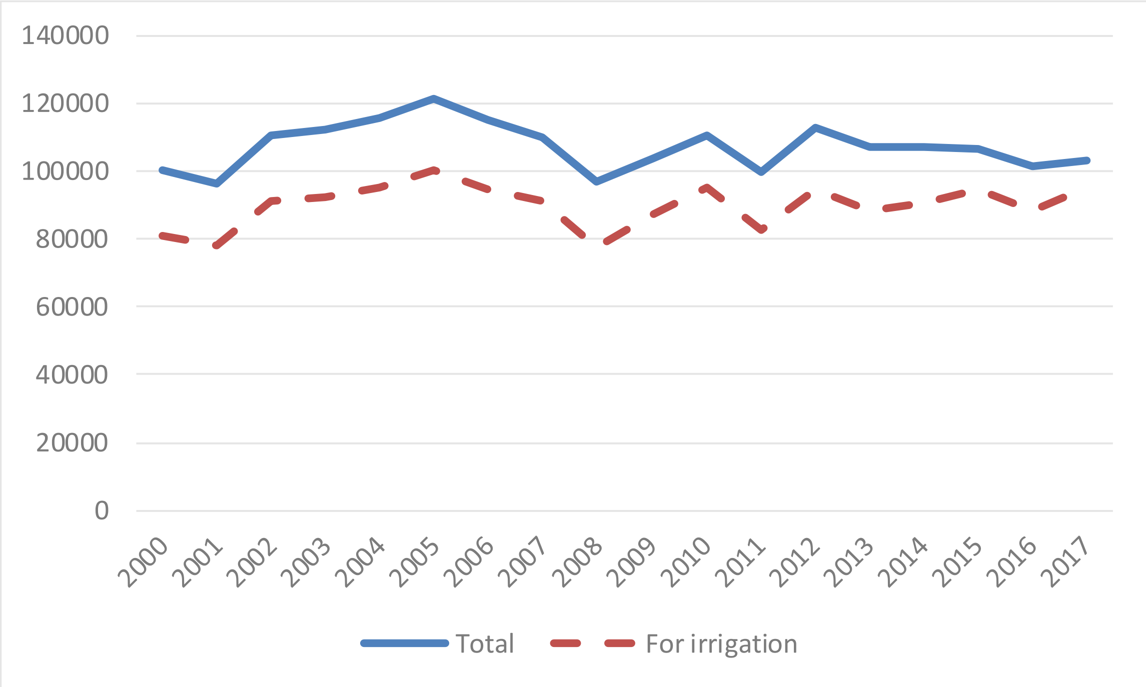
Table 3.1. Data on water withdrawal and water consumption in the Aral Sea basin (comparison of 2002 and 2018)

Country	TOTAL*		Irrigation		Drinking and household needs		Industry		Energy	
	2002	2018	2002	2018	2002	2018	2002	2018	2002	2018
Kazakhstan	13830	18732	10294	12301	600	895	2937	5536	65430	66650
Kyrgyzstan	4469	5526	4264	5240	128	204	77	82	3186	2739
Tajikistan	12691	12301	9623	10215	619	760	392	348	na	na
Turkmenistan	28334	25380	24990	22385	623	558	1700	1523	2860	na
Uzbekistan	60554	50947	47434	45086	3002	2870	4727	4852	64	130
TOTAL	119878	112886	96605	95227	4972	5287	9833	12341		

Note: * Due to lack of accurate accounting of water withdrawal for energy sector, total water use is estimated excluding the energy sector. The year 2002 is chosen for comparison since 2000 and 2001 were extremely dry. Figures in the Table characterize water withdrawals at province boundaries.
Source: The data of CA experts involved in the work on the Diagnostic Report

More detailed analysis of water withdrawal and general water balance is made for the Aral Sea basin. The water withdrawal in the basin has decreased by 12 km^3 from 119 km^3/year right since independence due to the decline in all economic sectors. Further, over 2000-2018, water withdrawal averaged 106 km^3, including 90.1 km^3 for irrigation. In dry years, water withdrawal decreased to: 100.4 km^3 (81.3 km^3 for irrigation) in 2000 and 96.7 km^3 (77.5 km^3 for irrigation) in 2008. There was also a period of time (2002–2005), when water withdrawal increased to 111 – 121 km^3/year.

Figure 3.1. Dynamics of total water withdrawal in ASB over 2000-2017 (km3/year)



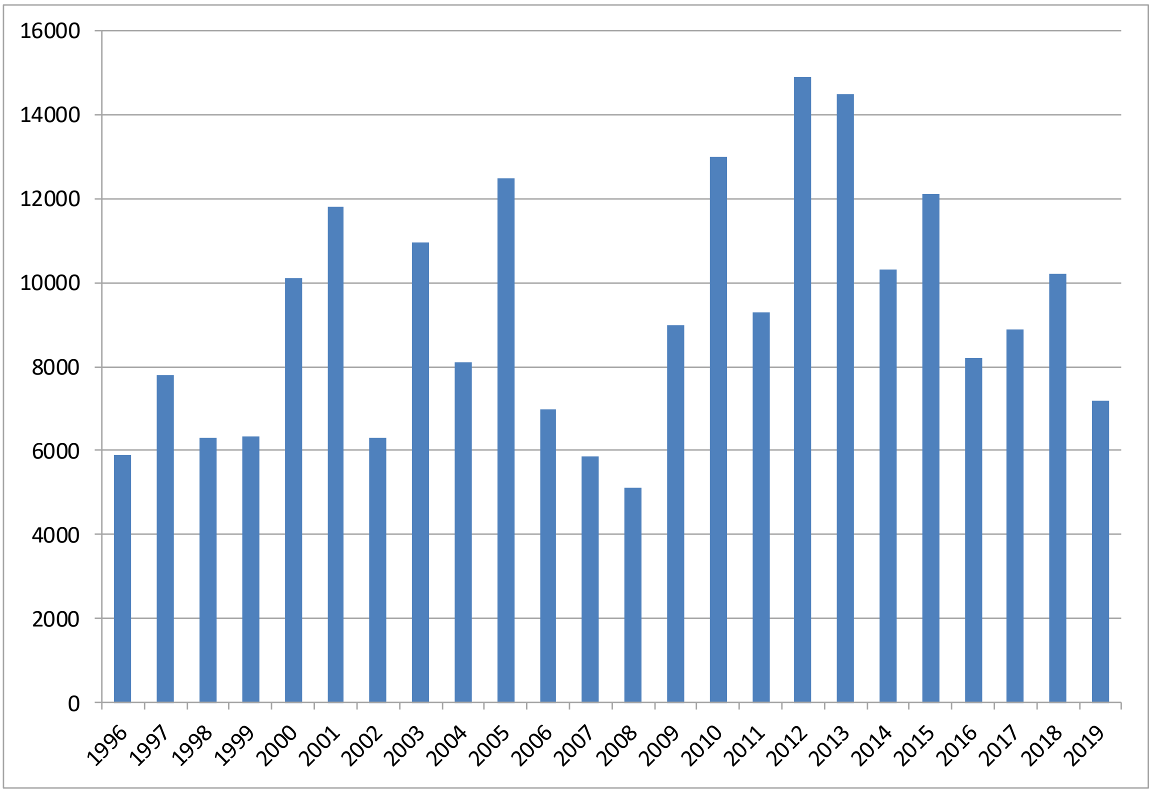
Source: The data of CA experts involved in the work on the Diagnostic Report

Evaluation of losses. The water withdrawal of 107 km^3 in the Aral Sea basin is provided from the available surface water of 115 km^3, groundwater of about 7 km^3, and discharged return water of approx. 17 km^3 (see Table 2.4). A portion of water resources (about 12 km^3) flows, virtually in equal parts from the Syr Darya and the Amu Darya, to wetlands of the Aral region and the Aral Sea. Based on those components of water balance, one may evaluate the average basin's water losses at countries' province borders (losses in rivers and reservoirs). Over hydrological years 1991/92 – 2018/19, open-channel losses in the Amu Darya River are estimated at 9.1 km^3 on average, including 6.2 km^3 (68% of annual losses) during the growing season. Moreover, 6.9 km^3 (77%) of the losses are observed in the lower reaches, i.e. downstream of Tuyamuyun hydroscheme.

Open-channel losses along the Syr Darya River to the point of the Shardara reservoir are estimated at 2.9 km^3 over the same period of time. The losses are estimated using the balance method as river channel balance discrepancy.

Open-channel losses in the Aral-Syrdarya basin are estimated at 2.8 km^3 (S. Ibatulin). Thus, the total open-channel losses in the two major rivers – the Amu Darya and the Syr Darya – amount to 14.8 km^3.

Figure 3.2. Open-channel losses along the Amu Darya River, Mm3/year



Source: SIC's estimates on the basis of BWO Amu Darya's data on main course balance

In Master Plans of water resources development and use for the Amu Darya and the Syr Darya, water losses are estimated at 3.15 and 2.74 km^3, respectively, or just about 6 km^3. The current overestimation of total losses mentioned above results partially from errors in water accounting. Therefore, those cannot be considered as losses in full since a portion of water flows back in form of return water, i.e. roughly this amount of almost 15 km^3 should be reduced by the average long-term value of return flow of 4.5 – 5 km^3 a year. In any case, we should aim to cut those water losses through automation of waterworks facilities.

To have a fair picture of losses, it is advisable to carry out joint research and organize a regional project for water monitoring in the Amu Darya River basin. The supposed factors of losses also could include: "unwillingness of downstream countries to maintain water record-keeping in the basin"; "water theft and its attribution to water losses"; "lack of water record-keeping in the lower reaches along newly formed water bodies, wetlands, and failure to maintain the record-keeping form '2TP-vodkhoz'; "absence of IS", etc. Convincing is the fact that water has not been reaching the Aral Sea for almost 40 years.

Out of the total water used in river basins in Kazakhstan (outside the Aral Sea basin) the share of agriculture varies from 31.5% to 34.2% showing an upward trend. However, here accounting of water for energy generation disguises the picture of water distribution between water use sectors. Irrigated agriculture consumes 90% of water in the Aral Sea basin.

As compared to the Soviet period, **per capita water withdrawal** has dropped dramatically and will be **decreasing**. **Because of population growth, water withdrawal dropped from 3,500 m^3 to 1,900 m^3 a year per capita,** approaching the UN's water stress threshold of 1,000 m^3. Ironically, the region's water richest country – Kyrgyzstan – has already reached this level. This indicates to poor development of water management infrastructure.

Drinking and household water supply

Since 1990 till present, water use for drinking and household needs has increased by 670 Mm^3.

A number of state programs were initiated in the domestic water supply and sanitation sector in all the countries in the region over the last 20 years. However, all those programs have not solved yet the key water supply and sanitation problems in most of settlements. At the same time, as part of the programs, the indicators of water and sanitation coverage were estimated more precisely and show that the situation is still far from desired one. The actual average access of population to good quality water is: 62% in Kazakhstan; 45% in Kyrgyzstan; 65.7% in Tajikistan; 63% in Turkmenistan; and, 64.8% in Uzbekistan (Table 3.2).

The rate of depreciation of public utilities' assets is still very high in the region and substantial public and private investments are needed in this context. More than half of water mains and sewage networks are in a critical condition. Moreover, at present, the visual tendency towards growing investment in new housing construction, particularly in big cities, creates additional problems. New, often quite large apartment houses, commercial and other buildings are connected to old and over-worn engineering networks and increase the system's working load even more.

Table 3.2. Drinking and household water supply in CA countries (2016)

Country	Access to water, %*	Actual average water consumption, l/day/capita**	Water losses, %***	Tariff, $/m^3$	Fee collection rate, %**
Kazakhstan	62	220	30	0.10 – 0.58	85
Kyrgyzstan	45	140	50	0.07-0.11	65
Tajikistan	65.7	180	45	0.4-0.8	75
Turkmenistan	72	320	55	0.5	70
Uzbekistan	64.8	290	45	0.11-0.25	85

Note: *** Water losses include both technological (leakage in distribution networks and unavoidable losses) and commercial (unauthorized use, etc.) losses.
Source: * Data collected by national experts , ** Asian Water Development Outlook 2016: Strengthening water security in Asia and the Pacific. Mandaluyong City, Philippines: Asian Development Bank, 2016. (Asian Development Bank, 2016[7])

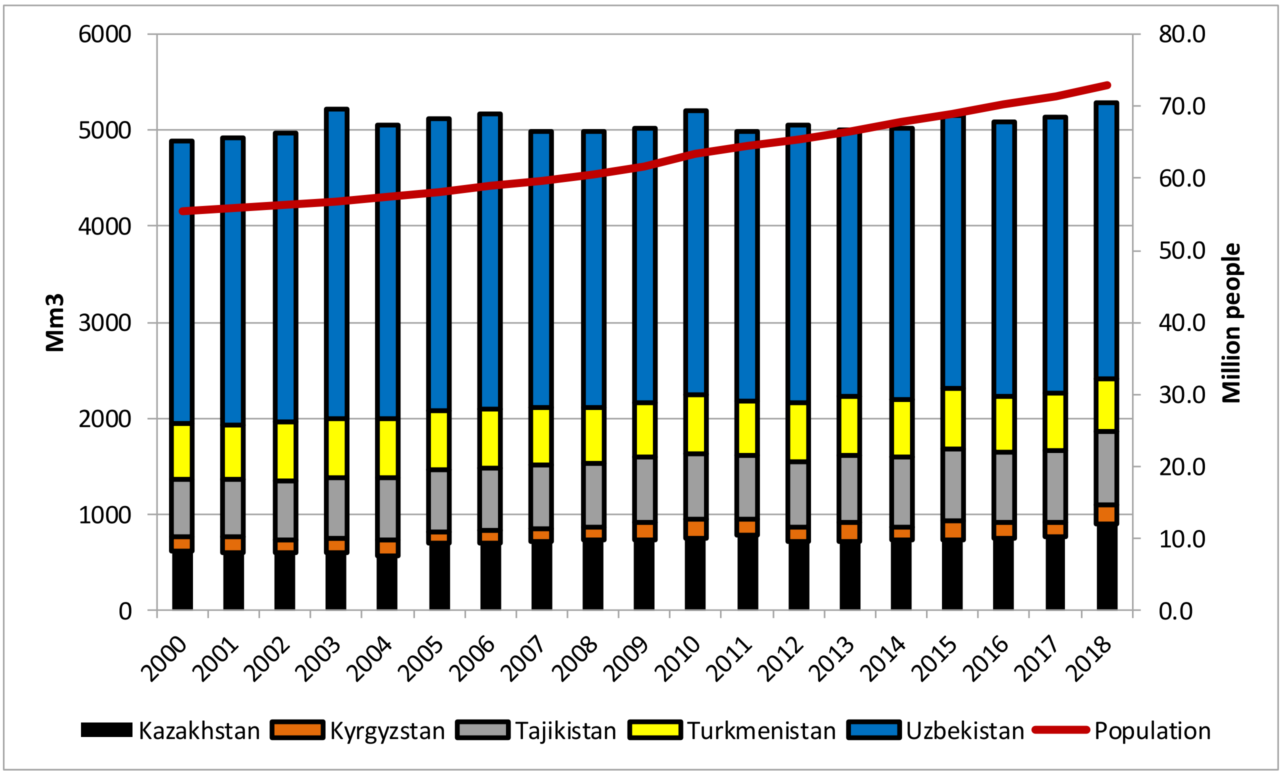
In Kazakhstan, tariffs for drinking water supply in urban areas at the end of 2019 ranged from 41.5 tenge (10 US cents) in Nur Sultan to 223.9 tenge (58 US cents) in Aktau. In Almaty, the tariff was 50 tenge (12 US cents). (Turan Times, 2019[8]) In Kyrgyzstan, drinking water tariffs are set well below the estimated cost. So, if the average tariff for drinking water in the country in 2018 was 22.61 soms (33 US cents) per person, its cost was 54 cents. (State Agency of Architecture, Construction and Housing and Communal Services under the Government Kyrgyz Republic, 2018[9]) Until November 15, 2019, the tariff for a cubic meter of drinking water in Bishkek was 5.38 soms (7 US cents), whil its actual cost was 7.7 soms (11 US cents). Since November 2019, it amounted to 8.1 soms (12 US cents). (Orlova, 2019[10]) In Tajikistan, drinking water tariffs range from 3 to 6 somoni (40-80 US cents) per person per month, depending on the region and the type of connection to the water source. (World Bank, 2017[11]) In Uzbekistan, the highest water tariffs are observed in South Karakalpakstan (25 US cents), and the lowest in one of the districts of the Ferghana region (11 US cents); in Tashkent, the tariff is about 21 US cents. (World Bank, 2015[12])

In all the countries, there is a situation in which households without centralized water supply incur higher costs per cubic meter of water. For example, in some rural areas of Tajikistan, the household's annual costs for water supplied by tankers may be about 17% of annual income (World Bank, 2017[11]). Another example is from the Khorezm region of Uzbekistan, where pilot projects of small-scale rural drinking water supply facilities were implemented through a grant from KfW Bank (Germany). In the project area, the cost of one cubic meter of water is about 3800 soums (40 US cents), or 4.5 times more than in other areas of this region.[12] Despite this fact, collection rate is 100%, and water losses in 2018 amounted to 8% only.

In 2018, the total use in the household sector in CA (excluding Afghanistan) was about 5.3 km^3. Since 2000 till 2018, the water use increased by 8%. In the same period of time (19 years), the population growth was 32% of the level 2000. Population grew by 17.5 million and reached 72.89 million in 2018.

Figure 3.3 shows dynamics of annual water use in the household sector (Mm^3) against population growth (thousand persons) in the Aral Sea basin countries, whereas Figure 3.4 shows dynamics of unit indicators of water use in this sector (m^3 per person a year).

Figure 3.3. Dynamics of annual water use in the household sector (Mm3) against population growth (million persons) in ASB



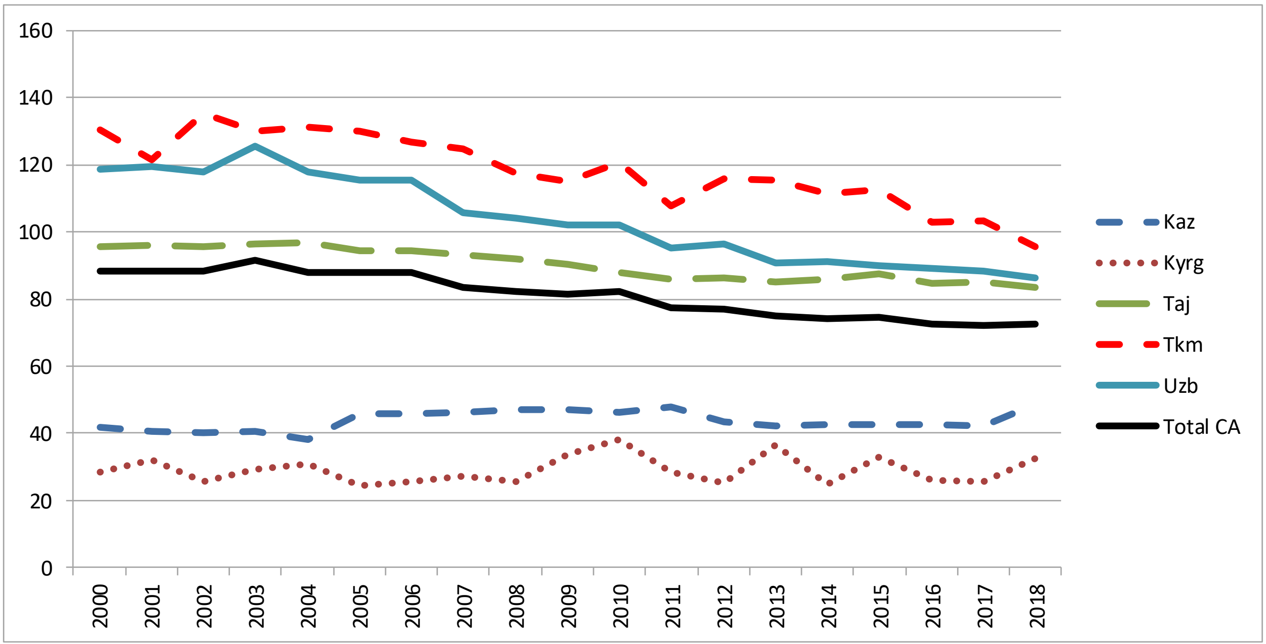
Source: Calculations based on the data collected by national experts

In 2018, unit water use in the household sector (m^3 per person a year) in CA as a whole amounted to 69.25 m^3/pers, including: Kazakhstan – 48.6, Kyrgyzstan – 32.6, Tajikistan – 83.3, Turkmenistan – 95.4, Uzbekistan – 86.3.

Over 2000-2018, this indicator increased by 16% and 15% in Kazakhstan and Kyrgyzstan, respectively, and decreased in other republics (by 14% in Tajikistan and by 37% in Turkmenistan and Uzbekistan).

[12] The average tariff for drinking water supply to population in the Khorezm region since 11/21/2018 for 1 cubic meter of water is 1100 soums (13 US cents).

Figure 3.4. Dynamics of unit water use in the household sector in ASB countries (m3 per person a year)



Source: Calculations based on the data collected by national experts

Irrigated agriculture and its water consumption

Reduction of irrigation water by 7-8 km^3 a year in first years of independence took place through the extension of winter cereal areas and a slight decrease in cotton area[13] because of the change in flow regulation regime from irrigation to irrigation-energy generation and even full energy generation one. Thus, irrigated agriculture had to adapt to the established regimes of flow regulation by energy sector. **Irrigation norms in the Aral Sea basin were decreasing and amounted to the following values in 2017:** 9,700 m^3/ha in South Kazakhstan; 7,400 m^3/ha in Kyrgyzstan; 13,300 m^3/ha in Tajikistan;[14] 15,500 m^3/ha in Turkmenistan; and, 11,700 m^3/ha in Uzbekistan.

Agricultural production as a whole and irrigated agriculture in particular have underwent dramatic institutional changes at the lower level. Instead of rather large collective and state farms of different specializations on 1,500–4,000 ha, smaller farms were formed. Moreover, new farms were developed following diverse principles. Kyrgyzstan distributed all irrigated land among rural people, with the average land plot area of 0.5 ha. Kazakhstan distributed land for rent between the employees of collective and state farms, depending on the role of each employee in farm, and sizes of land plots were very different. In Uzbekistan, land was given for rent through tenders and the rent was periodically reviewed for optimization of land use. Here, farm sizes vary from 150 ha for cotton and cereals and 25 ha for fruit and vegetables. It is characteristic that the breakdown of former cooperative and socialistic farms affected the mechanization level of agriculture, stability of land use, agronomic and agrochemical services, and, mainly, productivity and financial stability of farms. Elimination of large state and collective farms – the agglomerates of multisectoral specialization – comprising big settlements with full infrastructure has turned

[13] One should take into account that, at present, high yielding cereal varieties that consume more water are practiced in Tajikistan.

[14] According to the Tajikistan's Agency for Land Reclamation and Irrigation, in 2017, the actual water withdrawal was 7.99 km^3, i.e. the irrigation norm was 10.5 m^3/ha.

them into unattended, while multiple former employees have become unemployed and started searching for job, also outside their homeland. This caused huge labor migration of rural people from densely populated countries (Kyrgyzstan, Tajikistan, and Uzbekistan) to Russia and Kazakhstan. In some estimates, labor migration involves from 2.5 to 4.3 million people annually or 10-15% of economically active population in CA. (Chekhovskykh, 2019[13]) This is closely linked with agricultural transformations in the countries.

Since the collapse of the Soviet Union, cropping patterns has changed radically in the countries of the Aral Sea basin. The share of food crops has started to grow fast, while the share of industrial crops in the total crop acreage in the basin has started to decrease – from 40% of the total crop acreage in the basin in 1990 to 25% in 2017. This is explained, first of all, by breakdown of the common agricultural market on the CIS scale, loss of former interregional economic ties and All-Union specialization patterns. However, the share of grain, mainly, of wheat increased rapidly in national cropping patterns from 20% of the total crop acreage in the basin in 1990 to 45% in 2017. Grain acreage has doubled. Given an abrupt drop in gross incomes of families and living standards as a whole, it was necessary to create conditions for calorie and protein supply of population and that could be reached only by increasing grain production.

Simultaneously, fodder crop acreage was reduced by half in the Aral Sea basin countries since independence. Substantial reductions were observed in Uzbekistan (more than 60% as compared to 1990) and in Tajikistan and Kazakhstan (by more than 40%). This had a destructive effect on the livestock sector that, in turn, had led to decline in meat and milk production.

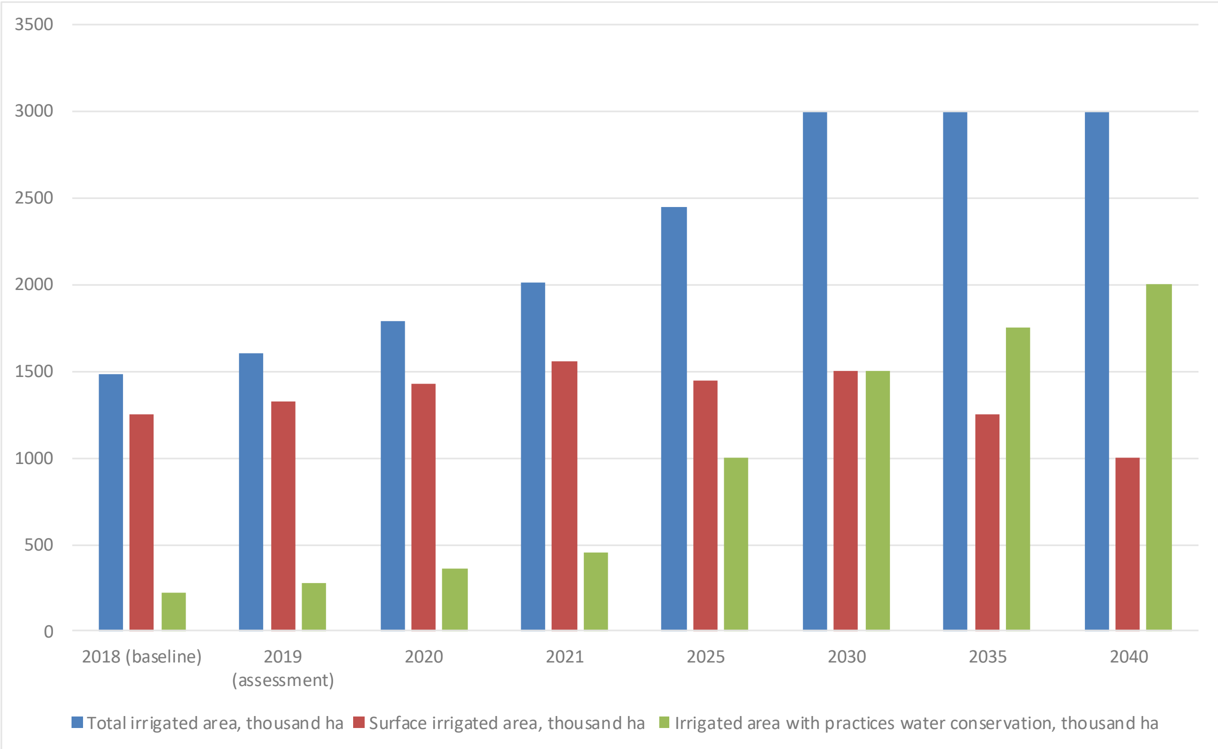
Despite all negative consequences from the destruction of the former land use system and agricultural sector as a whole (accompanied by complete loss of large-scale agricultural engineering industry base that ensured mechanized land treatment with local machines), **all countries in the region have managed to mobilize financial and material resources to boost agricultural production under new economic conditions and radically improve productivity over 2005-2008**. Exactly in these years, the average productivity of irrigated hectare and water productivity in irrigated agriculture reached the level that was before independence and, since 2012, exceeded this level, with gradual increase in absolute values. The governmental efforts that legalized dekhkan farms using homestead plots – *tamarka* in Uzbekistan, *melek* in Turkmenistan, etc., and, since 2001, organization of Water User or Consumer Associations as a voluntary alliance of peasant farms contributed to such an increase. According to our findings, substantial portion of food basket was formed by dekhkan farms. (Pavel Krasilnikov, 2016[14])

As a result of taken measures, **all countries in the region but Afghanistan have maintained their food security.** Kazakhstan reaches its security through the higher share of grain export and, accordingly, import, at gained revenue, of lacking foodstuff. Moreover, export and import are approximately the same. Other countries are self-sufficient for the most part but still depend on import of some components of the food basket (10-20%). For example, food import was substantial - $1.27 billion – in Uzbekistan in 2017. Typically, since independence, all the countries have managed to reduce quantity of malnourished people to less than 5% of population, except for Tajikistan, where this indicator is 33.2%. (Sputniknews, 2018[15])

Currently, the agrarian sector shows **new tendencies to formation of larger forms of business patterns.** In Kyrgyzstan, this was manifested in the revival of collective business pattern. A brand new and, to a certain extent, revolutionary approach is shaped in Uzbekistan, where since 2017 the cluster-based farming has been developed. At present, such form is also developed in Kyrgyzstan and Turkmenistan. This approach consists in transfer of agricultural production management to leading companies – producers of final product - that sign contracts with farms for supply of raw material and, in turn, provide fertilizers, agronomic and agrochemical services and even loans. Their main objective is boosting production of final products. Here, mobilization of external funds is welcome. Examples of such cooperation can be found in Japan, which shows highly effective production of final products. Cotton, grain and horticultural clusters have been established already.

Agriculture plays a critical role in the economies of the basin countries. It is often said that irrigated agriculture is significant to the economies of downstream states, with Uzbekistan as a top-ten global exporter of cotton and Kazakhstan a major wheat exporter. In fact, agricultural sector continues playing a key role in economies of all other countries too, with the highest rate of share in GDP in Afghanistan (21%), Tajikistan (21.1%), Uzbekistan (17.3%) and Kyrgyzstan (12.9% but as much as 22.3% in the areas belonging to the Aral Sea basin). Agriculture also accounts for significant share of employment in the region, with the highest rate in Afghanistan (62%) and Tajikistan (52%). It is important to note that agricultural development boosts development of other sectors, which process crops and livestock products and which provide fertilizers, agricultural machines, marketing, delivery and storage of agricultural products. In general, for example, agriculture and associated sectors account for almost 45% of GDP in Uzbekistan.

Figure 3.5. Planned increase in irrigated area in Kazakhstan by 2040



Source: S. Ibatullin. Forecast of irrigated agriculture development by 2040 (2019)

Diversification from cotton to other crops is ongoing in all the countries in the region. Kazakhstan is among the world's largest producers and exporters of grain and takes solid positions in the world market of barley (FAO, 2019). However, wheat area has been decreasing in recent years. According to USDA, in 2017/18 the harvested wheat area was reduced to 11.8 Mha against 12.4 Mha in the year before. This is related to national crop diversification policy in Kazakhstan. In the last few years, the Kazakh government supports and encourages production of oil crops by subsidizing farmers and, consequently, the interest in production of wheat and other cereals declines. (APK-Inform, 2019[16]) Moreover, one should take into account that most crops are rainfed in Kazakhstan.

Recently, Uzbekistan has also shifted from cotton dominance to more than 500,000 tons of grain export. It also exports large quantities of horticultural products, including fruits. Turkmenistan relies on crop export to a lesser degree thanks to its relatively large oil and gas reserves. Kyrgyzstan and Tajikistan have diversified agricultural sector but limited export of livestock and horticultural crops. Until recently, all the countries held back from irrigation development. Nevertheless, in 2019, Kazakhstan adopted a program for irrigation expansion and rehabilitation of irrigated areas that existed before independence (2,150,000 ha), with following extension to 3 Mha, mainly, in steppe zones (Figure 3.5). Kyrgyzstan also plans irrigation expansion by 66,500 ha by 2026 on the base of the Government Decree No. 440 of 21 July 2017. The need for additional irrigated area exists in Tajikistan and Uzbekistan as well; however, this could be done only through the improvement water use.

Industry

Within a short timeframe – about two decades – industrial production has grown 5.1 times in Kazakhstan, 4.1 times in Kyrgyzstan, 3.13 times in Tajikistan, 5.91 times in Turkmenistan and 6.12 times in Uzbekistan (Table 3.3). Higher growth is observed in the countries that produce crude organic materials and related processed products. Another important direction of industrial development is the deepening of processing of agricultural commodities to reach full load in situ.

Table 3.3. Industrial production in CA countries (2002, 2018), $ million

Country	2002	2018
Kazakhstan	15285.5	78959.3
Kyrgyzstan	909.5	3738.4
Tajikistan	790.7	2609.0
Turkmenistan	1798.0.	22543.0.
Uzbekistan	4633.0.	29162.4

Source: Data of national statistical agencies, except for Turkmenistan. The data on Turkmenistan for 2002 – World Bank, for 2018 – expert estimation.

It is characteristic that water intensity of the industrial sector is quite low in Kazakhstan and Turkmenistan (0.0448 m^3 and 0.0438 m^3 per 1$ of output, respectively), highest in Uzbekistan (0.17 m^3) and slightly lower in Tajikistan (0.07 m^3). The figure on Kyrgyzstan - 0.018 m^3 per 1$ of output – is unrealistic, probably because of errors in reporting. Such wide variation in figures is explained by differences in industrial production patterns and, particularly, by inclusion of the cost of electric energy produced on the base of crude organic materials.

Hydropower

Over 2000-2017, the total electricity production in the CA countries (excluding Afghanistan) is estimated on average at 174 billion kWh, while the electricity consumption (estimated as net consumption, i.e. electricity production plus import and minus export and electricity losses through transmission and distribution) is 143 billion kWh. Electricity consumption increased from 115 billion kWh in 2000 to 185 billion kWh in 2017, i.e. 1.61 times, while electricity production (at electric stations) grew from 136 billion kWh to 226 billion kWh, i.e. 1.66 times.

Thus, over 2000-2017, the difference between production (G – generation) and net consumption (C) of electric energy was 31 billion kWh, i.e. 17.8 % of the electricity production represent electricity losses and export (minus import) outside Central Asia.

In 2018, electricity production in CA, including Afghanistan, amounted to **227.38 billion kWh**, of which: Kazakhstan – 107.1 billion kWh; Kyrgyzstan - 15.6 billion kWh; Tajikistan – 19.7 billion kWh; Turkmenistan

– 21.2 billion kWh; Uzbekistan – 62.8 billion kWh; and Afghanistan – 0.98 billion kWh. That year, hydropower stations generated 49.6 billion kWh or 21.8 % of the total electricity generation.

Hydropower makes a substantial contribution to regional electricity production by providing one fifth of the total electricity production. Moreover, the bulk of electric energy in Kyrgyzstan and Tajikistan is generated at hydropower stations. Therefore, hydropower is one of priority water users and is the backbone of energy security and economic development in the upstream countries.

The total capacity of all hydropower stations (HPS') in the countries of the Aral Sea basin is 10,240 MW, of which 32% of the capacity refers to HPS' in Kyrgyzstan, 48% - in Tajikistan, and 18% - in Uzbekistan. Major generation is provided by the Vakhsh, Naryn-SyrDarya, and Chirchik-Bozsu HPS cascades. The largest hydropower stations are Toktogul, Nurek, and Charvak that have the total capacity of 4,800 MW, i.e. 47% of the whole hydropower capacity in the basin. Reservoirs at these HPS' account for about 20 km^3 of the regulating capacity.

Although hydropower does not withdraw water from a streamflow and is a non-consumptive user, operation regimes of HPS' and the resulting flow regulation have considerable influence on integration of interests of all water users and, simultaneously, on water use efficiency. Available hydroenergy potential of rivers in the Aral Sea basin is under-exploited. This is the subject of constant discussion between IFIs and the countries.

The total hydropower potential is estimated at 460 TWh/year, including: 27 TWh/year in Kazakhstan, 99 TWh/year in Kyrgyzstan; 317 TWh/year in Tajikistan; 2 TWh/year in Turkmenistan; and, 15 TWh/year in Uzbekistan, of which only 30% is used.

Since independence, a considerable increase in hydropower generation has been reached by Kyrgyzstan (Kambarata-2 at the Naryn River), Tajikistan (Sangtuda-1, Sangtuda-2, first two aggregates of Roghun project at the Vakhsh River), and Uzbekistan (Tupolang HPS) and reconstruction of Charvak HPS). It should be noted that maximal utilization of energy potential puts irrigation, drinking water and nature needs in jeopardy. Increase in capacity and number of hydropower stations with associated reservoirs will lead to higher irrecoverable losses in water body capacities and growing idle discharges from cascades and could break water distribution schedules. From the experience of operation of the Vakhsh and Naryn cascades, effective regulation and control over fulfillment of cross liabilities of basin water organizations and the energy sector are needed. Such attempt, based on mutual material and financial commitments of the riparian countries, was made in the 1998 Syr Darya Agreement. Unfortunately, this attempt proved to be a failure due to lack of agreed principles of regulation and substitution of the core agreement by continuously changing annual protocols.

River flow regulation

At present, river flow is regulated by 121 reservoirs of seasonal and partial multiyear regulation, with the total capacity of 148.4 km3 and the active storage of 105.3 km3 (Table 3.4). The bulk load of seasonal regulation is born by multipurpose hydroschemes located along interstate rivers and constructed in Soviet times for regulation of river flow during the season for irrigation purposes. Seven of such hydroschemes located at interstate watercourses, with the total design volume of reservoirs of 51.44 km3 and the regulating capacity (useful volume) of 34.8 km3. The regulating capacities amount to 25.1 km3 in the Syr Darya basin and 9.7 km3 in the Amu Darya basin.

It must be understood that this option ensured the maximal regulation efficiency, i.e. accumulation of water in winter and spring served for meeting irrigation needs, while HPS' produced cheap electricity, which was fully consumed based on a plan of intersectoral exchange between the republics in the region, and energy deficit was compensated by thermal stations working on fossil fuel (coal, oil, residual oil, and gas).

However, since independence, such common planning of all electricity and fuel supplies in the region has been broken and hydropower producers had to replace irrigation regime of regulation, without prior arrangement, by irrigation-energy regime along the Amu Darya or energy regime along the Syr Darya. Later, the 1998 Syr Darya Agreement legitimize this regime.

Table 3.4. Large reservoirs in CA countries

Country	River basin	Quantity	Full volume, Mm^3	Useful volume, Mm^3
Kazakhstan	Aral-Syrdarya	4	8889	6179
	Yertis	3	52120	36490
	Yesil	2	1104	774
	Nura-SarySu	3	1120	780
	Chu-Talas	2	734	514
	Balkhash-Alakol	1	18600	13000
	Total	**15**	**82567**	**57737**
Kyrgyzstan	Syr Darya	12	20666	15542.7
	Chu	4	611.01	583.61
	Talas	1	550	540
	Total	**17**	**21827.01**	**16666.31**
Tajikistan	Amu Darya	8	11006.5	4782
	Syr Darya	4	4413	2813
	Total	**12**	**15419.5**	**7595**
Turkmenistan	Amu Darya	20	7014	6350
	Total	**20**	**7014**	**6350**
Uzbekistan	Amu Darya	32	15253.6	11497.5
	Syr Darya	25	6304	5464.2
	Total	**57**	**21557.6**	**16961.7**
Total by country	Kazakhstan	15	82567	57737
	Kyrgyzstan	17	21827.01	16666.31
	Tajikistan	12	15419.5	7595
	Turkmenistan	20	7014	6350
	Uzbekistan	57	21557.6	16961.7
	GRAND TOTAL	**120**	**148385**	**105310**

Source: Data collected by national experts involved in preparation of the Diagnostic Report

Nevertheless, for a number of reasons shown in Chapter 8 the current regulation is not effective and should be brought to mutually acceptable format either through an agreement or the proposed water-energy consortium, where virtually the former, practiced in Soviet times regime of regulation would be restored in the context of market relations.

At present, the extra electricity generated by the Naryn HPS cascade to accommodate irrigation needs during growing season, inter alia at the account of multiyear regulation (multiyear storage in Toktogul reservoir), above the domestic needs of Kyrgyzstan is transferred to Kazakhstan and Uzbekistan as requested and agreed. At the same time, upon agreement between the countries, Kyrgyzstan's energy deficits are compensated by energy resource supplies from Kazakhstan and Uzbekistan in order to ensure necessary accumulation of water in the Toktogul reservoir for irrigation needs in the growing season. Thus, river flow is regulated to the benefit of irrigation, with compensation provided to the hydropower sector. Currently, the price of flow regulation is not set. However, the CA countries have proposals on pricing and compensation scheme to be implemented in water-energy relations between the

CA countries. For example, Tajik energy experts (Petrov G.N. Problems of utilizing water and energy resources of transboundary rivers in Central Asia and ways of their solution, 2009) propose to set for the Toktogul hydroscheme the cost of flow regulation in energy equivalent at 40.65 kWh per 100 m^3. In money terms (assuming that costs are equivalent to energy generating cost by HPS in the amount of 0.17 cent/kWh), the cost of flow regulation will be equal to 0.07 cent per 1 m^3 for additionally supplied water for irrigation, above the domestic needs of Kyrgyzstan.

The region is characterized by availability of numerous intra-system reservoirs at irrigation canals that help to increase seasonal regulation.

In practice, in-stream reservoirs in cascades (Vakhsh-AmuDarya, Naryn-SyrDarya) are operated autonomously (in isolation), without allocation of regulation functions between them. Only in extraordinary situations, in case of critical water shortage in the basin, some hydroschemes start to deliver specific functions of compensators or compensated hydroschemes. Moreover, basically, operation of in-stream reservoirs is not coordinated with regulation by intra-system reservoirs at large canals that have own specific characteristics in dry and wet years (or seasons). In dry years, operation of intra-system reservoirs, first of all, should be aimed at reducing water shortage in the growing season, which is to be compensated through maximum possible water diversion from the river during the non-growing season and accumulation of water in the reservoirs by the beginning of the growing season.

In the Irtysh River basin in Kazakhstan, seasonal regulation is provided by Bukhtarma, Shul'ba and Ust-Kamenogorsk reservoirs for energy generation and flood control.

The degree of flow regulation is quite high along the Syr Darya (96%) and the Irtysh (97%) and slightly lower along the Amu Darya (78%), the Ili (47%) and the Ural (6%).

Ecosystem water demand

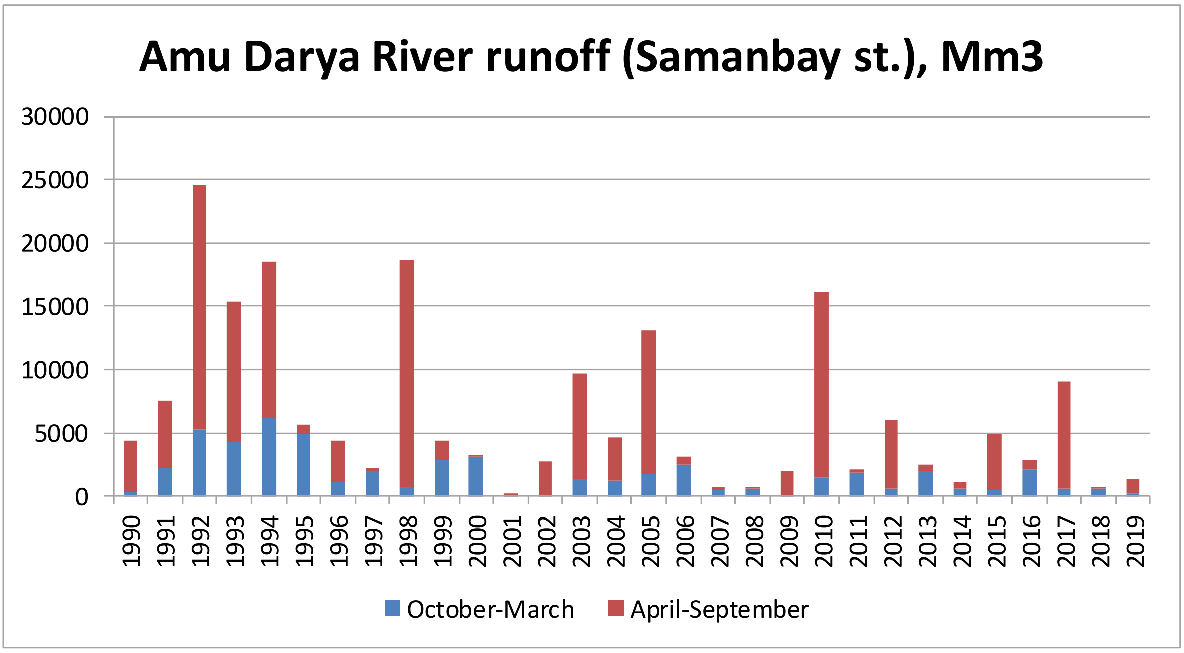
Environmental requirements of a river are comprised of water releases to its delta and inland water bodies, instream flow needs along the river and environmental water releases to some canals. Deltas' demands for water were determined in the "Fundamental provisions of the regional water strategy"[15] (1998) in the amount of, at least, 8.5 km^3 for the Amu Darya basin and 3.5 km^3 for the Syr Darya basin (item 42). Then, these values were reduced in ICWC decisions to 4.5 km^3 and 3.0 km^3, respectively. Actually, though environmental water releases amounted to 8.0 km^3 and 6 km^3, respectively, on average in last decade, stable water supply in the course of year was not ensured for the Amu Darya delta in contrast to the Syr Darya delta. As a result, the status of Southern Prearalie is much worse than that of the Northern part. Evaluation of economic losses resulted in $144 million for Southern Prearalie as of 2001 as compared to 1960 and only $49 million in the Kazakh part. Further target investments in the northern delta in the amount of $85.8 million allowed increasing fish catch to 8,000 tons a year, organizing livestock farming and industrial processing.

The reason of such difference is that Kazakhstan has constructed primary deltaic infrastructure with the World Bank's support and thus created a sustainable water body of the Northern Aral Sea at a level of 42 m. In contrast, Uzbekistan tried to implement an infrastructural project in the Amu Darya delta using its own resources with smaller involvement of the World Bank for the improvement of Lake Sudochie. Thus, implementation of the project lasted as much as 15 years. All water bodies in this zone were watered unsustainably due to low regulating capacities of the Mezhdurechie reservoir, which is still under construction.

[15] IFAS (1997). Fundamental Provisions of the Regional Water Strategy in the Aral Sea Basin. Executive Summary. www.cawater-info.net/library/rus/hist/regstr/pages/001.htm

The Syr Darya basin also faces the challenge related to sustainability of the Aidar-Arnasay system of lakes that were formed in 1969 as a result of a catastrophic flood (29 km^3 of peak flow were discharged into the lakes). Further maintenance is provided through the inflow of 3 km^3 of collector-drainage water from the Golodnaya Steppe and the emergency spills from Chardara reservoir.

Figure 3.6. Instability of water supply to the Amu Darya Delta



Source: UzHydromet

4 Environmental Matters Related to Water

Aral Sea and Prearalie

The modern period of the Aral Sea, since 1961, may be described as the period of active anthropogenic impact. Since 1961, the water level of the sea has begun dropping steadily. The average annual rate of level lowering was about 0.5 m, reaching 0.6-0.8 m/year in dry years. The gradual lowering of water level in the sea has considerably exceeded predicted rates. In fact, the water level has dropped below 34 m +BSL instead of 38.5 m predicted by 2000. Similarly, the seawater salinity has increased at higher rates.

The major consequence of the Aral Sea shrinkage, apart from the decrease of its water volume and area, increase in water salinity and modification of salinity pattern is the formation of a vast saline desert on an area of almost 5.5 Mha on the place of the exposed seabed, of which 3.4 Mha refers to Uzbekistan and 2.1 Mha to Kazakhstan.

In 1989, the Aral Sea was separated into the Northern Sea and the Southern Sea as a consequence of lowering of the water level and drying up of the Berg's Strait. The Large or Southern Aral Sea was transformed into a hypersaline water body by the end of 90-s. Water salinity amounted to 57‰ (per mille) in 1997. The Barsakelmes Island joined the mainland in 1997 and the Vozrozhdeniye Island became the mainland in 2001. In 2003, the Southern Aral Sea was divided into eastern and western bodies. Small Tuschibas Lake, which previously was the similarly-named bay of the Aral Sea, completely separated from Eastern body of the sea in 2004. In 2005, the Small Aral Sea was hedged off the Large Aral Sea by the Kokaral Dam constructed in the area of Kazakhstan. And the two water bodies became completely isolated from each other.

At present, the water surface area of the Aral Sea is less than 10% of the level 1961. The residuals are divided among the three water bodies as follows: Western Sea - 3,380 km^2, Eastern Sea – 1,710 km^2, and Small (Northern) Aral - 3,100 km^2. The volume of the Aral Sea decreased almost 40 times.

Unfortunately, until now no regular systematic monitoring over hydrological and environmental conditions has been organized within the dried bed of the Aral Sea and the Aral region. Nevertheless, SIC ICWC experts monitor monthly the dynamics of water surface areas in Eastern and Western parts of the Large Aral Sea and of lake systems in the Amu Darya delta in South Prearalye by using Landsat 8 OLI images (http://www.cawater-info.net/aral/data/monitoring_amu.htm). The derived RS-based data for 2010–2019 allowed assessing actual changes in the area of wetlands and open water surfaces of Western and Eastern bowls of the Aral Sea.

Table 4.1. Comparison of open water surface and wetland areas within the Large Aral Sea (2010-2019), thousand ha

	2010 Aug	2011 Aug	2012 Oct	2013 Aug	2014 Aug	2015 Aug	2016 Aug	2017 Aug	2018 Nov	2019 June
Western part of the Aral Sea, thousand ha										
Wetland	182.34	165.86	161.25	224.78	186.99	264.65	265.54	283.15	293.0	296. 5
Water surface	379.59	396.08	369.66	360.69	337.52	315.78	295.81	278.2	268.4	264.81
Eastern part of the Aral Sea, thousand ha										
Wetland	964.14	1243.9	1214.53	1155.3	1019.59	1183.95	1340.79	1036.02	1353. 0	1480.1
Water surface	532.68	252.94	215.99	184.31	103.22	149.19	156.04	460.81	128.3	16.7

Source: Satellite data processed by SIC ICWC. Database on the Aral Sea http://cawater-info.net/aral/data/index_e.htm

And only in 2018, thanks to attention and the decision of Uzbek President Mirziyoyev, efforts on watering of small local water bodies were initiated at a proper pace. However, stability of supply of water in appropriate quantity to the delta requires additional solutions on mobilization of both river water, which is currently lost due to poor record-keeping, and collector-drainage water from Bukhara, Khorezm and Karakalpakstan to guarantee year-round supply to the delta and the residuals of the Aral Sea. Since 2004, afforestation has been started in Uzbek territory of the dried seabed, first of all, on erosion threatening sites. Ten expeditions conducted by SIC ICWC in the period over 2005 to 2010 and combined with RS-observations allowed classifying conditions of the dried seabed, identifying first-priority risk zones and assessing results of afforestation. This detected 244,000 ha of artificial plantations and 200,000 ha of self-organized vegetation as a result of dispersion of seeds from growing trees. At present, the Government of Uzbekistan has accelerated afforestation efforts. Financing in the amount of 400 billion soums was allocated from the state budget for afforestation of the dried Aral Sea bed in 2019. The afforestation efforts were started in December 2018 to cover more than 1 Mha of the exposed seabed by the end of 2019. In October 2019, SIC ICWC together with UNDP and the International innovation center of the Aral Sea region at the President of Uzbekistan conducted next expedition for comprehensive monitoring of the exposed seabed. The results of the expeditions are analyzed at present.

Land reclamation and collector-drainage water management

More than half of the land fund in Central Asia is subjected to salinization to a greater or lesser degree. Given the total area of the Aral Sea basin of 155 Mha (excluding Afghanistan) and the available drained land fund of 32.6 Mha, non-saline land area is 8.6 Mha and saline land area is 23.9 Mha. Most unfavorable land fund is in Turkmenistan and southern provinces in Kazakhstan, where roughly 54% of irrigated land is characterized by salinized soil and located in groundwater dispersion and discharge zones in the deltas of Amu Darya and Syr Darya. These territories are poorly- or non-drained and have closely bedded saline groundwater. In Uzbekistan, 2 Mha or 47% of land out of total irrigated area is subjected to salinization. Moreover, if strongly saline land accounts for 12% and 18% in Turkmenistan and Kazakhstan, respectively, this indicator is 6% in Uzbekistan, mainly, because of geomorphological and hydrogeological conditions.

Table 4.2. Characteristics of land fund in the Aral Sea basin countries

Country	Year	Irrigated area, thousand ha	Land area, thousand ha				
			Non-saline soil	Salinized soil	of which:		
					poor saline	medium saline	strongly saline
Kazakhstan	1990	752	377.9	374.1	178.6	123.2	72.3
	2015	798.2	376.0	422.2	166.0	166.8	84.4
Kyrgyzstan	1990	419.8	434.8	26.4	16.1	5.8	4.5
	2015	429.3	377.5	24.1	14.1	5.9	4.2
Tajikistan	1990	678.5	676.7	73.8	47	20	6.8
	2015	752.3	716.3	88.2	67.8	16.7	3.7
Turkmenistan	1990	1209.1	574	661.1	341.2	243.1	76.8
	2015	1551.9	729.3	854.3	440.9	314.1	99.3
Uzbekistan	1990	4186.5	2186.7	2138	1267.4	647.2	223.4
	2015	4273.1	2253.7	2040.4	1342.9	584.8	112.7
Total	**1990**	**7245.9**	**4250.1**	**3273.4**	**1850.3**	**1039.3**	**383.8**
	2015	**7804.8**	**4452.8**	**3429.2**	**2031.7**	**1088.3**	**304.3**

Source: SIC ICWC, 2019 (www.cawater-info.net). (SIC ICWC, 2019[17])

In this context, irrigation, which causes intensive water exchange between groundwater and aeration zone, should be accompanied by the development of collector-drainage networks as a way to maintain good soil conditions by disposing excessive saline water from insufficiently naturally drained land, as well as to ensure leaching of salinized land and maintenance of optimal watering regime. Given the total irrigated area of almost 8 Mha, 5.7 Mha need to be drained, while the actual drainage coverage is 5.5 Mha, including horizontal drainage on 4,750,000 ha and vertical drainage on 764,000 ha. Availability of such significant amount of drainage facilities contributes to generation of huge quantity of collector-drainage water. Moreover, only about 20% of land out of the total area drained by horizontal drainage is provided with subsurface horizontal drains; the most part of drainage refers to surface drains and collectors, thus, causing intensive exchange between surface water and groundwater and increased drainage flow. Most of salinized land and drainage schemes are concentrated in Uzbekistan and far fewer in Kazakhstan, Turkmenistan and Tajikistan. Preventive leaching irrigation and repair of subsurface and vertical drainage are not sufficient and do not meet the requirements. Consequently, vast land areas (600,000 ha in Uzbekistan) produce less yield than due and need additional water for leaching in the amount of about 3 km^3.

Over 1990-2015, the area of salinized land increased from 3.3 Mha to 3.4 Mha in the Aral Sea basin mainly through growth of such land area in Turkmenistan, Tajikistan and Kazakhstan by 1.29, 1.19 and 1.5 times, respectively. In Uzbekistan, thanks to establishment of a land reclamation fund and the ongoing measures as part of three State programs for irrigated land improvement (2008-2012, 2013-2017 and 2018-2019), the area of medium and strongly saline land is decreasing.

As a result of measures taken in the last 40-50 years to control salinization of irrigated soil, we observe paradoxical situation: the growing scale of soil salinization due to deterioration of water quality requires that leaching rates be increased or even that extensive leaching irrigation be restarted in case of Dzhizak, Karshi and Golodnaya steppes. However, this is difficult to implement in view of water shortage. Besides, an increase in leaching irrigation will cause intensive salt withdrawal and, hence, further deterioration of irrigation water quality. This, in turn, again will require more water for leaching. In this context, it is obvious that the prevalent concept of fundamental improvement of salinized land is unfeasible and irrigated agriculture in Uzbekistan and in the Aral Sea basin as a whole will have to be developed under conditions of permanent salinity.

The unit volume of drainage flow generated in the Amu Darya basin varies from 3,500 to 12,700 m^3 per hectare. This volume ranges from 1,700 m^3 to 8,300 m^3 per hectare in the Syr Darya basin. Moreover, considering the average long-term period, 37% of drainage flow generated in the Amu Darya basin is discharged to the stem stream and re-used, 60% is discharged to closed lakes and only 3% is used for irrigation. The picture is different in the Syr Darya basin: 60% of drainage flow is discharged to the stem stream, 21% is discharged to depressions, and 19% is used for irrigation. Although a lot of research and development efforts (A. Usmanov, Kh. Yakubov, E. Chembarisov, I. Rabochev, A. Babaev, etc.) were dedicated to applicability of drainage water in the region, no clear regulations and rules on their use is available in the countries. Moreover, financing for chemical analysis, quantity and frequency of sampling have been cut in recent years.

Return water is an additional source of water; however, because of relatively high salinity, this water is a source of pollution also. Huge amounts of drainage flow generated in large collecting drains (e.g. Achikul, South Hunger Steppe, etc.) contribute to discharge of dissolved salts to river systems. At the same time, return collector-drainage flow discharged to rivers is considered as an increase in irrigation capacities of streamflow or in available water resources. The master plans of comprehensive water use and conservation in the Aral Sea basin developed by design institutes (Soyuzvodproyekt, Sredazgiprovodkhlopok, Uzgiprovodkhoz and others) stipulated an increase in irrigation capacity of streamflows by 15-20% through return drainage flow.

However, such re-use and increase in available water resources through river stem stream are ‘useful’ to a certain threshold, beyond which those cause extensive damage to both drinking water supply and other economic sectors. This is mainly related to return of huge amount of salts and consequent increase in river water salinity in middle and lower reaches to 0.9-1.3 g/l (in dry years, to 1.5 g/l against 0.5-0.7 g/l in 1960-1965). Random application of this kind of water for irrigation results in salinization of land, especially in irrigation schemes in middle and lower reaches and reduces land productivity. Moreover, enormous amount of water discharged to rivers without any limits and restrictions makes good freshwater poor saline and hardly usable for any needs.

Water bodies in desert zones and in periphery of irrigated land are fed by collector-drainage water in random manner, leading to the loss of environmental and nature-stabilizing value of such bodies. Several hundred water bodies were formed on the base of collector-drainage water and wastewater: from Aidar-Arnasay depression of more than 20 km^3, Sarykamish lake of about 100 km^3, Dengizkul, Solyonoye, and Sudochie to smaller flowless lakes of several million cubic meters. Fish productivity, fauna and flora in those water bodies are not sustainable because of instable water-salt regime.

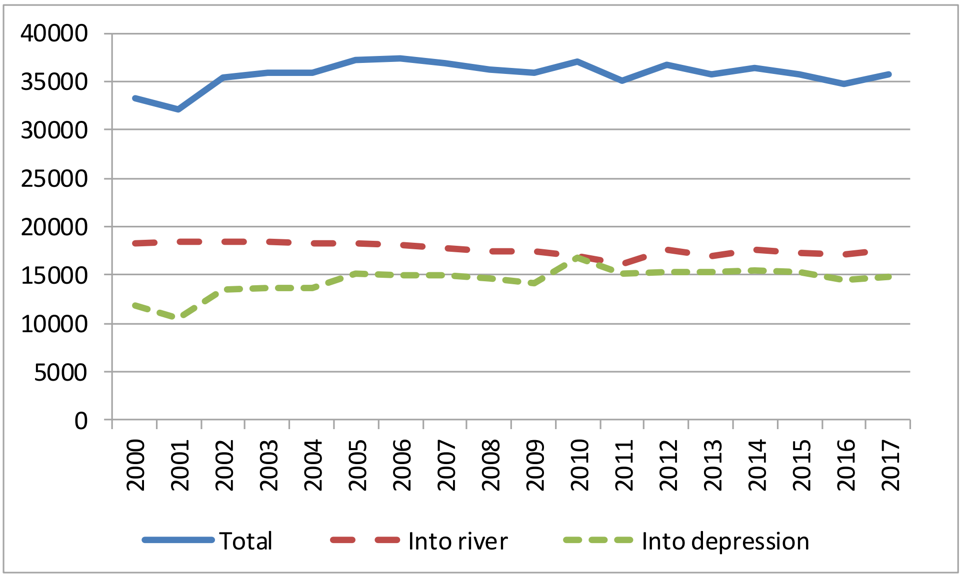
Recently, due to intensive breakage of drainage and insufficient repair and maintenance (it is required that 7% of subsurface drainage is flushed annually, while only about 2% is flushed in fact), river water quality has deteriorated. This contributes to accumulation of salts and, accordingly, makes it impossible to reduce salinity of drainage water. In dry years, collector-drainage water is used widely for irrigation in pure form or in mixture with irrigation water. Moreover, drainage modulus tends to decrease in such years. The “Fundamental provisions of the regional water strategy” in item 48 propose to provide management of both surface and collector-drainage flow, with strict rating of water diversions and also of discharges of salts and pollutants, proceeding from dynamics in the balance of salts and pollution in the river. It was planned to establish water and natural resource quality services at BWOs to control over meeting of water quality requirements at basin level. Evidently, time has come to recognize that collector-drainage water generated in each of the republics should be considered as their internal resource. In the future, when sharing water from interstate sources, it will be necessary to exclude drainage water and wastewater generated within republican boundaries from the amount of water withdrawal limits. And each country, based on its requirements, should individually deal with the use and management of this kind of water.

To reduce pollution of river water by salts and avoid deterioration of land through spreading of collector water, two major measures were taken in the Amu Darya basin. The first one is the construction of a combining collector via the desert area of Karakum, which intercepts all wastewater from the Murghab and Tejen river basins and the Karakum canal and delivers this water to the Karashor depression, where Turkmenistan plans to create Golden Age Lake (*Altyn Asyr*). The second measure was taken by the Uzbek side by completing the Right-bank collector, initiated as early as in Soviet times, along the right bank of the Amu Darya River, which intercepts water from most of collectors that flowed earlier into salty lakes or the Amu Darya and delivers this water to Eastern part of the Aral Sea.

Actually, at present, as a result of remaining discharges of collector-drainage water, the average annual salinity in the Amu Darya River has increased both at initial section (at Termez city) and, especially, at Darganata, Tuyamuyun, Kipchak and Samanbay sections. Moreover, whereas in wet years salinity at those sections is 0.515, 0.68, and 1.183 g/l, in the dry year 2018, the salinity increased to 0.654, 0.829, 1.566 and 1.500 g/l, respectively.

In the Amu Darya basin, return water management, first of all, is linked to the project of Golden Lake of XXI century. It is planned to deliver as much as 10 billion cubic meters annually to the lake in the future. Furthermore, the diversion of return collector water will lead to discontinuance of its discharge from the left bank into the Amu Darya and to lowering of river flow by 1.0-1.6 billion cubic meters a year and, consequently, to reduction of inflow to Prearalie by 0.8-1.3 billion cubic meters. Therefore, the prerequisite condition for implementation of the Turkmen lake project should be an agreement signed between Turkmenistan and Uzbekistan, which assesses the risks of lowering the Amu Darya river water flown to the lower reaches and makes provisions for minimization of these risks. Given agreement needs to specify minimum environmental water releases to Sarykamysh lake and set shares of Turkmenistan and Uzbekistan for this to ensure preservation of this aquatic ecosystem of interstate importance. Moreover, there is an option to use waters from the Ozerniy collector that are formed in Uzbekistan in order to increase inflow to the Aral Sea in the amount of more than 3 km^3, and, in our opinion, this is more reasonable.

Figure 4.1. Dynamics of return water generation and distribution in the Aral Sea basin, Mm3 (2000-2017)



Source: SIC ICWC, reconstructed from incomplete data on return water in DB of SIC ICWC http://www.cawater-info.net/

Figure 4.1 shows dynamics of return flow generation, including discharge of return water to rivers, lakes and depressions.

State monitoring of irrigated land, assessment and forecast of irrigated land conditions are the main tasks for identification of the causes of deterioration and changes occurring in the zones of direct influence of irrigation in the riparian countries of the Aral Sea basin. However, no generally accepted rules have existed yet for state monitoring and assessment of irrigated land conditions and maintenance of geo-information databank on conditions of agricultural land in the countries of the Aral Sea basin.[16] For the improvement of legal and regulatory framework of irrigated land assessment in the region, the following is needed:

- harmonization of laws and regulations, norms and specifications in the field of governance, design, construction and operation of land reclamation schemes, assessment and inventory of conditions of irrigated agricultural land[17];
- organization and improvement of collection and processing of ground-based measurements of groundwater table and salinity and soil salinity, using new GIS-based programs and new laboratory equipment and field devices;
- establishment of a common system for assessment of irrigated land (mapping, explication, units, etc.);
- collection of historical data of irrigated land monitoring and assessment and further organization of their electronic collection and exchange between governments and states;
- contractual relations on exchange of data between land reclamation field offices and other relevant state institutions for better assessment;
- determination of conditions and dates of data exchange between state institutions, including land reclamation field offices and water and land user organizations for robust assessment of irrigated land conditions. Involvement of research institutes for checking of reliability and comparison of multisectoral data and information;
- organization of tenders early in the year to ensure transparency of involvement of potential institution-candidates, taking into account actual requirements of water-management organizations in situ;
- assessment of personnel needs for land reclamation sector;
- training of staff of land reclamation field offices and water user associations in operation and maintenance of new modern reclamative equipment. Equipping with GPS for remote control of operation of reclamative equipment. Development of a database on technical specifications of equipment, operation terms, etc.

Water quality

Water quality monitoring bodies. Monitoring of water quality in the CA countries is carried out by different national agencies. Monitoring of surface water quality is under responsibility of hydrometeorological services (except for Turkmenistan), that of groundwater is within the competence of geological agencies. Drinking water is monitored by sanitary-epidemiological services and quality of return water (agricultural wastewater) is under monitoring of water-management organizations. Overall monitoring of pollution is under responsibility of nature conservation agencies. By expert assessments, the countries have problems

[16] Currently, the only regulations exist in Kazakhstan: Order No.330 of 25 July 2016 of the Deputy Prime Minister of Kazakhstan, Minister of Agriculture “On adoption of the Rules of state monitoring and assessment of irrigated land in the Republic of Kazakhstan and organization of databank on agricultural land conditions” (Registered at the Kazakhstan’s Ministry of Justice, No. 14227 of 9 September 2016).

[17] According to para 1.2 of the Plan of first priority measures for implementation of the Concept on cooperation of Commonwealth of Independent States (CIS) member states in the field of land reclamation, approved by the decision of the Council of Heads of CIS Governments on 3 November 2017, Tashkent

related to lack of coordination in water quality information structure, absence of unified data formats and insufficiently rapid exchange of data. In case of Turkmenistan, the lack of consistency and fragmentation of the data on water quality analyses make it difficult to track trends and changes in the multiyear range and by season and river reach and complicate appropriate assessment of pollution along rivers, sources and scales of pollution.[18]

At interstate level, BWO Amu Darya and BWO Syr Darya make hydrological and hydrochemical observations over water quality parameters in order to deal with the tasks of distribution and disposal of saline drainage water. The following quality parameters are monitored: total salinity by solid residue; content of main ions (HC03‘, S04z, CГ, Ca2+, Mg2+, Na++K+); water hardness; physical parameters (water temperature, odor, taste, color); and, biogenic components (NH4, N02, N03, P, Si, Fe).

Water quality standards. On the whole, national systems of water quality standardization in Central Asia contain all the required components to facilitate appropriate monitoring. The current standards needs to be improved for (a) optimization of a vast list of polluting substances; (b) extension of the present limited number of water uses, for which water quality standards are set (household and drinking water, municipal supply and fisheries); (c) consideration of new approaches to regulation of water quality, adoption of new technologies and facilities; (d) harmonization of mechanisms and procedures for water quality monitoring and management, especially in an interstate context.[19]

Surface water quality. Most CA countries use the water pollution index (WPI) for classification of watercourses in accordance with surface water quality. The WPI is calculated as the arithmetic mean value of six key hydrochemical indicators, including the biological oxygen demand (BOD). WPI divides water bodies into seven classes, starting from I (very clean, WPI ≤ 3.0) to VII (extremely dirty, ≥ 10). Since 2015, water quality is estimated by four classes of water classification by the size of the complex water pollution index (CWPI): from I (clean according to the norms, CWPI ≤ 1.0) to IV (extremely high level of pollution, CWPI ≥ 10).

Most surface water bodies in Kazakhstan (as of 2017) (UNECE, 2019[18]) *and Uzbekistan (2017-2018)* (UNECE, 2019[19]) *refer as moderately polluted. In Kazakhstan in 2017, of all surface water bodies monitored, extremely high levels of water pollution were observed in the Kylshakty River, Shagalaly River and Lake Maybalyk. In Uzbekistan, the highest salinity and sulphate contents were recorded in lower reaches of the Zarafshan River, where MAC of sulphates was exceeded 6.1-12.0 times. In 2018, Arnasay Lake (Aidar-Arnasay lake system) fed by collector-drainage water showed the average salinity within 10.3-16.2 of MAC, referring to class IV (polluted water) according to WPI.* (UNECE, 2019[19])

Monitoring of interstate (transboundary) rivers. Water quality monitoring in most interstate rivers in Central Asia is performed by one of riparian countries only; the exception is the Karatag-Surkhandarya and the Chu-Talas rivers and the Amu Darya and the Syr Darya (main course). There is not much observation points for monitoring of water quality in interstate rivers (one point per 200-800 km). The periodicity of taking water samples is low and the spectrum of quality parameters monitored is limited. In Kazakhstan all basic transboundary watercourses are monitored. All posts are active, every year from 12 to 36 samples are taken on them. In Kyrgyzstan the water quality monitoring is carried out in the basin of the Chu River only. In Tajikistan all main interstate watercourses are covered by water quality monitoring system. The intensity of observations on the majority of interstate rivers has reduced over the last years. Thus, from 9 observation points only 6 were more or less active, and only 1-3 samples are taken every year on some posts. In Turkmenistan three monitioring posts provide information on water quality along the Amu Darya River. In Uzbekistan the monitoring of water quality is carried out on the main courses of

[18] Study of the needs of surface water quality monitoring system in Turkmenistan - Almaty, 2018. 68 p.

[19] UNECE & CAREC (2011) Development of regional cooperation to ensure water quality in Central Asia: Diagnostic report and cooperation development plan. http://www.cawater-info.net/water_quality_in_ca/files/diagnostic_report.pdf

the Amu Darya and the Syr Darya, as well as along Surkhandarya and Karadarya rivers. (UNECE, CAREC, 2018[20])

Table 4.3. Water quality observation points on large interstate rivers in CA

Interstate watercourse (>200 km)	Country	Qty of posts	Number of samples per year (2012-16)
AMU DARYA BASIN			
Kyzylsu-Vakhsh	Kyrgyzstan	-	-
	Tajikistan	2	1-9 (1 post active)
Kafirnigan	Tajikistan	1	-
	Uzbekistan	-	-
Karatang-Surkhandarya	Tajikistan	1	3-12
	Uzbekistan	1	11-12
Zarafshan	Tajikistan	1	-
	Uzbekistan	-	-
Amu Darya (main course)	Tajikistan	1	1-2
	Turkmenistan	3	4 (2 posts active)
	Uzbekistan	3	3-12
Total in the basin		***13***	
SYR DARYA BASIN			
Naryn	Kyrgyzstan	-	-
	Uzbekistan	1	5-8
Karadarya	Kyrgyzstan	-	-
	Uzbekistan	1	12
Keles	Kazakhstan	1	12
	Uzbekistan	-	-
Isfara	Kyrgyzstan	-	-
	Tajikistan	1	12
	Uzbekistan	-	-
Syr Darya (main course)	Uzbekistan	2	12
	Tajikistan	2	12
	Kazakhstan	1	14
Total in the basin		***9***	
CHU-TALAS BASIN			
Chu	Kyrgyzstan	9	4
	Kazakhstan	1	36
Talas	Kyrgyzstan	-	-
	Kazakhstan	1	36
Total in the basin		***11***	

Source: UNECE and CAREC (2018) (UNECE, CAREC, 2018[20])

Kazakhstan carries out regular transboundary monitoring and sampling with China and Russia. Since 2002, during annual meetings of the Kazakh-China commission the parties exchange the hydrochemical data on 28 quality parameters of the Ily, Kara-Irtysh, Tekes, Korgas and Yemel rivers. According to an agreement signed in 2010, joint sampling and exchange of hydrochemical information is maintained with Russia on 16 transboundary rivers. Water in the rivers shared with Kyrgyzstan is monitored monthly and every ten days on 48 quality parameters at 8 river sections. Kazakhstan itself performs monthly and ten-day monitoring of water quality on 49 parameters in one section of the Syr Darya River.

Quality of water in the Amu Darya. Water salinity is 0.47-0.58 g/l in upper reaches of the river, increases to 0.69-0.86 g/l in lower reaches close to Tuyamuyun point and exceeds 1.23 g/l at the Nukus city (Samanbai section). The prevalent chemical composition is sulphate-chloride-magnesium-calcium-sodium. (E.I. Chembarisov et al, 2019[21]) Table 4.3 shows dynamics of the average annual salinity in the Amu Darya River over 1960-2017 (SIC's data). The data on average long-term water salinity along the Amu Darya River shows that the limit of allowable water salinity – 1 g/l – is reached close to the boundary with Karakalpakstan and further there is some exceedance of this limit in lower reaches, downstream of Takhiatash and Samanbai. According to the data of acad. V. Yegorov, the acceptable salinity can be 1.5 g/l.

Table 4.4. Dynamics of average long-term water salinity in the Amu Darya River by gauging station, g/l

Year	Gauging station						
	Termez	Kerki	Darganata	Tuyamuyun	Kipchak	Takhiatash	Samanbay
1960- 1970	0.51- 0.57	0.56	-	-	-	0.60- 0.65	0.50-0.51
1971- 1980	0.60- 0.65	0.67- 0.73	0.88	0.68-0.89	1.1	0.72- 0.93	0.69-0.84
1981- 1990	0.57- 0.62	0.73- 0.78	1.05-1.15	0.91-1.07	1.08- 1.12	1.1- 1.15	1.09-1.41
1991- 1995	0.65	0.70	0.70 – 0.99	0.81	0.91 – 1.1	1.03 – 1.22	1.02
1996-2005		0.50	0.66 – 0.85		0.82 – 1.57	0.88 – 1.56	0.95 – 1.66
2006-2016		0.57	0.66 – 0.89		0.75 – 1.0	1.1	
2017		0.64	0.75		-	-	
Average long-term over 1991-2017	0.60	0.56	0.78	0.89	1.10	1.19	1.17

Source: SIC ICWC (2019).(www.cawater-info.net).

Quality of water in the Syr Darya. Elevated concentrations of sulphate compounds (up to 40-45%) are observed in waters of the Syr Darya River in last decades. Ammonium and nitrate nitrogen contents in river water are subjected to seasonal variations. Periods of reduced runoff and intensified anthropogenic impact are characterized by lowering of relative calcium and hydrocarbonate indicators and stability of magnesium ions because of growing leaching of sulphate compounds. (N.S. Sambayev, TOO Kazakh Fishery Research Institute, 2017[22]) According to dynamics of average long-term salinity in the Syr Darya River, water quality is deteriorating. Recent statistics of river water quality confirms negative tendencies towards an increase in river water salinity both in time and space.

The data on salinity in the Syr Darya River indicate to further deterioration of water quality both in upper reaches (Kuiganiar, Kal', Uchkurgan), middle reaches and especially in lower reaches, where salinity increases to 1.5 g/l and more.

Table 4.5. Water salinity in the Syr Darya River by gauging station, g/l

Year	Gauging station					
	Kuiganiar dam	Kal'	Uchkurgan hydroscheme	Akjar	Entry point to Karadarya	Kazalinsk
2000	0.41	0.43	0.41	0.40	0.46	1.55
2005	0.64	0.70	0.45	0.71	0.51	
2010	0.61	0.76	0.54	0.8	0.56	1.62
2015	0.57	0.62	0.48	0.64	0.54	1.48
2019	0.68	0.84	0.55	0.87	0.64	

Source: BWO Syr Darya (2019)

Hence, it is possible to improve the quality of surface water by radically improving operation of drainage systems, reducing discharges of drainage water to rivers and saving water.

Environmental problems in runoff formation area

Upper catchment ecosystems and biodiversity in Central Asia are threatened due to population growth and economic development. Pastures suffer from overgrazing, with consequent deterioration of ecosystem quality. The use of forest timber for heating is another topical problem. Moreover, there is lack of consistent and reliable data on flow formation in highlands. Therefore, systems analysis of current biological resources, ecosystems and biodiversity is needed for highlands.

The runoff formation areas are under risks of mudflows, avalanches, landslides and rock-dammed lake breaches. The Central Asian mountains accommodate 5,600 lakes, most of which pose serious risks for downstream land and structures. Tajikistan is most affected by natural disasters. On average, 170 natural disasters, including 70 mudflows took place in the country over the last 20 years.

In this context, it is essential to enhance regional cooperation, sign agreements, conduct joint research, involve local authorities and NGOs and organize joint monitoring of biodiversity. Joint activities would help to:

- Improve the state of biodiversity, identify rare, endangered and vulnerable species of flora and fauna
- Enhance monitoring and forecast of biological resources
- Re-generate transboundary ecological corridors (especially in highland and alluvial areas)
- Take urgent steps to preserve rare, endangered and vulnerable species
- Develop eco-tourism
- Raise awareness and build local capacities.

There is a need to assess the current state of snow cover and glaciers, analyze current and future climatic processes in highlands, and forecast glacial and snow cover areas, including their behavior. Transboundary monitoring and forecast of glacial structure and processes are advisable to organize in each river basin. Additionally, joint measures are needed for:

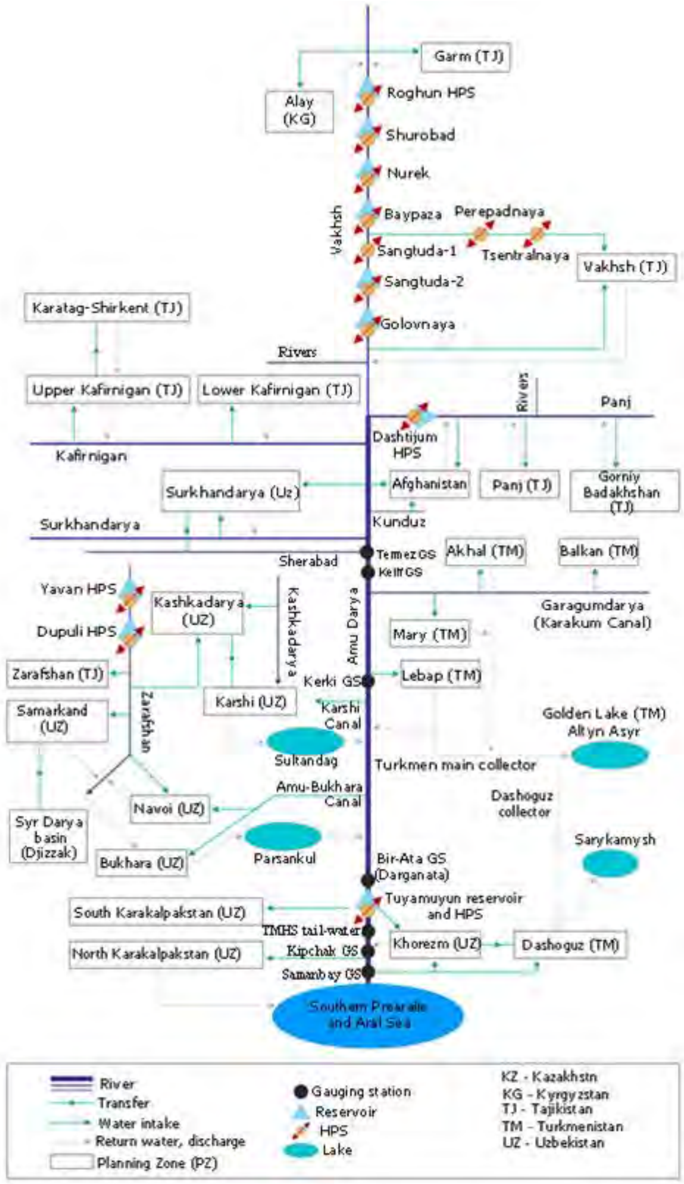
- establishment of a network of weather stations in highlands;
- organization of glacial expeditions (joint groups);
- building of a system for glacial studies based on RS and GIS (volume and coverage);
- assessment of quantity of glaciers and their balance in respective basins (Syr Darya, Amu Darya, Zarafshan, etc.).

Another problem in the runoff formation area is represented by uranium tailings storage sites. According to the State mining wastes inventory, Kyrgyzstan has 92 tailings ponds and slag heaps with toxic and radioactive mining wastes, of which 33 tailings ponds and 25 slag heaps comprising 11.9 Mm3 of wastes are under responsibility of the national Ministry of Emergency Situations. Virtually all those sites are located in interstate basins (Naryn, Mailuu-Suu, Sumsar, Chu) and pose risks for both Kyrgyzstan and neighboring countries. The ongoing climate change is accompanied by enhancement of natural hazards, such as mudflows, floods and landslides in the area of radioactive tailings storage sites, with growing risks of their destruction and resulting ecological catastrophes on a transboundary scale. (O.V., 2016[23])

5 Water Management at National Level

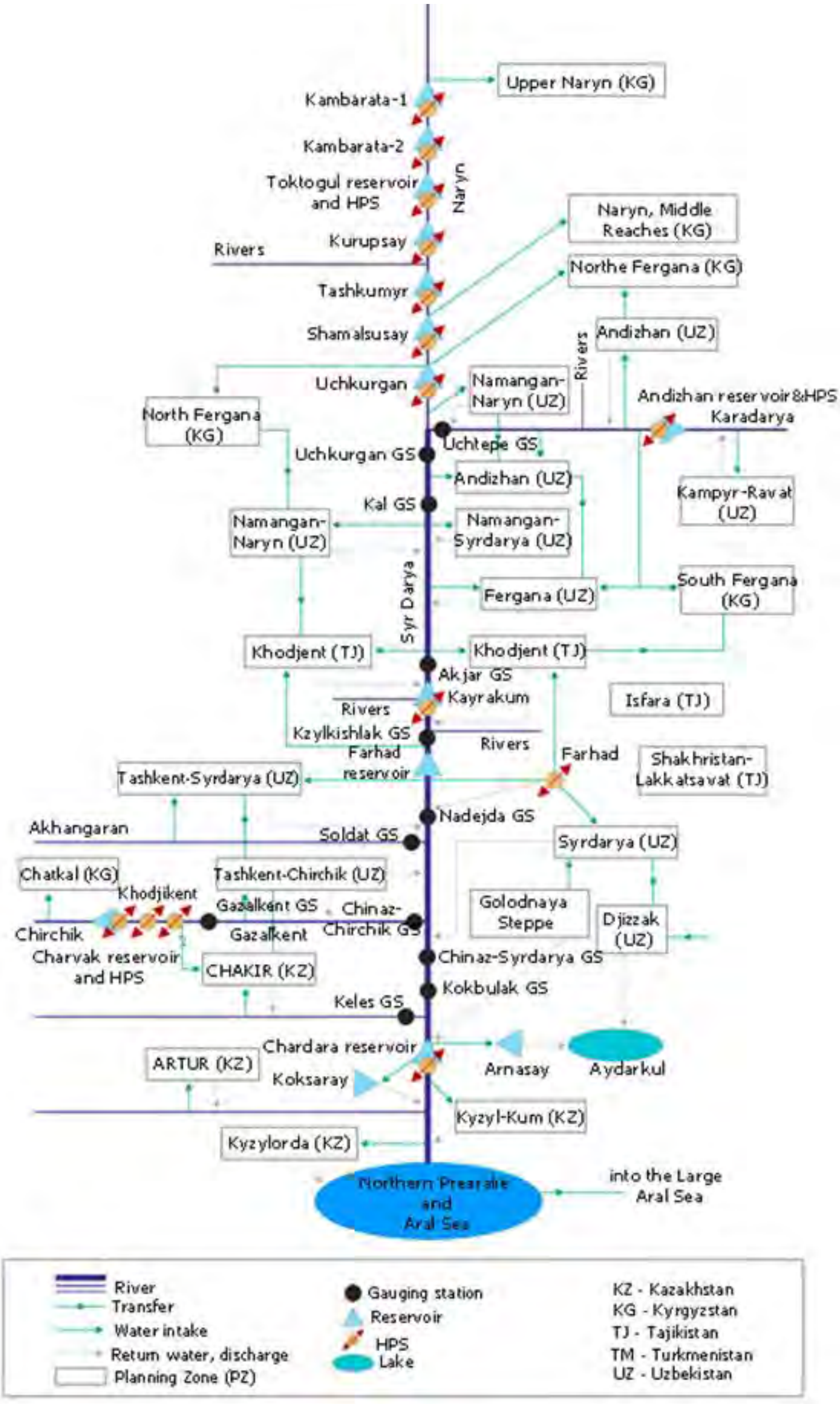
Water management in Central Asia is represented by a complex system comprising a set of regulating and intake structures at interstate and national levels. The complexity of the management system is clearly demonstrated by linear schemes of the Amu Darya and the Syr Darya (Figure 5.1 and Figure 5.2).

Figure 5.1. Linear scheme of the Amu Darya



Source: SIC ICWC

Figure 5.2. Linear scheme of the Syr Darya



Source: SIC ICWC

Legal framework and degree of implementation of IWRM and water conservation

All the CA countries underwent several stages of legal reforms in water management and laid the foundation for implementation of integrated water resources management (IWRM). New water codes that embrace IWRM were adopted in Tajikistan (2000), Kazakhstan (2003), Turkmenistan (2004, 2016) and Kyrgyzstan (2005). Appropriate amendments were made in the Law on Water and Water Use in Uzbekistan (2013).

However, the degree of implementation of IWRM in CA countries is still rather low. Two countries – Kazakhstan and Uzbekistan – provided the data on SDG indicator 6.5.1, which tracks the degree of IWRM implementation across four key components: enabling environment; institutions and participation; management instruments; and, financing. (UNEP-DHI Centre on Water and Environment, 2019[24]) Out of the maximum score of 100, Kazakhstan collected 30 points (low degree), while Uzbekistan collected 45 points (medium-low). (UN WATER, 2019[25])

Kazakhstan has minimum score in “Institutions and participation” (24) and maximum score in “Management instruments” (40). The highest score (60) was given to “Organizational framework for transboundary water management for most important basins/aquifers”, “Sustainable and efficient water-use management from the national level” and “Basin management instruments”. Uzbekistan has the lowest score in “Financing” and the highest one in “Management instruments”.

The “Revenues raised from dedicated levies on water users at basin, aquifer or subnational levels” of the “Financing” component collected the lowest score (20) in Uzbekistan. The highest score (70) was given to “National monitoring of water availability”, “Organizational framework for transboundary water management for most important basins/aquifers”, and “Arrangements for transboundary water management in most important basins/aquifers”.

Unfortunately, full implementation of all components of IWRM have not been achieved in the countries. High effectiveness of IWRM in enlargement of water reserves was proven by the project “Integrated Water Resources Management in the Fergana Valley” (IWRM-Fergana) successfully implemented in four provinces in Kyrgyzstan, Tajikistan, and Uzbekistan by national water agencies, SIC ICWC and IWMI, with the support of SDC. All components of IWRM – hydrographic principle, public participation, updating of water requirements, inter-sectoral and inter-level coordination, improvement of water accounting, water conservation, and consideration of environmental demand – were developed in the project. As a result, on an area of 130,000 ha of agricultural land, water withdrawal into irrigation system decreased from 1 billion cubic meters per season to 750-800 million cubic meters from 2004 to 2010 and to 670 cubic meters in the dry year 2008. Moreover, thanks to introducing extension services in the project area, land productivity was improved substantially and water productivity increased twofold. At the expense of $7 million spent by the project, 200 million cubic meters of water were saved a year in addition to increased agricultural production.

It should be noted that national funds are not enough for implementation of large-scale projects on IWRM and water conservation. Therefore, contributions of donors to such projects as the project of the Asian Development Bank (ADB), which approved the loan of $249.8 in local currency (tenghe) to the republican state enterprise “Kazvodkhoz” for rehabilitation and improvement of irrigation networks serving 171,000 ha in four provinces in Kazakhstan, are very reasonable. The loan will be implemented in East-Kazakhstan, Karaganda, Kzyl-Orda and Zhambyl provinces. It is planned to rehabilitate and improve about 245 irrigation schemes, including coating and repair of canal sections. The total length of newly coated canals will be about 1064 km, and 1976 km of earthen channels will be improved. Other infrastructural measures include construction and reconstruction of 4185 hydraulic structures, including water meters; improvement of 358 km of collecting drains; installation of drip irrigation system on 9300 ha in Zhambyl province; and, installation of 24 supervisory control and data acquisition systems.

Recently, drip irrigation has become widespread in the region as one of major directions of water conservation. This irrigation technique is introduced on 25,000 ha annually in Kazakhstan and Uzbekistan, respectively. By the beginning of 2019, the area covered by drip irrigation reached more than 70,000 ha in each of the countries. Additionally, Uzbekistan practices irrigation from mobile flexible hoses on 83,000 ha and furrow irrigation under film on 26,000 ha.

Water management organizations

Water management in the CA countries is under responsibility of relevant ministries, committees, agencies and their territorial divisions that have common characteristics and also differences in the water-management hierarchy (Table 5.1).

National water management agencies in the CA countries have different status and undergo regular organizational changes. As a whole, since gaining independence, the water sector in all the CA countries has lost its integral nature and power. This had a negative effect on the quality of state water regulation, the financial and technical basis of the former single sector, and the capabilities to invest in technology, innovations and human resources. At present, some countries have started to restore the higher status of national water agencies. In 2018, the Ministry of Water Management was established in Uzbekistan; in 2019, the State Agency for Water Resources was formed at the Kyrgyz Government and the State Committee for Water Management was established in Turkmenistan.

In the course of institutional reform in Tajikistan, policy-making and governance functions were separated from management and operation functions in the water sector. In 2013, the Ministry of Energy and Industry was re-organized into the Ministry of Energy and Water Resources of Tajikistan (MEWR) assigned with water policy-making and governance. At the same time, the Agency for Land Reclamation and Irrigation was formed at the Government of Tajikistan. In 2014, Open Joint-Stock Holding “Barki Tojik”, which was responsible for operation and maintenance of projects in the hydropower subsector, was removed from MEWR.

For implementation of the basin principle of water management, territorial water-management organizations at **provincial level** were transformed into **basin organizations** in Kyrgyzstan and Uzbekistan. However, despite such re-organization, a number of basin organizations still have had their authorities within former provincial boundaries.

Water-management organizations at the **level of irrigation systems** were traditionally established on the basis of both hydrographic principle (Irrigation System Administrations) and administrative-territorial principle (District Water Management Authority). In 2003, district water management authorities were closed down in Uzbekistan; however, at present, they have been got back in place. This level of water management is characterized by a certain degree of stability and adherence to a more traditional way of management by state water bodies. These bodies do not interact with stakeholders directly due to WUAs establishment.

After disruption of the former system of cooperative and public land use, the **former on-farm water use has turned to be the most sensible part in the system of water supply to farmers.** At the local level, water management is under competence of users’ organizations. Those organizations have different forms: water user/consumer associations (WUA/WCA) in Kyrgyzstan, Tajikistan, and Uzbekistan; agricultural production cooperatives (APC) in Kazakhstan; and, peasant (daikhan) farm unions (PFU) in Turkmenistan. Those organizations of water users remain the weakest chain in water hierarchy of the CA countries (except for Turkmenistan). Virtually all WUA’s bodies (general assembly, council, arbitration commission, inspection committee) do not function or have deficiencies in functioning. Because of poor material base, lack of efficient loan system and not sufficiently clear legal status, WUAs do not get state support, despite partial fulfillment of public functions on water delivery to end users, and, due to huge debts from the side of water users, cannot function sustainably. There is a vicious circle: poor financial viability of WUA is the consequence of low level of fee collection for irrigation services provided by WUA, while the low level of fee collection is the result of poor quality of the irrigation services, which is caused by weak financial viability of WUA. It is obvious that this vicious circle cannot be broken unless effective state support is provided. As a way out of such situation, it is proposed to introduce mechanisms of public-private partnership to WUAs. Also, a note of hope remains that the establishment of the cluster-based system can help to improve the water use system in the agrarian sector.

Table 5.1. Governance and management bodies at different water hierarchical levels in CA

Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Inter sectoral level				
Inter-agency Council on Water Resources at the Government	National Water Council	Water-Energy Council at the Ministry of Energy and Water Resources	Water Council at the State Committee for Water Management	Water Council at the Ministry of Water Management
Sectoral level				
Committee for Water Resources of the Ministry of Ecology, Geology and Natural Resources	State Agency for Water Resources at the Government	Ministry of Energy and Water Resources Agency for Land Reclamation and Irrigation at the Government	State Committee for Water Management	Ministry of Water Management
Inter-basin level				
			Garagumderya-suvkhodjalyk Administration	Administration of Operation of Large Main Systems
Basin (provincial) level				
Basin Inspectorates Provincial Departments (Branches) of RSE "Kazvodkhoz"	BasinWaterAuthorities	State Provincial Authorities for Land Reclamation and Irrigation	Provincial (veloyat) Water Authorities	BasinIrrigationSystem Authorities
Basin Councils	Basin Councils	-	-	Basin Councils
Irrigation system level				
-	-	State Authorities of Main Canals	Canal Operation Authorities	Irrigation System Authorities
District Production Units	District Water Management Authorities	District Water Management Authorities	District (etrap) Water Management Authorities	District Irrigation Departments
Lowest (local) level				
Agricultural Production Cooperatives	Water Use Associations and their Unions	Water User Associations	Peasant (daihan) Farm Unions	Water Consumer Associations

Source: Compiled by authors (2019)

Organizations of water users in CA differ between countries in size, membership, tariff rates for irrigation services, irrigation fee collection, salaries of staff, equipping with communication and transport, and functions delivered. APC (Kazakhstan), PFU (Turkmenistan) and WUA (Tajikistan), in contrast to WUAs in Kyrgyzstan and Uzbekistan, are multipurpose organizations that offer both water delivery and other services to farms. In Kazakhstan, such organizations were established initially in the form of WUA and later on were transformed into "Limited Liability Partnerships" (LLP) or “Agricultural Cooperatives of Water Users” (ACWU). In 2015, ACWU and other water user organizations were liquidated and replaced by agricultural production cooperatives (APC). The difference between ACWU and APC is that, first, the latter is commercial and, second, multipurpose organization, which renders services to peasants – members of APC (consultations, searching and delivery of fertilizers and fuel, marketing, etc.).

Currently, the countries search for ways to improve water user organizations through their integration and/or consolidation. The attempts to integrate WUAs into unions are made in Kyrgyzstan. It is supposed to establish district-level WUAs instead of existing ones in Uzbekistan. Moreover, formation of agro-clusters in Uzbekistan will call for revised forms of interaction between water and agricultural organizations at the local level.

Further steps in the establishment of Water Consumer or User Associations (WCA or WUA) have yet shown low productivity in general. Although in other countries (Turkey, Spain, Italy) WUAs proved themselves as an organization of users that manages and delivers water, WUAs' functions in the region are still unsatisfactory.

Inter-sectoral relationships and stakeholder involvement

For implementation of the IWRM principle - consideration of all types of water users and inter-sectoral coordination - attempts are made to establish organizations of inter-sectoral status in the form of **national water councils or basin water councils**. However, at national level the functions of inter-sectoral coordination are still fulfilled by water management ministries or departments, while national water councils play insignificant role. **At basin level**, there are difficulties in establishing or appropriate functioning of already formed basin councils. In most cases, the basin councils, as judged from their by-laws, functions and composition, are mainly technical management bodies rather than joint governance bodies involving all stakeholders. Basin councils are mainly comprised of the heads of BWO's branches, at which the former is established. This means that Council's members largely are water suppliers and include no or very few water users. In this context, yet the community is not actively involved in decision making, and activity of the basin councils is rather formalistic and its role as a governance body is still very small. **The exception is Kazakhstan, where basin councils function quite successfully**, though with some problems.

Most water managers at all hierarchical levels, including the interstate one, are **skeptic about the idea of involving stakeholders in decision making**. They think that water professionals should deal with water management, whereas a need to reach approval of decisions by BWU reduces responsiveness of management measures. One reason of such skepticism about public participation is that water actors (both stakeholders and managers) have wrong understanding of the functions of water governance bodies. The water governance bodies should not deal with the current routine water management but rather with the matters related to the improvement of water management in the short- and long-term.

Irrigation service fees

Water management reforms in the CA countries stipulate promotion of market principles to reduce water demand. For encouragement of better irrigation water management and water conservation, some CA countries apply water charges: Kazakhstan since 1994; Kyrgyzstan since 1999; Tajikistan since 1996. Operation and maintenance (O&M) of hydraulic structures at basin (provincial) and upper levels are financed by state budgets of the countries, while O&M at system (district) level is covered through both state budgets and fees collected from water users for irrigation services provided.

Water users in Kazakhstan, Kyrgyzstan and Tajikistan pay for irrigation services provided by both water-management organizations (WMO) and water user organizations (WUO). In Uzbekistan and Turkmenistan, water users pay for services provided by water user organizations only, while the irrigation services provided by state water-management organizations are still free. Tariff rates for irrigation services differ, depending on service provider and country (Table 5.2).

Table 5.2. Tariff rates for irrigation services in Central Asia countries (2019)

Country	Service provider	Tariff	
		National currency	US$*
Kazakhstan**	WMO	16.135 tenghe/m^3 (pumped irrigation)	4.15 cent/m^3
		29.5 tyin/m^3 (gravity irrigation)	0.074 cent/m^3
	APC	1600 – 2500 tenghe/ha	4.1 – 6.43 $/ha
Kyrgyzstan	WMO (DWMA)	3 tiyin/m^3	0.043 cent/m^3
	WUA Union	4 tiyin/m^3	
	WUA	400 – 800 som/ha	6 – 11 $/ha
Tajikistan	WMO	2*** diram/m^3	0.21 cent/m^3
	WUA	40 – 120 somoni/ha	4 – 12 $/ha
Turkmenistan	PFU	3% of farm's yield	
Uzbekistan	WCA	25 – 50 thousand soum/ha	2.6 – 5.2 $/ha

Note: * Exchange rate: $1=388.62 tenghe (Kazakhstan), $1=70 som (Kyrgyzstan), $1=9.52 somoni (Tajikistan), $1=9,500 soum (Uzbekistan)
** In 2018, Kazakhstan established uniform tariff for all provinces. Earlier, tariffs differed by province. It is planned to raise irrigation service tariffs every year (until 31.07.2023). Here, tariffs are given on WMO (excluding VAT) for 01.08.2019 to 31.07.2020. Kazakhstan also practices tax on water as a resource besides payment for irrigation services.
*** Until 2018, the tariff was equal to 1.5 diram/m3
Source: Compiled by authors based on interviews and field visits (2019)

Relative payment (actual/plan, %) and especially unit payment ($/ha) for irrigation services provided by WUO are insufficient, and, hence, major problem for most WUOs in CA countries is the lack of funds. This does not allow such organizations to employ as many mirabs (person, who distributes water between users) as needed to ensure the required quality of irrigation services to meet user needs. Relatively better situation with viability of water user organizations is in Kazakhstan, while the worst one is in Uzbekistan.[20]

The collected irrigation service fees in the CA countries are not enough to cover O&M and, all the more, ensure high quality of O&M of irrigation and drainage systems that are under responsibility of WMOs and WUOs (especially in pumped irrigation areas). Therefore, water charges are a weak incentive for better water management here. On the other hand, raising tariffs for irrigation services is a challenging issue as this depends on capabilities and willingness of users to pay for irrigation services. Failure to consider those factors may lead to social tension.

The Kazakh Government subsidizes user's costs related to irrigation services. Initially, the subsidies were allocated via WMO, which consequently reduced irrigation service tariffs by 40%. Later, subsidies were given via ACWU. At present, subsidies are given directly to peasants. The subsidies amount to 12,000 tenghe per 1 t of raw cotton. Thus, particularly thanks to the subsidies, institutional and financial viability of water user organizations is well higher in Kazakhstan than in other CA countries.

There is no objective evidence so far that the introduction of water charges in CA has brought expected outcome. This is because the tariffs for irrigation services provided by water-management organizations and water user organizations and the collection of fees are not sufficiently high to encourage water saving at field level and improve water management at system and local levels. State water management organizations and user organizations cannot be interested in water saving as, in general, the

[20] In Uzbekistan, it is planned to replace existing WUAs with district-wise WUAs. There is no good reason to suppose that re-organization of WUAs will lead to better water management at the local level. It is well-known that the causes of poor viability of existing WUAs are: weak protection of farmer's rights to land and water; interference of local authorities in water distribution; absence of an alternative to 'state order', etc.

funds collected from provided services depend on the amount of delivered water – the less water is delivered, the lower will be the payment for irrigation services, and, on the other hand, water users are not interested in voluntary water saving as water is distributed 'by sight' and the payment for irrigation services is area-wise and does not depend (or depends to a lesser degree) on the actual amount of water received by user.

Also, comparison of wages in water-management organizations in Kazakhstan with those in Kyrgyzstan, Tajikistan and Uzbekistan shows that the average wage of mirab is 80,000 tenghe or $206 in Kazakhstan against $100 in other CA countries. In places, where such wages are practiced, e.g. in Djetisai district of Turkestan province (Kazakhstan), the recorded water saving is more than 10%. Inability and unpreparedness of farms to pay higher irrigation service fees are mainly the result of low level of incomes. The lack of political will to change relations in agriculture and water sector also contributes to such situation.

Human resources

Because of financial difficulties in the CA countries since gaining independence, water management organizations tended to reduce their staff, while ignoring existing staffing requirements. In Uzbekistan, employees at all levels, especially the administrative and management personnel have been reduced. In the near future (early 2020), it is planned to reduce the staff of territorial branches of the Ministry of Water Management of Uzbekistan additionally by 20%.

Similar problems also exist in other CA countries. "In 1991, 38,500 specialists worked in the Kazakh water sector, particularly in design, construction, operation and basin organizations serving 2.3 Mha of irrigated land and the entire water infrastructure in the Republic (i.e. 17 specialists per 1,000 ha). For comparison: 5,000 specialists are employed in the national water sector at the moment (i.e. 3 specialists per 1,000 ha)"[21].

The water education and training system also needs to be improved cardinally.

Water Education System[22]

Until 1990, water education was based on a common for all HEIs curriculum, which was improved regularly, and a system of education was focused on preparation of multidiscipline specialists, taking into account diversity of water uses in national economies (irrigation, drinking and household water supply, agricultural water supply and flooding of pastures, industry, hydropower, etc.).[23] Full education, including building skills in survey work, design, construction and operation of water and hydropower facilities, forms the base of those curricula.

During the years of independence, the general state of higher education in Central Asia is characterized by an increase in the number of higher education institutions against a decrease in qualification requirements for research and teaching and by fragmentation of educational systems. Graduates that search for work in the water sector often do not meet the requirements of employers: lack of basic knowledge, poor engineering training, lack of skills to design water facilities, make assessment and analysis of problems and propose fully-fledged solutions on land reclamation and irrigated agriculture, taking into account current realities and prospective developments in the sector.

[21] Information of the national consultant on Kazakhstan S.Ibatullin.

[22] Prepared using materials of a review of the current state of water education in Central Asia; this review was made by a group of national and WB experts in 2018 under the prof. S. Ibatullin leadership.

[23] According to the Order of the Ministry of Higher and Secondary Specialized Education of the USSR № 831 of 05.09.1975, specialists for the water sector were prepared in 15 specializations and 7 fields.

Shortcomings of the existing water education system in the CA countries include among others:

- Mismatched curricula and education programs, inadequacy of specialization categories and blocks to qualification requirements, national and international standards, lack of future-oriented specialization fields that are relevant for future tasks set before the water sector;
- Lack of methodological base, experience and flexibility in teaching some disciplines to create a real system of continuous education in the Bachelor-Master-Doctoral chain;
- Insufficient usage of modern teaching technologies combined with advanced experience, latest achievements in interactive learning; absence of a regular training system for teaching staff;
- Outdated material and technical base of universities, lack of modern instruments and equipment;
- Insufficient interaction between industries and HEIs, involvement of employers in the development of curricula and organization of the educational process, low employment of graduates;
- Poor communication with sectoral research institutes and engagement of students; narrow thematic focus of performed work;
- Weak communications for academic mobility of students and academic staff, etc.

Water Sector Professional Development

In Kazakhstan [24], according to Regulations of the Committee for Water Resources at the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, the Committee's Chairman is responsible for the issues related to "training (retraining) and professional development"[25], while organization of vocational training is entrusted to territorial subdivisions under the jurisdiction of the Committee: Basin Inspections for Regulation of Water Use and Protection. Kazakhstan makes significant efforts to improve skills of personnel in the field of water: several training centers were established. However, those do not meet all needs of the sector in terms of scope of topics, coverage of target audience, provision with staff, teaching and learning materials, and material and technical base. In this context*, there is no well-organized system for water sector professional development in the country at the moment.*

In the Kyrgyz Republic, training centers were available in Bishkek and Osh for organization of training programs and seminars at the Department of Water Resources and Land Reclamation ((DWRLR) before its reorganization. In addition to training centers established at HEIs (KNAU named after K. I. Skryabin, Kyrgyz-Russian Slavic University named after B.N. Yeltsin, KSUCTA, etc.), vocational training is provided by NGOs as well: Training Center at KyrgyzHydroMet, National Water Partnership in Kyrgyzstan, and Training, Advisory and Innovation Center, etc. However, despite the need for water sector professional development, *there is still no base for its systematic and sustainable arrangement.*

In the Republic of Tajikistan, there is no training center for vocational training on systematic and regular basis at the moment. There are a number of centers that conduct water trainings: HEIs (Tajik Agrarian University named after Sh.Shotemur, Osimi Technical University), research institutes (Institute of Water Problems, Hydropower and Environment of the Academy of Sciences of Tajikistan, Tajik NIIGiM, institutes of the Tajik Academy of Agricultural Science), Training Center of the Agency for Land Reclamation and Irrigation at the Government of Tajikistan and some non-governmental organizations (as part of projects, with poor capacities). However, *the Republic of Tajikistan yet lacks a special document on establishment and strengthening of the water sector professional development system and the relevant institutional framework for vocational training needs to be strengthened and developed further.*

[24] Expert assessment of the existing training centers for water sector professional development in the CA countries was carried out by SIC ICWC on request of CAREC (2017, project "Promoting dialogue for conflict prevention related to environment, water nexus issues in Central Asia: Central Asia Water Nexus Cooperation" (*CAWECOOP*)

[25] Kazakhstan: National Organizations. Regulations on the Committee for Water Resources of the Ministry of Agriculture of the Republic of Kazakhstan// **http://www.cawater-info.net/water_world/kazakhstan.htm**

In Turkmenistan, there is no training center for vocational training on systematic and regular basis. Water sector employees, in general, improve their skills through participation in regional and other programs. Before reorganization, regional (velayat/provincial) agricultural production associations at the Ministry of Agriculture of Turkmenistan organized training courses within their competence and territorial jurisdiction and, as a rule, with involvement of leading experts in the relevant field and with the assistance of the higher authority. Resource centers and HEIs of Turkmenistan (Agricultural University of Turkmenistan named after S.Niyazov, Turkmen State University named after Makhtumkuli, etc.) are sufficiently well-equipped, where it is possible to organize professional development courses. The Centre of Technologies at the Academy of Sciences, "TURKMENSUVYLYMTASLAMA" of the Ministry of Agriculture and Water Resources, and the National Institute of Deserts, Flora and Fauna at the State Committee for Environmental Protection and Land Resources of Turkmenistan can also be involved in this process. *There is a high need to improve competences of water staff in Turkmenistan, but there is still no a comprehensive system of professional development.*

Uzbekistan has a well-developed legal framework that supports provision of the water sector with highly qualified personnel, and unlike other countries in the region, the Republic has managed to preserve and maintain the system of water sector professional development at premises of TIIAME (Center for Vocational Training and Retraining of Personnel). The Uzbek Ministry of Water Management has a budget for organization of regular training courses and engages national HEIs and SIC ICWC in this work.

At the regional level, there is a Regional Training Center (RTC) at SIC ICWC, which was established in 2000 by the decision of ICWC to: (1) maintain and improve personnel's skills and knowledge, and (2) strengthen cooperation between countries in the region and develop common approaches to the use and management of water resources in the region. (SIC ICWC, 2002[26]) *By present, activity of RTC has gone down due to the lack of funding from the founder-states of ICWC and from international donors.*

Among the key problems of vocational training at the national and regional levels are:

- Strong dependence on donor aid for organization of training and insufficient financial public support to ensure a systematic and long-term approach to water sector professional development.
- Poor coordination between national, regional, and international organizations that leads to duplication in some fields and lack of attention to other ones.
- Lack of clear standards on periodicity of courses, number of trainees and development of training, methodological, logistical and other bases.
- Disconnection of vocational training activities for the regional water sector from national education systems in the Central Asian states.
- Lack of efficient incentives for water professionals to improve their skills.

Research and design framework of water management

By 1990, Central Asia had the most powerful research and design capacity, with the most qualified professionals over all post-Soviet space. The mighty school of Russian hydro-technicians, starting with G.K. Rizenkampf, V.V. Poslavskiy, A.M.Askochenskiy, V.D. Zhurin, etc., created the most powerful school of water and irrigation science and design.

In Central Asia, there were more than 20 research and 20 design organizations, with more than 2,000 people working in each of such institutes, such as Sredazgiprovodkhozkhlopok, Kazgiprovodkhoz, CAO Gidroproekt, Tajikgiprovodkhoz, and Turkmengiprovodkhoz. The Central Asian research and design institutes worked in all fields of water, hydrology, hydrometeorology, irrigated agriculture, drainage, mechanized land reclamation, and riverbed processes. It is not a coincidence, therefore, that a huge number of water meters, technical solutions and advanced technologies were developed in Central Asia and spread from here to the whole Soviet Union and even beyond. Additionally, comprehensive construction and development of land in the Golodnaya Steppe and then in Karshi and Jizzak Steppes and Karakalpakstan served as examples of how to address the problem of employment and ensure fundamental growth of agriculture in the arid zone. This is why Central Asian experts worked in Afghanistan, Algeria, Yemen, Lebanon, Egypt, Mozambique, Angola, Iraq and many other countries.

Since independence, the transition period in the Central Asian states resulted in substantial budget cuts for research in the water sector and consequent lowering of research capacity. More than dozen research institutes were active in the region; the largest of them was Scientific and Production Association "SANIIRI", with research, engineering and implementation staff of 1,300 people and the total budget of 14 million rubles. If we take into account that additionally the Institute of Water Problems, TIIAME, Gidroingeo, and 4 design institutes, with research departments and laboratories, and geographical faculties in 5 universities were functional in the field of water in Uzbekistan, the budget for research and adaptation was about 30 million rubles per year. This accounted for 3.37% of the total budget (890 million rubles) of water management organizations in Uzbekistan. At present, the budget of research institutions in Uzbekistan is $1.5 million plus almost the same amount granted by IFIs. Given the budget and capital investments of $700 million in the water sector, the relevant research budget accounts for 0.4% or *ten times less!!!*

The State Programs on Irrigation Development and Land Improvement in the Republic of Uzbekistan adopted in 2007, 2013 and 2017 for sustainable and favorable state of irrigated land and implementation of a set of measures for the development of irrigation, improvement of irrigated land and efficient use of water and land resources also lack the block for "scientific justification of the activities envisaged in the State Program".

The design institutes were destructed mainly because of the fact that design of new facilities was primarily financed by donors, which established their own rules for participation in design work on the basis of Western system of tenders. Tenders were to be secured with cash collateral. Under transition period, obviously design institutes did not have enough resources and they were forced to serve as sub-contractors of foreign consultants. At the same time, the state neglected its design capacity and, as a result, a huge amount of design materials accumulated over the years, including cartographic materials and know-how found its way into the hands of foreign companies almost free of charge.

At present, the task is set to rehabilitate this design and research capacity, build new laboratories, provide the institutes with equipment and high-qualified staff. It is more complicated to improve the water sector and rehabilitate and build capacities than construct new structures and develop new land. In this context, high-class professionals are needed. Rehabilitation of both research and design institutions and their effective interaction will help the Central Asian water management organizations to grasp new areas, such as the transfer of the fraction of Siberian rivers flow to Central Asia, the development of interconnected water management system in Central Asia, where the interests of hydropower, environment, and irrigated agriculture are addressed based on automation, digitization, and remote sensing. Such program was already prepared three years ago, and unfortunately, was not supported in sectoral development. We hope that water leaders will gain understanding that progress in water management and conservation is indispensable of solid research, engineering and design capacity.

Water information systems in Central Asia

Among the Central Asian countries an online national water information system (accessed by authorized users) exists in Kyrgyzstan only. The **Kyrgyzstan's**[26] water information system is a distributed database containing textual and geo-referenced spatial data stored on different servers but integrated via a network system and on the web-site of the State Agency for Water Resources at the Government of KR. Its integral "Water Use" information system is designed for real-time analysis, planning and record-keeping of irrigation

[26] https://www.water.gov.kg/index.php?option=com_content&view=article&id=426&Itemid=1524&lang=ru

water supply. This information system is used only by the State Agency for Water Resources and its branches at district and basin levels. The system consists of three main sections: 1) reference information; 2) irrigation water distribution planning; 3) water supply to farm businesses (http://wuse.water.gov.kg/).

The automated information system of state water cadaster was to be completed by 2020 in **Kazakhstan** as was provided for by the Kazakh President's Decree No. 786 of 4 April 2014[27]. For a number of reasons, the system has not been finalized (web search of IS gives no results). As reported by the EB IFAS in the Republic of Kazakhstan[28], at present, according to a decision of the national Security Council and the Development Strategy 2050, the Institute of Geography together with its partners develops two large scientific and technological projects – Water security in the Republic of Kazakhstan: geospatial information system "Kazakhstan's water resources and their use" and Water security in the Republic of Kazakhstan: sustainable water supply strategy.

By May 2020, as part of the Program of water sector reform in **Tajikistan** for 2016-2025 approved by the Government Decree No. 791 of 30 December 2015[29], a draft Concept of the national water information system for the Republic of Tajikistan (NWIS) has been developed. NWIS is to accumulate the data on water quantity and quality, water rates and limits, water catchments and basins, hydrotechnical constructions, special water use permissions, etc. from 10 authorized state agencies. The Ministry of Energy and Water Resources, including future River Basin Organizations (RBO), the Agency for Land Reclamation and Irrigation, Open Joint-Stock Holding (OJSH) "Barki Tojik", Hydromet, GUP "HMK" (household sector) and other large water supply operators are the key agencies for NWIS. The information in NWIS will contain both tabular data, including on river runoff, water releases from reservoirs, irrigated area and water delivery to irrigation systems, and geo-referenced spatial data on inventoried water-management sites and irrigation system geometries. By present, the Water Information Center has been established at the Ministry of Energy and Water Resources, as well as sectoral information centers at OJSH "Barki Tojik", Hydromet, GUP "HMK" and other.

At the meeting of the Cabinet of Ministers of **Turkmenistan** on 9 February 2018[30], the Head of State gave instructions to develop a "Program of water sector development in Turkmenistan for 2018-2030". The President has outlined a number of current tasks to be solved for efficient utilization of the existing potential of the national water sector and improvement of its functioning. Among the key focus topics of the Program is the development of an integrated scientific and technological information system.

In **Uzbekistan**, the Decree of the President of RUz "On approval of the Concept of water sector development in the Republic of Uzbekistan for 2020-2030" provides for the development of "a single water information system based on the up-to-date methods of record-keeping of water distribution and consumption, collection and analysis of information on water volumes and storage, collection of data on water resources, demand and supply"[31]. The Ministry of Water Management is assigned responsible for this activity direction. At the same time, the existing Decree of the President of RUz No. UP-5883 of 26 November 2019 "On measures to improve water management in the Republic of Uzbekistan for greater access of population to drinking water and improvement of drinking water quality" assigns the Uzbek Ministry of Housing and Communal Services additional tasks on "coordination of adoption of up-to-date innovation technologies in the water use area, including the automated water quantity and quality monitoring system, and their integration into a common national water balance information system".[32]

A number of international donors supported these activities in Uzbekistan. For example, the Korean International Cooperation Agency (KOICA) carries out a project for the Ministry of Water Management on implementation of ICT in the national water sector in Uzbekistan. As part of the project, the Master plan of

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[27] Decree of the President of Kazakhstan No. 786 of 4 April 2014 "On the State water management program and supplements to the Decree of the President of Kazakhstan No. 957 of 19 March 2010 on approval of the list of state programs". Repealed by the President's Decree No. 420 of 14 February 2017. Available on: http://adilet.zan.kz/rus/docs/U1400000786

[28] http://kazaral.org/bezopasnost-kazaxstana-v-kazhdoj-kaple-vody/

[29] https://www.mewr.tj/?page_id=447

[30] https://uzbekistan.tmembassy.gov.tm/ru/news/9964

[31] http://www.water.gov.uz/ru/posts/1545735855/396

[32] https://uza.uz/ru/documents/o-merakh-po-sovershenstvovaniyu-upravleniya-vodnymi-resursam-27-11-2019

the common water information system has been developed. The EU Program “Sustainable management of water resources in rural areas in Uzbekistan” contains the component “National framework concept for water management and integrated water resources management” implemented by GIZ in cooperation with the Ministry of Water Management and among the project deliverables is the development of water cadaster in Uzbekistan.

At present, there is no common water information system available **at the regional level** in Central Asia. The Regional Information System on water and land resources in the Aral Sea Basin[33] (CAWater-IS) developed by SIC ICWC with SDC’s support covers only the Aral Sea basin (full territories of Uzbekistan and Tajikistan and provinces in Kazakhstan, Kyrgyzstan, and Turkmenistan that fall within ASB), which is within the scope of ICWC. The useful tool developed as part of the project for Central Asian water professionals – “Analysis of water-related situation in river basins of Amu Darya and Syr Darya”[34] – provides analytical reviews that give possibility to assess water management situation along the Amu Darya and the Syr Darya and their reaches. The data contained in CAWater-IS is also used in the Aral Sea Basin management model (ASBmm, http://asbmm.uz:2017/index.php/), which was developed to judge on correctness and timeliness of decisions made. Finally, an online tool “Water Use Efficiency Monitor in Central Asia” was developed from 2015 to 2019 within the CAWa project, the Regional Research Network “Water in Central Asia”, funded by the German Federal Foreign Office (WUEMoCA, http://wuemoca.net/app/). The online tool provides access to information on irrigated areas on province or district scale, crop yields for cotton, rice, wheat, vegetables and fruits based on open-source optical remote sensing products (MODIS 250 m) and climate data.

The current legal framework as applied to exchange of water information is mainly comprised of documents in the nature of a declaration, having no binding force and enforcement mechanism and lacking needed financial support. It was attempted within the framework of ICWC to put the development of a common regional information system on a legal basis. A draft Agreement was developed between the Governments of Kazakhstan, Kyrgyzstan Tajikistan, Turkmenistan and Uzbekistan on the information and analytical support of water management, use, and protection in the Aral Sea Basin and the arrangement of interstate exchange of information. The matter was repeatedly discussed during ICWC meetings and, eventually, the 74th ICWC meeting made the following decision: “2. Take into account the fact that the Tajik side refrained from work under the Draft Agreement until its own national information system of water resources was developed.”

The regional project “Capacity building in data administration for assessing transboundary water resources in the EECCA countries”[35] funded by FFEM (French Global Environment Facility) with participation of the IFAS Executive Committee, the International Water Assessment Center (IWAC) c/o Slovak Hydrometeorological Institute (SHMI) was implemented in 2010-2013. The project has produced the data metabase on all water and environmental information resources in Central Asia. Unfortunately, the server with the project results has not been accessible anymore, even in web-archive (http://web.archive.org/).

The Coordination group on regional space for water, energy, environmental and hydro-meteorological information was established with the support of UNECE in 2015-2016[36]. The Group consisted of representatives of EC IFAS, the Secretariats of ICSD and ICWC, SIC ICSD, SIC ICWC, BWO Amu Darya, BWO Syr Darya, CDC “Energy”, the Regional Center of Hydrometeorology, the Regional Mountain Center of CA, and CAREC. The objective of the Coordination group was to develop a regional platform for improved information management via the existing information space on water, energy, environment and hydrometeorology in CA to contribute to more effective decision support for IFAS founding states and organizations. However, further activities of the Group at the regional level have been stopped due to lack of donor’s financing.

[33] http://cawater-info.net/carewib/index.htm

[34] http://cawater-info.net/analysis/

[35] FFEM Project / Capacity building in data administration for assessing transboundary water resources in the EECCA countries. Project information can be found on https://www.iowater.org/projet/ffem-project-capacity-building-data-administration-assessing-transboundary-water-resources. Project server - https://www.aquacoope.org/ffem-eecca – has not been accessible anymore.

[36] http://cawater-info.net/information-exchange/

6 Water Management at Interstate Level

Legal framework

The foundation of the current water management in the Aral Sea basin were laid by the Agreement on Cooperation in the Field of Joint Management of the Use and Conservation of Water Resources in Interstate Sources (Almaty, 1992). By this Agreement the five CA countries have agreed to adhere to the existing structure and principles of water allocation that were formed in the Soviet period.[37] At the time of independence, the legal framework of cooperation extended through conclusion of new multi- and bilateral agreements between the region's countries and accession to multilateral environmental agreements.

Shortcomings of the current legal framework of cooperation in the Aral Sea basin include the lack of clear procedural obligations for exchange of information, consultations, notification on planned measures, monitoring and impact assessment, as well as insufficient regulation of process of interstate watercourse use taking into account the interests of all riparian states and the fundamental principles of international law, such as equitable and reasonable utilization, no harm and aquatic ecosystem protection. Another issue of concern is the lack of compliance with agreed water allocation principles due to absence of regulatory and enforcement mechanisms, the breaches of reservoir operation regime as a result of absence of an agreed optimal and mutually beneficial option of balancing irrigation and hydropower needs, failure to provide water for environmental needs due to lack of agreed updated norms and rates, record-keeping system and relevant agreements, and also non-fulfillment by the countries of provisions stipulated by international treaties concerning environmental monitoring and information systems.

Over the last 25 years, repeated attempts have been made to improve the existing legal framework. As part of three Aral Sea Basin programs (ASBP), dedicated activities were planned in this area. Most recently, in 2017, the United Nations Regional Center for Preventive Diplomacy for Central Asia proposed to the countries to resume negotiations on mutually acceptable mechanism of regional water use based on two draft agreeements for the Amu Darya and the Syr Darya basins. Only Uzbek Ministry of Foreign Affairs supported this proposal, while other countries refused the idea to discuss draft documents that were prepared without their involvement. Instead, Kyrgyzstan proposed renewing cooperation within the framework of the 1998 Agreement between the Governments of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan on the use of water-energy resources in the Naryn-Syrdarya basin that makes provisions for a compensatory mechanism of water and energy use.

[37] Principles of water allocation were laid in Protocol 566 of the meeting of the Scientific-Technological Council at the USSR Ministry of Land Reclamation and Water Resources (Minvodkhoz) of September 10, 1987, which approved the "Revised Master Plan for comprehensive use and conservation of water resources in the Amu Darya River basin" (Sredazgiprovodkhlopok, 1984), and in Protocol 413 of the meeting of the Scientific-Technological Council at the USSR Ministry of Land Reclamation and Water Resources (Minvodkhoz) of February 7, 1984, which approved the "Adjusting note to the revised Master Plan for comprehensive use and conservation of water resources in the Syr Darya river basin".

Other Central Asian river basins. A number of bilateral agreements were signed by Kazakhstan on water sharing in other transboundary rivers, including agreements with China on all 24 transboundary rivers (including 6 rivers in the Irtysh basin, 7 rivers in the Ili basin, 3 rivers in the Emel basin, etc.), with Russia on transboundary rivers Ural, Irtysh, Ishim, Tobol, Big and Small Uzeni, Kigach River arm, and with Kyrgyzstan on Chu and Talas. Although the agreements signed for the Ili and Irtysh river basins are aimed to run ahead of new problems and challenges, the disadvantage is that the former are bilateral and do not ensure appropriate approach to basin-wide water management that is mutually agreed by Kazakhstan, China and Russia. Later in 2000, an agreement was signed for sharing of Chu and Talas river basins. List of structures and cost-sharing were determined. An information system was developed and some hydraulic structures were automated.

Institutional framework

The institutional foundations of the interstate water management in the Aral Sea basin were laid in the 1980s through the establishment of two basin organizations – Amu Darya Basin authority (named Uprvodkhoz “Amu Darya”) and Syr Darya Basin authority (named Uprvodkhoz “Syr Darya”) for inter-republican allocation of water resources. In 1992, to keep integrity of water management since the collapse of USSR, the Interstate Commission for Water Coordination in Central Asia (ICWC) was established. The earlier formed Uprvodkhozes were transformed into basin water organizations (BWO) and became the executive bodies of ICWC. Then, the Scientific-Information Center of ICWC was formed on the base of the former Central Asian Irrigation Research Institute (SANIIRI) and its branches and later the ICWC Secretariat and the Coordination Metrology Center were established.

Among the key achievements of ICWC are:

- keeping stability in the use of water in interstate sources that contributed to peaceful relations between the CA countries;
- clearly developed system of annual and seasonal planning of water distribution between the countries and its control every ten days;
- the CAWater-Info Portal containing more than 62 Gb of information on water, land, energy and environment topics and the Information System on water and land in the Aral Sea basin (CAWater-IS) containing more than 150 parameters since 1980;
- developed and successfully promoted in education processes curricula and training modules on integrated water resources management, improvement of irrigated agriculture, international water law and policies, and regional transboundary cooperation;
- developed and implemented major positions of integrated water resources management on an area of 130,000 ha in the Fergana Valley (Kyrgyzstan, Tajikistan, Uzbekistan). This made it possible to reduce substantially irrigation water intakes into canals, while simultaneously increasing crop yields and revenues;
- successfully implemented system of automated remote control over structures in the upper reaches of the Syr Darya River. This system helped to reduce unproductive losses from 10% to 2% through continuous monitoring of water discharge along the river and canals instead of three-time measurements in ordinary practices. The partnership with the Swiss Development Cooperation Agency, which supported IWRM and automation, has largely promoted such success;
- capture of the remote sensing-based monitoring of water and land use, with the technical and financial support from Germany, and development of a special tool for monitoring of water efficiency in Central Asia – WUEMoCA.

The key bottlenecks of ICWC activity include:

a) **Generally unresolved issue related to political and economic frameworks for sustainable and mutually acceptable sharing water from interstate water sources in the region**. Changing national water use priorities are constantly reviewed by ICWC but call for agreed decisions from the side of senior leadership of the countries. The ICWC mandate to ensure sustainable water supply for all cannot be fulfilled efficiently unless the above matters are resolved.

b) **Neglected aspects of future development in ICWC activity**. In the first decade of ICWC operation, the program of its actions was uniformly spread between the current water allocation and the improvement of transboundary water management and use. In the later period of work, the Commission focused mainly on current issues of annual water allocation and reconciliation of interests of all member countries. One of its main tasks, such as determination of water policy and development of long-term water supply program has remained unsolved. At present, there is no single water conservation plan as the main countermeasure to future challenges, no common strategy for the long-term flow regulation, and no regional measures for adaptation. In 2014, the 63rd ICWC meeting in Tashkent made a decision to develop a Plan for the improvement of ICWC activity in four key areas: water conservation; promotion of IWRM as a tool of green growth and adaptation; improvement of quality and accuracy of water accounting; and capacity building of regional and national organizations. Four regional working groups were established for implementation of this Plan. However, by present, besides formulation of core positions by the working groups, no progress has been made in implementation of the Plan.

c) **Technical difficulties** arise in planning and fulfilling the plans of flow distribution along the Amu Darya and the Syr Darya due to:

    o poor quality of flow forecasts for the main course of the rivers as a whole and the lack of flow forecasts for many tributaries of both the Amu Darya (especially Panj) and the Syr Darya;
    o late provision of forecasts: final forecast is ready by mid of April;
    o under-accounting of the time-lag of flow, which is especially important for the Amu Darya basin, where this time-lag is 10-15 days;
    o under-accounting of open channel losses, as well as of in-stream regulation;
    o unsatisfactory accounting of inflow and re-use of collector-drainage water, especially deviations in case of dry year.

    A project of the World Bank on the improvement of the regional monitoring system ($29 million) was implemented by hydrometeorological services without involvement of and coordination with regional and national water organizations and, therefore, its effectiveness in terms of practical help for the water management process was low. It should be noted that all these factors contribute to higher deviations from established plans, particularly during the non-growing season. All above listed problems can be solved, first of all, through the improvement of quality of flow accounting and monitoring. Herewith, it is necessary to organize water measurements also at outlets from river and at mouths of all collectors that have discharge of more than 5 m3/s.

d) **Unresolved issues related to revision of legal and institutional framework of ICWC to meet new realities.** In 2009, the heads of CA state emphasized the need to further improve the institutional and legal framework of IFAS for enhancement of the Fund's activity. However, yet, no changes have been made in these directions. In 2016, Kyrgyzstan decided to "freeze" its participation in IFAS and its bodies on the ground that the reforms of IFAS repeatedly proposed by the Kyrgyz side have not been implemented. At the Summit of the heads of states in Turkmenbashi in August 2018 the President of Kyrgyzstan reiterated his support of thorough reformation of IFAS and its bodies, taking into account the interests of all the states in CA. At present, a regional working group on the improvement of IFAS institutional framework has been established under umbrella of IFAS.

e) **The lack of interaction with all water use sectors and the public.** The Kyrgyz President stressed that "activities of IFAS are focused on water for irrigation and ecology, while ignoring other uses, including hydropower". Since the ICWC member from Tajikistan is the first deputy minister of energy and water resources, the energy sector of Tajikistan is represented in ICWC. It is obvious that given the country needs and approaches to integrated water management, all stakeholders must be involved in water decision making; however, extension of ICWC should be accompanied by harmonization of principles and rules for operation of multipurpose hydroschemes, taking into account the socio-economic and ecological roles of water. Otherwise, ICWC may become a broad platform for disputes rather than remain the space for decision making. Another matter of concern is the omission of Afghanistan in the coordinated system of water management at the interstate level.

f) **Difficulties in enforcing fulfilment of the ICWC-established schedules of water releases and operation regimes of water infrastructure in the Amu Darya and the Syr Darya basins.** Though BWOs draft schedules of water releases and water distribution and confirm them with all heads of water agencies, the accuracy of fulfilment of these schedules is far from perfect. The access to transboundary hydroposts to check accuracy of records is restricted. Most of structures that are important for basin management are beyond the competence of BWOs and operated out of accord with ICWC decisions.

g) **Poor material and technical base and financing of ICWC's executive bodies.** Sustainability of ICWC bodies is provided through financial and staffing support from the side of founder-states: all executive bodies of ICWC are funded from the budgets of countries, where these bodies are dislocated. The budget funds are allocated regularly but are not sufficient for fulfilment of all functions by those bodies. In particular, no budget items are provided for professional development of the staff, business travels, improvement of material and technical base and for long-term joint programs. Nevertheless, available expert knowledge in various disciplines allow the organizations to implement projects at the expense of donors that provide additional – but not stable – source of income.

h) **Lack of coordination among executive bodies of ICWC, national agencies and other organizations of IFAS**. There are no clear rules and procedures of interaction, including regulations for meetings, rules of procedure for branches, their reporting, financing and involvement in regional and national projects; order of rotation of the chairmanship in regional organizations; modalities of cooperation between regional organizations and participation in meetings, etc.

In this context, ICWC must activate joint efforts for continous improvement of its activity, including organizational, legal, technical, human and information aspects, in order to be proactive in the face of destabilizing factors. Among the priority actions should be automation of hydroschemes, reduction of flow losses, enhanced water monitoring and accounting, promotion of better observance of water distribution plans and water releases schedules and improvement of flow forecast accuracy. Involvement of the public and all water use sectors (energy, environment, water-supply, local authorities) in ICWC activity will facilitate consensus building in water management and contribute to sustainable water future.

Joint bodies in other river basins in CA

Since 1992, the ***Kazakhstan-Russian Commission*** on joint use and protection of transboundary waters (Ural, Irtysh, Ishim, Tobol, Big and Small Uzeni, Kigach River arm) has been functioning under the guidance of two co-chairs on a permanent basis in the framework of transboundary water cooperation between Kazakhstan and Russia. For instance, to address the problem of shallowing the Irtysh River, the Krasnogorsk hydroscheme near the Omsk city in Russia is currently being under implementation for lifting water from the Irtysh river bed at 4 meters, which will enable navigation during the dry-years period. In addition, regular database exchange on hydrological and ecological regimes on the Irtysh River has been established between the countries.

The Chu-Talas Water Commission (CTWC) was established in 2006. 25 meetings of the Commission were held over this period of time. Special working groups have been established for concrete tasks, including on environmental issues, on adaptation to climate change and long-term action programs, on dam safety and other topical matters. A number of international partners rendered assistance in the establishment of CTWC, including UNECE, UNESCAP, OSCE, Asian Development Bank, European Union. Analysts list the following key shortcomings in CTWC activity:

- unsustainable operation of the Commission since the countries do not allocate budget financing for the Secretariat;
- incomplete execution of the 2000 Agreement and the tasks set in statutes of the Commission and its Secretariat, as well as non-fulfilment of some decisions made by the Commission;
- lack of integrated approach to water management in the Chu-Talas basin as a whole at the interstate level: the Commission has no due authorities with respect to other ministries and departments of the countries to enforce fulfilment of its decisions; the interests of financial, economic, environmental, and law-enforcement agencies, hydrometeorological service and local authorities are not appropriately addressed in activities of the Commission;
- inappropriate coordination between ministries and agencies makes it difficult to elaborate a concerted national policy on the involvement of the countries in development and implementation of joint measures and actions. (Chu-Talas Water Commission, 2018[27])

As part of the 2011 Agreement, a ***Kazakh-Chinese Commission on cooperation in the field of environmental protection*** was established. To address the environmental issues, 5 joint intergovernmental programs were approved: 1) The program of research on the impact of climate change on water resources; 2) The research program for glacier resource changes and implications on water resources; 3) The work program for analyzing the ecological status of the Ili River delta and Lake Balkhash; 4) The work program for studying the impact of human activities on ecosystems of Ili and Irtysh/Ertis river basins; 5) The work program for water-saving technologies in irrigated agriculture. These programs are executed by joint working groups of Kazakhstan and China in accordance with the approved plans and procedures. Thanks to the Commission, a number of hydroschemes and gauging stations have already been built (some being under construction) on transboundary rivers, where water allocation works on an equal footing 50/50, regardless of the population number in coastal zones – i.e. in compliance with hydrographic principle of water allocation.

Collaboration of regional water and environmental organizations

Two commissions – for water (before mentioned ICWC) and environment (ICSD) – function under umbrella of IFAS. The Interstate Commission for Sustainable Development (ICSD) was established by the decision of the Interstate Council for the Aral Sea Basin in 1993 with the mission of coordination and management of regional cooperation in the field of environmental protection and sustainable development of the CA states. Over the period under consideration, several regional environmental programs and projects were prepared and the Framework Convention for sustainable development in Central Asia was developed (Ashkhabad, 2006) within the framework of ICSD. In opinion of the Head of the Regional Mountain Center of Central Asia (I. Dairov), the Ashkhabad Convention, which is based on well-recognized principles and norms of international law, has great but still unexploited and unclaimed potential for the enhancement of regional cooperation in the field of water and environment, especially, in the future.

Unfortunately, collaboration between ICWC and ICSD has been still inefficient. In Dairov’s opinion, it could be more productive if national and regional water agencies paid more attention to recommendations of environmentalists and maintained a close dialogue with them, on the one hand, and if donors also supported such dialogue and collaboration at national and regional levels, on the other hand. The same is true regarding cooperation between water managers, hydropower producers and environmentalists on bi- and trilateral basis at national and regional levels.

The groundwork has been laid already for better cooperation. The Memorandum of cooperation was signed between the Scientific-Information Centers of ICWC and ICSD, the work is underway on a regional expert platform for joint multidisciplinary research, which was initiated by the President of Uzbekistan at the IFAS Summit on 24 August 2018 in Turkmenistan.

7 International Assistance and Aral Sea Basin Programs

International assistance to the CA countries

The international assistance for national and regional water projects in CA is provided as part of general external aid to regional development. In the structure of funds allocated in the post-Soviet period by donors for promotion of development, CA is not in the top. According to OECD's data, in 2011, the five CA countries had only 0.98% of the total amount of official development aid (ODA), while Afghanistan received five times more, $6.7 billion. However, the next years showed decline in financing for Afghanistan as well, and, in 2017, the aid dropped from $3.2 billion to $2.8 billion. (OECD, 2019a[28]) The aid per capita was as follows in 2011: Kyrgyzstan – $95; Tajikistan – $50.8; Kazakhstan – $13; Turkmenistan – $7.5; Uzbekistan – $7.5. Almost the same picture of foreign aid was observed in subsequent years.

Experts note considerable differences in countries' abilities to utilize the provided aid. Kazakhstan uses the aid more effectively than Kyrgyzstan or Tajikistan. It is interesting that in 2014 Kazakhstan decided to become an international development partner and started to submit reports to OECD on its contributions since 2015. The reports say that the key recipients of aid from Kazakhstan are Afghanistan, Tajikistan and Kyrgyzstan.

The Aral Sea Basin Programs since 1992 to 2019

Since 1991 to 2019, many international partners worked in CA in the field of water, including UN agencies (UNDP, FAO, UNECE, UNESCAP, UNESCO, UNRCCA); development banks (WB, ADB, EDB, IDB), international development agencies from Canada, German, US, Great Britain, the Netherlands, Norway, other international organizations and donor countries (OECD, European Commission), as well as private foundations (Aga Khan, Soros). It was supposed that the overall focus of regional projects would be determined by the Aral Sea Basin Programs (ASBP) developed jointly by countries and international partners. But history has shown it has not always been possible to achieve this in practice.

ASBP-1. In first decade, the largest aid at the regional level was provided by the World Bank, UNDP, European Union and USAID. In June 1998, a donor meeting was organized in Paris to develop the Aral Sea Basin Program (ASBP-1). The Program was comprised of 8 components and 19 projects that, eventually, formed the main tools and mechanisms of ICWC, Fundamental provisions of the regional water strategy; Water Resource Management Information System (WARMIS); Water Use and Farm Management Survey (WUFMAS); collector-drainage flow management; enhancement of hydrometeorological network. The Program included three water supply projects "Clean water, sanitation and health" (Kazakhstan, Turkmenistan and Uzbekistan) and efforts for preservation of Sudochie Lake. ASBP-1 was the program, which was successfully implemented thanks to closer coordination between representatives of the countries and donors under the guidance of the World Bank. It was during this period that necessary foundation was laid for implementation of large regional projects on integrated water resources management in the Fergana Valley, automation of water control systems, development of the ICWC Training center was and organization of a number of study tours for managers of national water agencies. Since the 2000s, CIDA, GIZ, SDC, Government of the Netherlands, and Asian Development Bank provided important support to the development of regional water organizations and maintenance of the regional dialogue. Regional projects allowed the CA country experts to learn together, share experience and problems. This contributed to maintenance of personal and professional contacts and laid the basis for conflict-free interactions. It is significant that at the beginning of the 2000s a water saving competition was organized as part of GEF project and engaged 142 entities in 8 provinces, including 25 district water organizations, 12 WUAs, 47 large farms and 58 farmers.

ASBP-2. In 2002, the "Program of concrete actions for environmental and socio-economic improvement in the Aral Sea Basin over 2003-2010" (ASBP-2) started to be developed and was approved by the IFAS Board on 28 August 2003. ASBP-2 included 14 priority directions grouped into 4 blocks: water, socio-economic, environment, and environmental monitoring. In the course of implementation, about $2 million were utilized; moreover, the donor aid did not exceed 1% of the total sum. (The Executive Board of the International Fund for saving the Aral Sea in the Republic of Kazakhstan, 2019[29]) According to donors' assessments and by the results of thorough internal analysis of the IFAS Executive Committee, ASBP-2 has remained unimplemented in many positions. (UNECE, IFAS, 2010[30])

ASBP-3. In April 2009, the Summit of the Heads of IFAS Founder-States was held in Almaty. The Heads entrusted to develop a new ASBP and improve IFAS activity. Despite complicated relations between the countries, the IFAS Executive Committee in Kazakhstan has managed to organize effective preparation and coordination with donors of the Aral Sea Basin Program 3, which was approved by the IFAS Board on 15 May 2012. The Program included four main topics: integrated use of water resources; environment; socio-economic; improvement of institutional and legal mechanisms.

Since 2012, the following tendency has been observed - shift away from regional projects focused on the main rivers (Amu Darya and Syr Darya) in favor of local and bilateral projects for small rivers, such as Chu, Talas, Khojabakirgan and Isfara. Donors has substantially reduced aid to regional organizations of the IFAS system, while requiring the agreement of all riparian states for implementation of regional projects as prerequisite for allocation of funds; and that requirement is not always possible to fulfil.

Also, the same period, most regional water projects started to be implemented via the Central Asia Regional Environmental Center (CAREC), the initial mandate of which included environmental issues. This has critically reduced involvement of ICWC members in selection, approval and monitoring of water-related projects. None of regional water projects implemented in this period of time was discussed at ICWC meetings. In April 2018, this issue was raised at the ICWC meeting, where the members underlined a need for more effective coordination by ICWC of regional projects on topics, which are included in its mandate. It is important that regional water projects implemented with the involvement of ICWC executive bodies visually demonstrate sustainability. For instance, the CaWater-Info.net portal, developed with the support of SDC, continues functioning sustainably and developing even upon completion of relevant project in 2012. However, despite relevant ICWC decisions, donors did not give support to implementation of selected priority projects (Plan of ICWC strengthening, Capacity building for the improvement of water professional development system in the CA countries and others).

It should be noted that, despite the declaration of support to ASBP-3 by donors, only 5 regional projects were started by the moment, when the Executive Council finished its mission in Kazakhstan. Another 9 projects have been implemented as part of ASBP-3 after the Executive Committee had removed to Uzbekistan (2013-2016). The total cost of implemented projects in this Program was $96.7 million. Meanwhile, by November 2016, 374 projects were financed at the expense of national budgets for an amount of more than $13 billion. (EC IFAS, 2017[31]) ASBP-3, despite the very good preparatory work with both countries and donors, has faced huge obstacles in its implementation. This was caused by the lack of a procedure for implementation from both the side of donors and the executive bodies and directly country members. The analysis of work on ASBP-3 shows that:

- amount of funds that were planned by donors and riparian countries was far higher than actual investments on each of projects (e.g. on environmental direction, the size of investments in regional projects turned to be lower than planned by $3 million);
- despite an increase in initial budget, efficiency and effectiveness of most implemented projects was far from expectations under ASBP-3;
- basically, none of regional projects followed in full measure the format proposed by ASBP-3;
- too much time was spent for approval by national governments of even very important projects;
- there was no clear and effective transparent system of monitoring and reporting on individual projects and the ASBP as a whole.

ASBP-4. In June 2016, the chairmanship in IFAS was passed to Turkmenistan, which assigned priority to the development of a new phase of the Action Program (ASBP-4) together with the Central Asian countries. The IFAS Board approved the Concept for development of ASBP-4 on 23 August 2018. ASBP-4 kept four key topics of ASBP-3, namely: integrated use of water resources; environment; socio-economic; improvement of institutional and legal mechanisms. A Regional work group was formed among representatives of ministries and departments, ICSD and ICWC for the development of ASBP-4. As of December 2019, three meetings of the regional group were held (16-17 May 2018, 30-31 July 2019, 28 November in Ashgabad).

The Kyrgyz party also pays attention to the fact that hydropower dimension of regional water use has not been addressed under umbrella of IFAS and as part of ASBPs. None of hydropower development projects proposed by the Kyrgyz party has been implemented over the period of IFAS existence. This indicates to the lack of integrated approach to water management.

Projects impact

As a whole, despite significant positive impacts of implemented projects, one should note the duplication of efforts and the lack of focus on action effectiveness from both the side of donors and national agencies. Virtually, there is no monitoring of project impacts in the region. Analysis of more than 10 projects implemented in CA under IWRM lable (Dukhovniy et al., 2014) showed that only one project used the indicators of water use improvement. Those indicators were monitored only in the IWRM-Fergana Project, which helped to achieve substantial reduction (by 15%) of water use and an increase in crop yields and water productivity. Another identified problem was the fragmentation in implementation of IWRM principles and the inconsistent dissemination of project results. For instance, the WB-financed Project for Rural Enterprise Support included dissemination and up-scaling of IWRM-Fergana Project's results in Uzbekistan. In fact, the project focused on hydrographization of WUAs in seven provinces and on capacity building programs only. Other related matters of water management, such as main canal management, managerial tools necessary at WUA level (e.g. update of water requirements, daily irrigation scheduling and extension services) and social mobilization were not addressed. As a consequence, no marked reduction in water diversions or increase in agricultural production as a result of project interventions was observed in none of seven provinces. Observations over stability and equality of water delivery to head and tail parts were not organized either. Such partial dissemination of IWRM practices without sufficient evaluation of results puts the potential success of IWRM approach at risk.

The effectiveness of donor programs also depends on agreed selection and relevance of topic, assignment of executors by donors, work program and methodology set together with beneficiaries, result-orientation and payment strictly based on degree of provision of outputs as determined jointly by donors and beneficiaries. It is important to make use of high competence and knowledge of local experts, as well as their deep understanding of approaches to water management from the very beginning rather than to engage expensive foreign consultants for implementation of water projects in the region.

In this context, it would be useful to organize more detailed monitoring of actual project results and publish evaluations by external auditors. It seems that creation of a common regional base on past, on-going or planned projects will contribute to awareness on on-going measures in the countries, strategies of joint work for the future and effectiveness of expected results. This could also promote more effective coordination of international partners' activities.

Coordination of donors' activities

In spite of numerous statements by country representatives and international partners, the issue related to coordination of donors and their aid is still relevant. Periodical meetings, including coordination ones, address coordination in terms of presence of such problem but the coordination of donors' activity as a process is not considered.

In 2010, the World Bank initiated the Central Asia Energy-Water Development Program (CAEWDP), which aimed at coordination and effective utilization of donor community's contribution. (World Bank, 2010[32]) A Multi-Donor Trust Fund of CAEWDP was established with contributions from the European Commission, Switzerland (SECO), the United Kingdom (DFID) and the US (USAID). In 2018, CAEWDP was re-named as the Central Asia Water-Energy Program (CAWEP). (World Bank, 2012[33]) However, until now, activity under the Program failed to ensure required coordination to promote a common regional program with active involvement of regional organizations and focused mainly on evaluation studies.[38]

Hence, the coordination meeting of the IFAS Executive Committee with international partners on the development of programs for the Aral Sea basin (9-10 May 2018, Ashgabad) once again addressed new forms of cooperation with international development partners.[39] It was noted that the main focus in ASBP-4 will be made on the development of projects, interest to which was shown by donors, i.e. regional projects should reflect national country priorities in line with donors' priorities. International development partners decided to establish an Advisory panel to increase effectiveness of international support to CA. It is supposed that this panel should become the main channel for receipt and allocation of aid in the system of regional cooperation under umbrella of IFAS.

[38] http://documents.banquemondiale.org/curated/fr/678231557948626298/pdf/Central-Asia-Energy-Water-Development-Program-Promoting-Pathways-to-Energy-and-Water-Security-Impact-Report-2009-2017.pdf

[39] Coordination meeting of the IFAS Executive Committee with international partners on the development of programs for the Aral Sea basin / Ashgabad, 10 May 2018 // https://uzbekistan.tmembassy.gov.tm/ru/news/13096

8 Performance Review of Water Management System in the Aral Sea Basin

The water-management system in the Aral Sea basin is comprized of a quite complex set of water hierarchical levels (basin, sub-basin, national intake points, main and distributary canals, WUAs, water users), sectors and their structures and water consumers, as well as controlling systems. Although water management is concentrated mainly on the national and interstate levels, which are described in Chapter 5 and 6, having different management rules and coordination, its effectiveness depends on many factors. Those include appropriate estimation of water demands, accurate forecasting of water availability, realistic scheduling of water delivery from one to another level of water hierarchy, and coordination of intersectoral requirements. This chapter analyzes the causes of shortcomings and weaknesses in water management in the region as a whole.

Main principles of effective operation of water-management system

The theoretical basis of successful operation of the water-management system in CA was developed by D.Lauks, L.Dunin-Barkovskiy, G.Voropayev, and V.Dukhovniy as a clear insight of relations between all elements of this system and formulation of necessary rules and regulations. Those include:

- **Maintenance of water balance**, including balance of water losses and demands for each water-management unit (basin, sub-basin, country, planning zone, province, district). In this context, both local water and interstate sources are considered provided that for the latter, like for local water, **accurate forecasts of resource** are made, **losses** are estimated appropriately and a **usable share of the resource** is determined accurately.
- Water requirements – total of the country or of water planning units – **correspond to state standards and adequately reflect actual water demands of users and the natural system** (river deltas, runoff formation areas, etc.).
- **Accounting of resource** is kept on **all types**: surface water, groundwater, and return water, including wastewater.
- Based on forecasts of flow and other resources, basin water organizations set the flow regulation regimes – multiyear and seasonal ones – and get their approval by joint decisions (e.g. by ICWC) and draft schedules of water releases and distribution between the countries, while branches of these organizations prepare such schedules for country level. Schedules of water releases **should be observed by owners** and large regulating hydroschemes and BWO.
- Each water using sector must **respect the amount of water allocated** for its needs and is committed to **ensure productive water use** and contribute to financial base of water use through **water charges**.

- Overall water-management activity, especially water accounting, in the country is controlled and coordinated by a **single public agency**, directions of which are obligatory for all water-using sectors. The control indicators are the observance of water limits and consumption rates, water use efficiency factor, water productivity and equitable water supply for all users.
- Water supply is coordinated between sectors and hierarchical levels through relevant contracts that are **supported by financial obligations**, including penalties for breaches.

The following subsections address those seven prepositions in the context of the Aral Sea basin.

Water balance as a backbone of water management

The balance of any element of the water-management system is based on the forecast of resource, estimation of losses and correct determination of demands.

The analysis of water management made in IWRM-Fergana Project from 2000 to 2010 gives a good illustration of this rule. Table 8.1 shows an extract from water balance of the Fergana Valley over 2001-2002. Water management in the Valley was carried out on the base of several balances: the balance of external water, including water releases from two interstate reservoirs – Toktogul and Andizhan – to the Valley, water from small rivers, groundwater, and return water; six provincial balances of Andizhan, Namangan and Fergana provinces in Uzbekistan, Sogd province in Tajikistan, and Djalalabad and Osh provinces in Kyrgyzstan. Balance discrepancies in the Fergana Valley were less than 10% for all water types as a whole and averaged 4% in each province. As to surface flow, the discrepancy was maximal - 8.7%.

Table 8.1. Water balance of the Fergana Valley (example for 2001-2002)

Year	**Water resources**							**Water releases from reservoirs**		**Residue**
2001-2002	**Water releases from reservoirs**		**Lateral inflow**		**Groundwater**		**Total**			
	Toktogul	11523	Toktogul - Uchkurgan	1823	Andizhan	328.48		Kayrakum	19358	
	Andizhan	5151	Uchkurgan -Kayrakum	7732	Namangan	371.89				
			Along Karadarya	5034	Fergana	1206.68				
					Osh	15.5				
					Djalalabad	119.12				
					Sogd	303.81				
	TOTAL	**16674**		14589		**2345.48**	**33608.48**		**19358**	**14250.48**

Regional information base					National reports				
Total water withdrawal, Mm^3		Agricultural water withdrawal, Mm^3	Agricultural water withdrawal, Mm^3	From main course of the river, Mm^3	From small rivers, Mm^3	From collecting drains, Mm^3	From ground-water, Mm^3	Difference from agricultural, CAWATER IS	Difference in%
Andizhan	3377.02	2870.3	2833	803	1993	37	0	37.3	1.3
Namangan	3318.07	2896.2	3129	2658	379	15	77	-232.8	-8
Fergana	4810.44	3514.5	3903	2666	920	140	177	-388.5	-11
Osh	1220.04	1122.8	1123	1047	54	22	0	-0.2	-0.1
Jalalabad	1035.85	923.7	833	581	239	13	0	90.7	8.8
Sogd	4831.88	4232.9	2322	1854	318	136	14	1910.9	82
	18593	**15560.4**	**14143**	**9609**	**3903**	**363**	**268**	1417.4	10

Source: .A. Dukhovniy, V.I. Sokolov, M.G. Horst, A.G. Sorokin, A.M. Nazariy, A.G. Galustyan "Dynamics of modern water balance in the Fergana Valley". SIC ICWC Collection of Research Papers. Issue 13. 2012. pp.5-27. www.cawater-info.net/library/rus/sb_tr_13.pdf

Although it is obvious that maintenance of water balance is the only way to ensure efficient management that guarantees meeting of user's needs for water, it is common for basin management that balances are broken in river reaches, with consequent breach of water balance in the whole water hierarchy. **First reason of deviations** of planned water supply from actual one is low accuracy of seasonal flow forecasts, which was from -10 to +17.6% for the Amu Darya basin and from 22.3 to + 38.8% for the Syr Darya basin (Table 4.1). Moreover, **general lack of long-terms forecasts** is notable.

Second serious reason of river balance breach is – as noted in Chapter 3, p.14 – is the **open-channel losses that exceed those estimated in the Master Plans twofold and more.** As mentioned above, the value of water losses in river channels and closure error of flow are: up to 6% along the Syr Darya and 37% along the Amu Darya. This leads to **incorrect estimation of usable water resources at each river section.** Consequently, the difference between forecast (flow) and the actual availability increases by river reach, and the lower reaches, especially of the Amu Darya, are provided with water by only 30-60% for most of growing season. Besides, one should take into account also sectoral losses, the total effect of which we tried to estimate by combining RS and ground-based research for irrigation and through analytical data for the energy sector.

Accuracy of water accounting and water demand

The analysis of current water accounting in interstate and small river basins showed that accounting of surface water in natural watercourses is made mainly by national hydrometeorological services (NHMS), while water at intake structures is measured by water-management organizations of the CA states.

Water discharge is measured at all gauging stations using the 'area×velocity' method. Water level is measured by typical gage rods. Flow velocity is measured by current meter using standard methods. The discharge equation and the table of coordinates are calculated for each gauging station based on initial calibration. Daily water accounting is performed three times a day by the table of coordinates, except for structures equipped with SCADA system, where water level and discharge are measured every 10 min and averaged every hour. However, less than 30% of structures are covered with automatic control in the Syr Darya basin. As to large hydrotechnical constructions, water accounting is made by relating discharge measurements of gauging station in tail-water to opening of gate. Water accounting in the river basin is performed by NHMS within the territories, where the river flows. Generally, existing gauging stations along the Syr Darya River in all the republics allow accounting water inflow and withdrawal; however, record-keeping of return water has been stopped and this kind of water is included in forecasts on the base of average long-term indicators.

The picture is more complicated in the Amu Darya basin. Currently, actual water availability in the basin is usually assessed by flow at the nominal Kerki station, downstream of the Karakum canal. In this section the flow is equal to flow measured at the Kerki section itself plus water diversions into the Karshi canal, Karakum canal (KKC) and diversions upstream of KKC until the border with the Surkhandarya province, Uzbekistan. For the Surkhandarya province, the river flow is summed up by all intakes, including the Amu-Zang pumping station. The total water discharge along the Amu Darya also comprises accumulation or drawdown of the Nurek reservoir. Such complex and approximate calculation of river flow leads to discrepancies in the data on losses and discharge.

One-time check measurements of water discharge in the Amu Darya River are made using the ‘area×velocity’ method at motor-road bridge spans, ferries or pontoon crossings (Termez, Kelif, Kerki, Dargan-ata stations).

Experts estimate the **accuracy of water accounting along rivers and non-automated main canals at 10-15%**. **Generally, this may give the balance error of 10s of km^3**.

Water supply rating standards are not available in the region as a whole and even in each country. As a result, agencies supplying water to sectors set the standards themselves: ministries of energy – for HPS; ministries of utilities – for household water use; ministries of agriculture – for irrigation. All irrigation systems in the region plan water use according to outdated and overestimated irrigation norms determined in 1980. At the same time, FAO developed a methodology for improvement of irrigation norms that produces well lower rates and provides for adjustment of crop water requirements depending on weather conditions. It is necessary to update crop irrigation scheduling, including irrigation norms based on common methodology and parallel research to be carried out in the whole irrigated zone of CA during 3-5 years. In the context of changing agronomic practices, crop patterns and varieties, farming technique, climate, resource pricing and many other factors, biologically optimal crop water requirements need to be developed and approved as a reference document for all the countries in the region.

Operating efficiency of water regulating structures

Most of structures involved in basin management are out of command of BWOs and operated according to schedules of their owners. Although BWOs prepare schedules of water regulation, releases and distribution and get approvals for these schedules with all agencies – owners of structures, there fulfillment leaves much to be desired.

Table 8.2. **Average deviations of actual water withdrawals from ICWC’s plans set for growing** seasons 2000-2018 (%)

Country	Amu Darya basin	Syr Darya basin
Kazakhstan	-	- 21.8
Kyrgyzstan	-	- 26.1
Tajikistan	- 14.0	- 16.8
Turkmenistan	- 13.5	-
Uzbekistan	- 14.1	- 9.5

Source: SIC ICWC, 2019 (cawater-info.net)

Table 8.3. Evenness in distribution of flow during the growing season in the Aral Sea Basin for representative, in terms of flow conditions, years

Water content	Year	Syr Darya basin				Amu Darya basin		
		Kaz	Kyr	Taj	Uzb	Taj	Tur	Uzb
Dry	2000	61	106	106	102	126	98	92
	2001	70	91	108	101	139	92	92
	2008	119	73	89	101	131	101	88
Average		**83**	**90**	**101**	**101**	**132**	**97**	**91**
Normal	2007	107	79	97	101	101	101	99
	2009	110	94	87	102	94	99	104
	2015	96	89	101	100	94	99	103
Average		104	87	95	101	96	100	102
Wet	2002	65	95	106	102	81	103	105
	2003	75	60	105	102	94	103	100
	2010	110	87	83	103	88	98	106
Average		**83**	**81**	**98**	**102**	**88**	**101**	**104**

Source: SIC ICWC, 2019 (cawater-info.net)

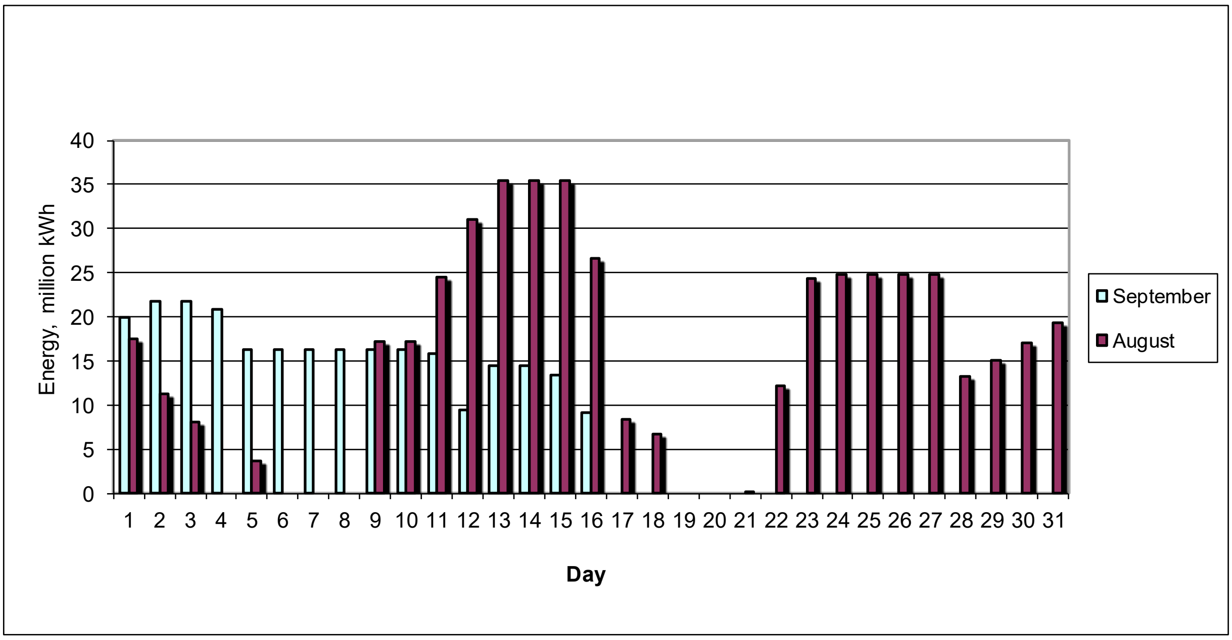
State-of-affairs in the Syr Darya basin in part of evenness and especially sustainability of meeting riparian countries' needs is characterized by deviations from 60 to 11 % (Table 8.4), with the average deviations of 26% in Kyrgyzstan and 21.8% in Kazakhstan (Table 8.3). Somewhat better situation is in the Amu Darya basin, where maximum deviations were 88% on country scale in dry year. At the same time, water supply to the delta of the Amu Darya is very irregular. And often the delta receives only 28% of its annual water limit! However, sustainability of water supply to canals and offtakes is even worse. For example, in the growing season 2019, given the average water availability of 96% in the Syr Darya by 10th of July, water supply to offtake canals varied from 160 to 64%. This can be explained by changes in operation regimes of hydropower stations, especially downstream of the Naryn cascade and Kairakkum reservoir.

The analysis of operation of the Toktogul and Nurek reservoirs reveals that when natural water deficit in the Naryn River and the Vakhsh River occurs during low-water years, energy and energy-irrigation regimes of these reservoirs lead to well lower water supply of irrigated lands. The main cause is an attempt to follow mainly seasonal (annual) regulation to the benefit of national hydroenergy sectors. To this end, early and excessive accumulation of water in reservoirs is practiced during the growing season to discharge the stored water in winter. Under such regime, peaks of irrigation water releases are reduced (this increases water deficit in June and July) and, at the same time, operation of hydropower stations becomes also ineffective in terms of energy losses. It is important to note here the opportunities and advantages of multiyear regulation that allows balancing annual volumes of accumulation and drawdown for a series of years, while optimizing final accumulation volumes for each year. Operation of Toktogul HPS in multiyear regulation mode lowers the risk of serious water deficits in summer and virtually eliminates idle discharges from hydropower stations.

Similarly, the use of Nurek reservoir as a multiyear energy-irrigation regulator would have allowed discharging additionally about 0.5-1.0 km^3 of water during the growing season 2000 (without sacrificing next years). Thus, water deficit in 2000 could have been reduced by 3-4 km^3 and limited to 7-8 km^3. In case of uniform distribution between users, water deficit would have amounted to about 20% of the established water withdrawal limit (the actual water deficit was 60% in Karakalpakstan). With growing water deficit and limited regulating capacity of the Nurek reservoir, Tuyamuyun Hydroscheme (TMHS) has become more important as a regulating body for the lower reaches of Amu Darya to the benefit of irrigation and aquatic ecosystems in Prearalie.

The analysis of idle discharges from Nurek HPS carried out by Petrov (2009) shows that over the period from 1991 to 2005 those amounted to: 2.74 km^3 (1992), 1.95 km^3 (1993), 4.07 km^3 (1994), 0.5 km^3 (1995), 1.89 km^3 (1996), 1.74 km^3 (1997), 2.57 km^3 (1999), 0.3 km^3 (2000), 3.26 km^3 (2002), 0.9 km^3 (2003), 0.2 km^3 (2004), and 1.3 km^3 (2005). On the average over 2010-2016, losses through idle discharges from Nurek HPS are estimated at about 20% of used energy, which was generated by this hydropower station. Similar value was got on average over 2015-2019 under the PEER USAID-SIC ICWC Project, which estimated losses through idle discharges at 2.4 billion kWh/year or approximately 20% of generated energy, given that idle discharges amounted to about 4 km^3 a year. As recommended by the Project, accumulation in Nurek reservoir should start 1-2 months later, tentatively in July-August, as compared to current beginning of accumulation. Such regime will be more suitable for irrigation water diversion from the Vakhsh River.

Figure 8.1. Energy losses through idle discharges from Nurek HPS in 2014



Source: SIC's estimate based on the data on idle discharges from CDC Energy

According to SIC's data, idle discharges from Naryn hydropower stations also take place. For the Toktogul Hydroscheme idle discharge amounted to: 165 Mm^3 (electricity losses – 70 million kWh) in July-September 2003; as high as 425 Mm^3 (185 million kWh) in August 2010; and, 875 Mm^3 (380 million kWh) in August 2017. In these periods of time, water level in Toktogul was maximal: reservoir was full of water as early as in July.

Generally, in 2015, electricity losses through its transmission and distribution (% of electric energy) are estimated at: 6% for Kazakhstan; 21% for Kyrgyzstan; 16% for Tajikistan; 14% for Turkmenistan; and, 9% for Uzbekistan. (UNECE, UNESCAP, UNSPECA, 2018[34]) As compared to 2003, electricity losses decreased: 4 times in Kazakhstan, 1.6 times in Kyrgyzstan, 1.8 times in Tajikistan, and 2.8 times in Uzbekistan.

Impact of flow regulation by large reservoir hydroschemes on irrigation water supply

With the current flow regulation pattern in the small Amu Darya basin and energy-oriented operation regime of Nurek HPS (i.e. maximum electricity is generated in autumn and winter), the annual water deficit may approach 25–30% of water withdrawal in 15 cases out of 100. Under operation of Nurek HPS in irrigation-energy regime (close to irrigation water diversion schedules, with maximum energy generated in the course of year), water deficit will not exceed 20% of water withdrawal and number of such cases (years) will decrease to 11 out of 100. Moreover, the irrigation-energy regime excludes idle discharges from HPS and consequent energy losses.

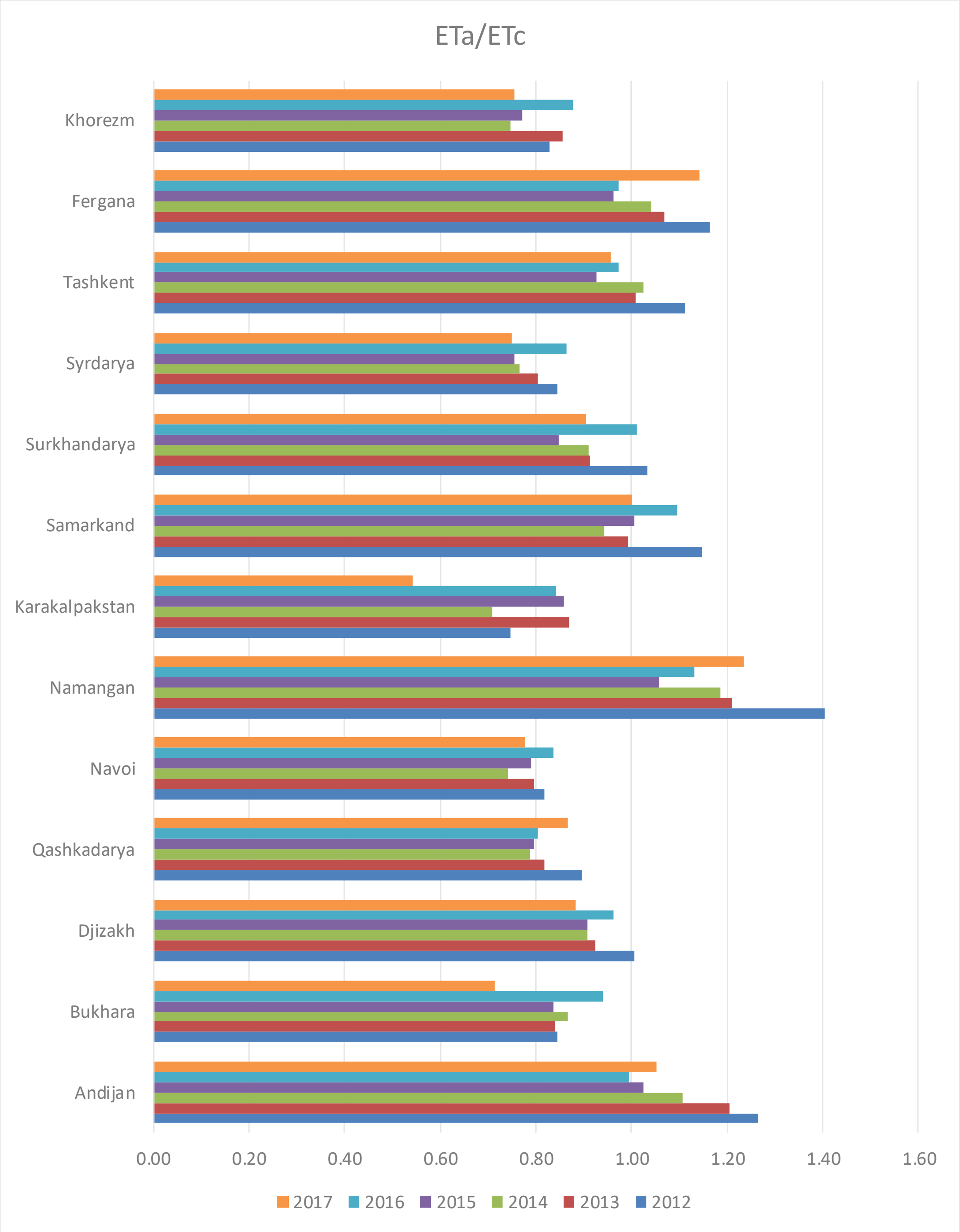
As calculated in the PEER Project [The Future of the Amu Darya Basin in the context of Climate Change. USAID, Tashkent, 2018], the cost of energy generation during the growing season by the Vakhsh HPS cascade is estimated on average over 2020-2050 at $538 million under energy operation regime of Nurek HPS and at $746 million under energy-irrigation regime, i,e, $208 million more (39 %).

Calculations indicated to the need for multiyear regulation of the Syr Darya under energy-irrigation operation regime of Toktogul HPS, which ensures additional water releases of 3-3.5 km^3 from the reservoir during the growing season above energy needs (2.8-3.0 km^3) in dry years. Under energy-oriented operation of Toktogul HPS (3.0 km^3 of water is released during the growing season and 8.5 km^3 during non-growing season), water deficit (water delivery to canals from the Naryn and the Syr Darya) of 20-30% in dry years causes a decrease in water supply in the Fergana Valley: by 15-25% on average during the growing season and even by 40-50% in some ten-day periods in summer.

Water management effectiveness indicators

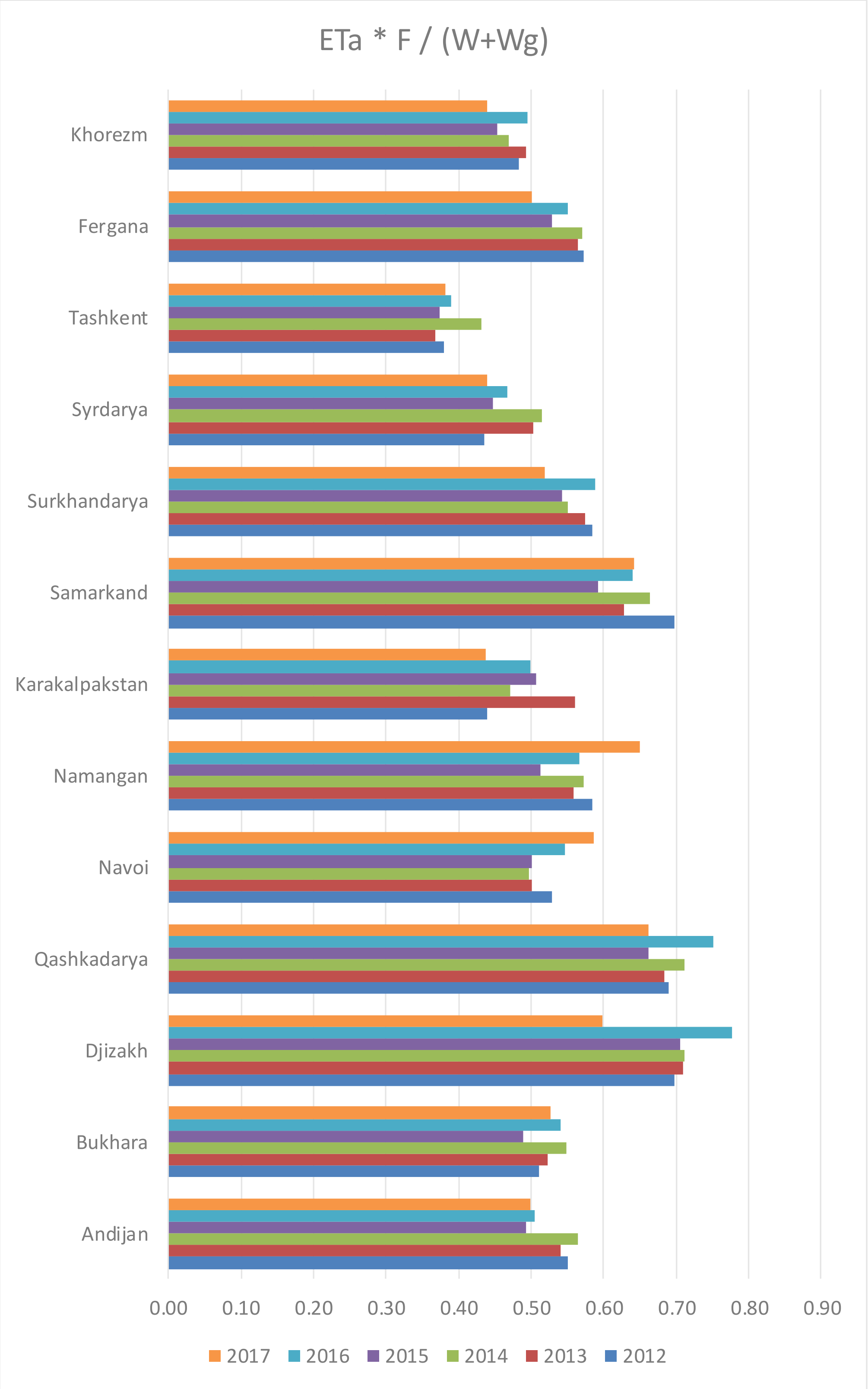
Development of RS-based monitoring in Uzbekistan allowed combining it with ground-based observations in a special WUEMoCA tool and analyzing degree of water supply of different provinces in the republic and the region. The results show that the above mentioned shortcomings in accuracy of fulfillment of water delivery schedules and water use plans and gaps between supply and use impacted the uniformity of available water supply in some provinces and districts. As diagrams below show, over the period from 2012 to 2017 irrigated land areas in Uzbekistan were 80% provided with water on average, except for provinces in the Fergana Valley and Samarkand province, where this indicator is close to 100% or even higher.

Figure 8.2. Dynamics of available water supply by province in Uzbekistan



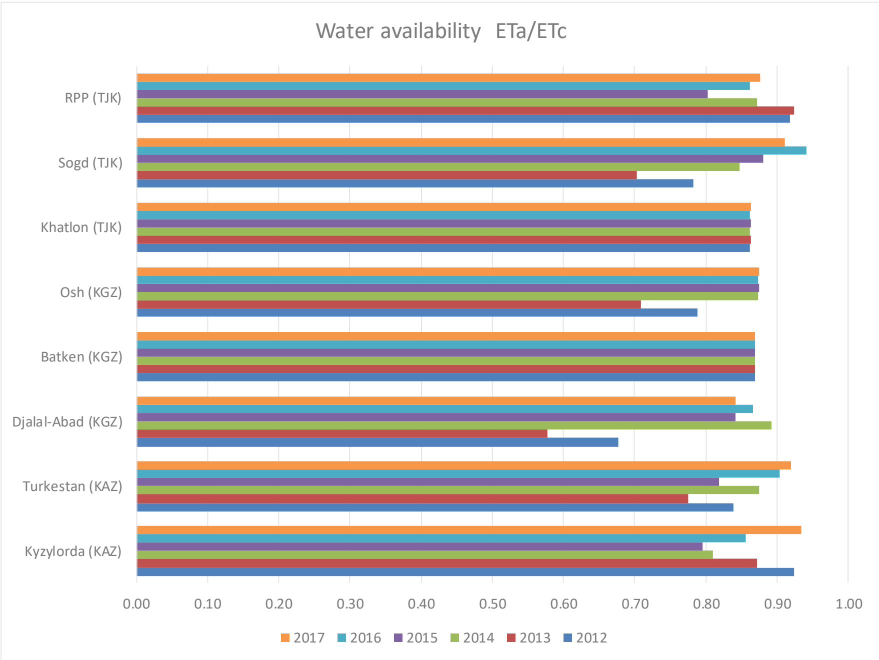
Source: SIC's estimates based on analysis of RS-data (http://wuemoca.net) and own calculations

Figure 8.3. Dynamics of water use efficiency by province in Uzbekistan



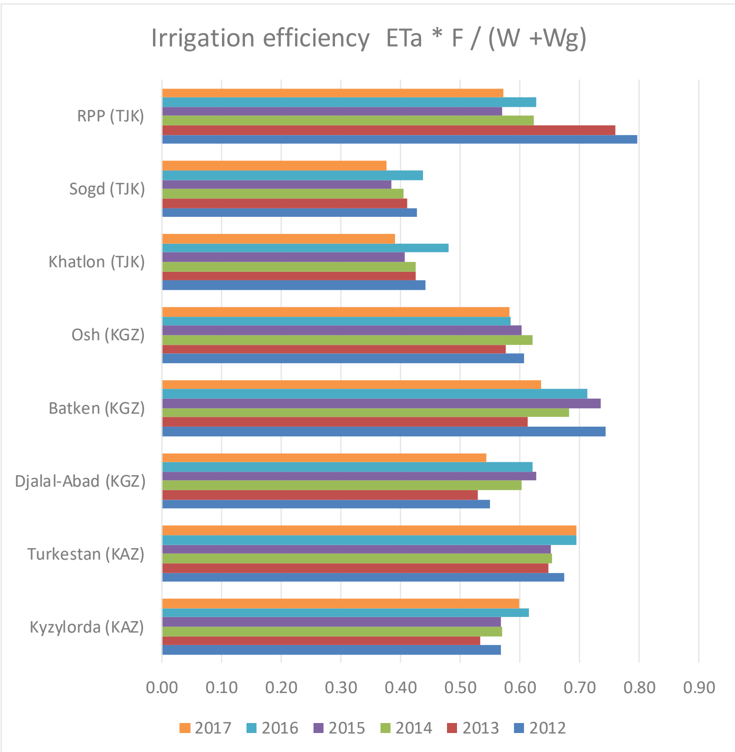
Source: SIC's estimates based on analysis of RS-data (http://wuemoca.net) and own calculations

Figure 8.4. Dynamics of available water supply by province in Tajikistan, Kyrgyzstan and Kazakhstan



Source: SIC's estimates based on analysis of RS-data (http://wuemoca.net) and own calculations

Figure 8.5. Dynamics of water use efficiency by province in Tajikistan, Kyrgyzstan and Kazakhstan



Source: SIC's estimates based on analysis of RS-data (http://wuemoca.net) and own calculations

Similarly, water use efficiency was assessed as a ratio of RS-based active evapotranspiration to total water delivery. The average indicator of water use is 50-52%, ranging from maximum of 75% to minimum of 30%. It is characteristic that this factor in the country increased on average to 58–59% in dry years. Thus, the need for detailed studies of the state of water supply and water use efficiency at each water use level and for differentiated measures to improve these indicators as part of the developed Program for rational water use is obvious.

In fact, the above factors do not consider losses in river channel and in inter-provincial main canals up to province boundaries. In the Aral Sea basin as a whole, those losses, as mentioned earlier in Chapter 3, amount to 15 km^3, of which half is unproductive losses or additional 78% of total water withdrawal. If those losses are taken into account in general water use, the water use efficiency will not exceed 43-45%.

Unfortunately, water and land monitoring systems are poorly developed in the countries. The attempts of SIC ICWC to popularize RS-applications in national water sectors did not receive support. The results of implementation by SIC are shown in given sub-section and in “Measures for sustainable water security in CA” sub-section.

Unit electric energy generation and consumption

Table 8.4 shows unit electric energy generation and consumption in CA countries on average over 2000-2017. The indicator of unit electric energy generation (G) in Central Asia as a whole (excluding Afghanistan) increased 1.21 times, while that of unit electric energy consumption (C) grew 1.25 times. Additionally, these indicators for Kazakhstan and Turkmenistan increased 1.66 (1.8) times and 1.8 (1.73) times, respectively. In contrast, for Kyrgyzstan, Tajikistan and Uzbekistan these indicators decreased 1.28 (1.02), 1.09 (1.36) and 1.05 (1.13) times, respectively. (Figures in brackets show the unit indicator of electric energy consumption).

Table 8.4. Unit generation (G) and consumption (C) of electric energy in CA countries in 2000 and 2017

Indicator	Unit	KZ	KG	TJ	TM	UZ	CA
Generation, 2000	kWh /person	3263	3207	2232	2049	1955	2456
Consumption, 2000	kWh /person	2985	1860	2121	1515	1662	2075
Generation, 2017	kWh /person	5411	2490	2039	3679	1868	2984
Consumption, 2017	kWh /person	5368	1829	1561	2620	1471	2590

Source: Data collected by national experts and CDC Energy

In 2018, the unit electric energy generation (kWh/person) amounted to: 5822 in Kazakhstan, 2493 in Kyrgyzstan, 2158 in Tajikistan, 3569 in Turkmenistan, 1888 in Uzbekistan, 27 in Afghanistan, and 2096 in Central Asia as a whole (including Afghanistan).

Conclusions: characteristics of water-user sectors

Finally, we attempt to give characteristics of water-user sectors (Table 8.5).

Table 8.5. Characteristics of water-user sectors

	Key water users					
	Hydro-power	**Irrigated agriculture**	**Household sector**	**Industry**	**Fishery**	**Nature**
Institutional form	Joint stock company	Farms, clusters	Water utility		Farms	Stateenviron. agency
WMO (water suppliers)	HPS authorities	BO, water-management organizations, WUA	Water utility	Water utility		
Use, *% of total water withdrawal*	0-80	15-95	1-8	1-6.5	0.1-0.2	7-20
Internal losses, *%*	3-10	30-65	30-55	Up to 20		
Water productivity, *cent/m³*	0.8-40 *cent/m³*	6 - 12 *cent/m³*		1.4 -12 *\$/m³*		
Water charges paid from budget, *cent/m³*		0.66-1.1	0.5-0.9	0.013 - 0.20		
Water charges paid by users	0.7 -4.6 *cent/m³*	0.043- 4.6 *cent/m³*	0.012 -0.14 *cent/m³*	0.4 -0.8 *\$/m³*		

Source: Authors (2019)

Here, review of the main water users (hydropower, drinking and household water supply, industry, irrigated agriculture, fishery, and nature) is provided. As shown in Chapter 2, all water users and consumers in different countries have diverse economic activities that impact overall water use in the region. Against the background of different institutional forms and business activities, there are quite common values for each type of water users that well illustrate efficiency of water use and financial sustainability, despite a wide scatter of the figures in different countries.

Hydropower acting in form of joint-stock companies with public share in all the countries and industry, which has lowest internal water losses and highest charges, are most robust sectors from institutional point of view. Those sectors are also in the focus of state agencies and donors that provide financing for re-equipping, reconstruction and maintenance of advanced technical level of the former. The sectors also allow for quick and maximal return on investments. Hydropower has already reached excess capacity in some months, and there is a risk of oversupply as a whole that should be picked through the CASA-1000. Well worse situation is in irrigated agriculture and the household sector, where losses prevail, water charges are not sufficient, and state support through long-term loaning is well lower. Because of lack of attention to available innovations, losses in those sectors are very high. There is big difference in irrigation water charges: from 0.043 cent/m^3 in Kyrgyzstan and 0.21 cent/m^3 in Tajikistan (under pumped irrigation) to 4.6 cent/m^3 in Kazakhstan.

9 Future Water Outlook of Central Asia

Threats of climate change

Scenarios of climate change impact on water resources are considered only for the Aral Sea basin, where a negative impact of climate change on water resources is supposed. In contrast, water resources are assumed to be increased in the Irtysh, Ili, and Ural basins.

The water-richer rivers in Central Asia, such as the Amu Darya and the Syr Darya are fed mainly by melt water from mountain snow and partially glaciers (here permafrost and perennial snow are also included). Seasonal snow feeding prevails in March-June, while glacial one - in July-September. Additionally, a share of flow in July-September is recharged through snow and rainwater.

Most flow formation models, which use 'moderate' climatic scenarios, do not show a noticeable reduction in runoff of main rivers in the Aral Sea basin until 2030. However, by 2050, water resources could decrease. Deviations of annual flow from average long-term values will increase. Warming would cause shifts in dates of flood water in intra-annual river regime: the peak of flood can occur earlier.

If climate changes by the REMO-0406 scenario - the projection for Central Asia of the medium scenario A1B, calculated by the global circulation model ECHAM 5 - by 2050, the normal flow would decrease in all large rivers in the Aral Sea basin. Over the period of 2020-2050, in the Syr Darya basin, the natural flow of the Naryn River will slightly decline – no more than 12% of the average annual flow over 2010-2020 – under influence of natural, cyclical and climate changes. We could expect both an increase and a decrease in flow rates, with certain 'drops' in June-August by 15-20 % below the observed minimal values (1997, 2001, 2008); it is important to note that flow rates would show the steady downward trend in June-August and the upward trend in March-April. In 2020-2050, the natural flow of the Karadarya River would have slightly downward trend of annual flow rates; local resources in the Fergana Valley would change within the limits of the observed variations.

As to the Amu Darya basin, from 2020 to 2050 water resources are expected to decrease during the growing season: by 5% in the Vakhsh and the Panj rivers; by 6% in the Surkhandarya River; by 8% in the Kafirnigan River; and, by 11% in the Zarafshan River. The highest reduction by 15-30% is expected in June-August in 2030-2050.

Variability of annual river flow, i.e. degree of its variations against the average in time series, can be characterized by the variation factor Cv. The higher is this factor, the wider is variability of the annual river flow.

Table 9.1 shows dynamics of flow variability for large rivers in the Aral Sea basin using three estimations: 1970 – the research data of Shultz [1965] and SANIGMI [USSR Surface Water, volume 14, Central Asia, issues 1 and 3, 1971]; 2000 – processed river flow based on the data used in the Diagnostic report on water resources in CA [SPECA, 2004]; 2018 – estimations by SIC ICWC over the period of 2000-2018.

Table 9.1. Dynamics of flow variability in large rivers of ASB

River	Flow in July-September, % 100*W_{7-9} / W_{year}			**Shultz's indicator** W_{7-9} / W_{3-6}			Annual flow variation factor ?v		
	1970	2000	2018	1970	2000	2018	1970	2000	2018
Syr Darya River Basin									
Naryn – inflow to Toktogul HPS	35	37	34	0.78	0.86	0.75	0.16	0.19	0.16
Karadarya – inflow to Andizhan reservoir	30	29	21	0.58	0.46	0.36	0.27	0.36	0.34
Chirchik – inflow to Charvak reservoir	32	32	29	0.60	0.62	0.52	0.23	0.20	0.20
Total interstate rivers	-	34	30	-	0.70	0.61	-	0.20	0.18
Amu Darya River basin									
Vakhsh – inflow to Nurek HPS	49	48	47	1.4	1.3	1.2	0.12	0.19	0.12
Panj – Lower Panj section	-	43	-	-	1.17	-	-	0.16	0.16
Kunduz	-	28	-	-	0.59	-	-	0.13	0.15
Kafirnigan – accounted surface inflow	-	30	29	-	0.5	-	-	0.19	0.20
Surkhandarya – accounted surface inflow	-	28	26	-	0.46	0.41	-	0.17	0.18
Total Amu Darya River	-	41	0.38	-	1.02	0.99	-	0.18	0.19
Kashkadarya – accounted surface inflow	-	27	-	-	0.47	-	-	0.23	0.20
Zarafshan – Dupuli bridge + Magiandarya – Sudji station	56	52	50	1.81	1.64	1.5	0.12	0.16	0.16

Source: SIC's estimate

The analysis of the data shows that there is minor downward trend of the Shultz's indicator and of glacial-snow component of the intra-annual river flow. Thus, since the 1970s, the glacial-snow contribution to river flow has decreased by 3% for the Syr Darya River, by 3% for the Amu Darya River (small basin), by 6% for the Zarafshan River, and by 2% for the Vakhsh River. Any trend in dynamics of the variation factor was not identified.

At present, the glacial-snow contribution to the main rivers of the small Amu Darya basin – the Vakhsh and the Panj – is about 20 km^3 only and that to three rivers in the Syr Darya basin (Naryn, Karadarya, and Chirchik) is 7 km^3. Thus, if hypothetically even half of the current glacial feeding is lost in the future, the permafrost and perennial snow and also the predicted increase in rainfall will prevent the total amount of surface water in the Aral Sea basin from dropping by 11–12%, the figure that sometimes appears in frightening and apparently speculative forecasts. In opinion of well-known glaciologist Prof. Gleb Glazirin, a glarier's impact is determined by a change in the aggregated water balance of flow formation area rather than by an amount of glacier melting and if take into account that the temperature rise would cause an increase in rainfall, such decrease in water resources cannot be substantial. In a maximum option it is assumed that climate change impacts are limited by **3-4 km^3** of water a year in the Amu Darya basin and **2 km^3** in the Syr Darya basin (other options give 2.5 km^3 and 0 km^3, respectively).

A certain positive effect of climate change found in SIC's research in form of increased thermal resources and reduction of crop growing period should be taken into account. This would allow extending double-season crop production and reducing (!) water requirements.

G. Stulina, G. Solodkiy made relevant calculations using the computer program PROGWAT, which is based on FAO CROPWAT methodology and considers groundwater contribution to soil moisture. Such calculations allowed estimating this effect quantitavely for the whole area of the Amu Darya Basin and the Fergana Valley in the Syr Darya Basin. Figure 9.1 demonstrates how growing season is reduced for early cotton under various soil-climatic conditions of the Amu Darya Basin. Thus, it is possible to shorten growing of cotton from 9 to 21 days in different zones of the basin. Given the crop varieties and soil-climatic conditions in highlands of Tajikistan and Kyrgyzstan, special studies are needed for these countries.

Figure 9.1. Shortening of early cotton growing season in the Amu Darya River Basin (days)

Source: G.V. Stulina, G.F. Solodkiy. Hydromodule zoning in Uzbekistan, SIC ICWC, 2012

Key factors of water demand growth in the Aral Sea Basin

In the future, the major factors of water demand growth will be demographic growth, industrial production growth, increase in technological inputs for flow regulation, and increasing demand by Afghanistan.

According to UN's forecasts, **population growth** in the CA countries will be approx. 1 million a year on average, thus the population will grow to about 83.3 million by 2030 and 96.7 million by 2045.[40] By SIC's forecasts, the population is expected to be 73.4 million in the Aral Sea basin (Table 9.2). Thus, the minimal demand for drinking and household water only would be additional **2 km^3** a year.

Table 9.2. Population forecast in CA countries within ASB by 2045 (million)

	2018	2020	2030	2040	2045
Kazakhstan	3.75	Annex 9.A. 4.1	Annex 9.B. 4.45	Annex 9.C. 5.2	Annex 9.D. 6.1
Kyrgyzstan	3.7	3.8	4.3	4.8	5.1
Tajikistan	9.1	9.5	11.6	13.8	15.1
Turkmenistan	5.1	6.0	6.8	7.4	7.7
Uzbekistan	33.2	33.5	37.4	40.6	41.9
Total ASB	**54.85**	Annex 9.E. **56.9**	Annex 9.F. **64.55**	**71.8**	Annex 9.G. **75.9**

Source: Authors estimations based on the data from https://population.un.org/wpp/DataQuery/, Kazakhstan - JSC "Center for the development of labor resources"

[40] Estimations based on the data from https://population.un.org/wpp/DataQuery/

This forecast can be corrected in the future through growing urbanization.

Industrial growth in the five CA countries. All the countries are aimed at industrial and agrarian development, which would result in achievement of 35% of industrial share in GDP, except for Tajikistan, where industry would account for 20-21%. The agricultural share in GDP will decrease, though it will continue growing in absolute volume of production. The services share will increase, except for Uzbekistan, where it is quite high (Table 9.3).

Table 9.3. Forecast of changes in GDP structure in CA countries by 2030

Country	Current status(2017)*				Forecast for 2030**			
	Industry	Agriculture	Services	Other	Industry	Agriculture	Services	Other
Kazakhstan	26.8	4.6	57.2	11.4	35.0	9.0	45.0	11.0
Kyrgyzstan	18.7	12.5	51.6	17.2	30.0	11.0	40.0	19.0
Tajikistan	17.2	21.2	40.4	21.2	20-21	17-18	30-30.6	33-30.4
Turkmenistan	32.2	11.0	23.7	33.1	33.8	8.9	45.8	11.5
Uzbekistan	22.2	34.0	38.1	5.7	33.3	20.0	39.3	7.4

Source: * Information on 2017: Kazakhstan – http: //stat.gov.kz; Kyrgyzstan – http://www.stat.kg/ru/publications/; Tajikistan – https://www.stat.tj/ru/tables-real-sector; Uzbekistan – https://stat.uz/ru/164-ofytsyalnaia-statystyka-ru/6602-natsionalnye-scheta; Turkmenistan – https://sng.today/ashkhabad/9339-vvp-turkmenistana-sohranil-vysokie-tempy-razvitija. html.
** Forecast indicators up to 2030: Kazakhstan – S .Ibatulin; Kyrgyzstan – estimated by 2040 on the base of the Kyrgyz National Development Strategy for 2018-2040, http://www.m-economy.ru/art.php?nArtId=6441; Tajikistan – based on industrial-innovation scenario of the Tajik National Development Strategy by 2030; Uzbekistan – based on the Uzbek Investment Policy by 2025 and the Agricultural development strategy for 2020-2030; Turkmenistan – estimated by 2025 on the base of the Turkmen Socio-Economic Development Program for 2019-2025, http://tdh.gov.tm/news/articles.aspx&article16574&cat11

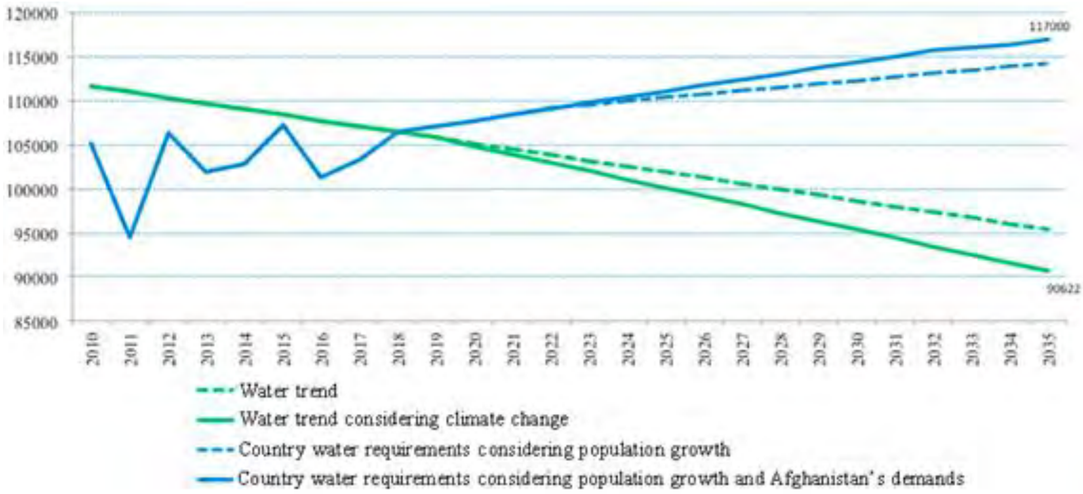
Growth in industry, transport and services is supposedly to be proportional to economic growth, ensuring job places, and to population growth. Meanwhile, in 2007, UNDP in the report “Water: Critical Resources for Uzbekistan’s Future” forecasts that by 2025, given the population of 40 million, the water demand of the country will be 72.4 billion m^3, including 8 km^3 for drinking and household water supply, 1.6 km^3 for industry, 1.7 km^3 for agricultural water supply, 4.15 km^3 for hydropower sector, and 2.4 km^3 for fishery. The total non-irrigation demand is 17.85 km^3. Based on this, population growth in the basin to 20 million will require additional 6.3 km^3 for non-irrigation use or, if exclude drinking and household water supply, 4.3 km^3.

Growing technological water inputs for flow regulation related to construction of reservoir cascades will cause additional losses of **2-3 km^3** that imply losses through evaporation, filtration and, mainly, non-coordinated operation of structures in the cascades. Continued or planned construction of hydroschemes at major water sources will lead to an increase in losses, at least, by 2 km^3.

Afghanistan’s demand. According to different sources, from 13 to 20 km^3, including 11-15 km^3 of water directly in the small Amu Darya basin, are formed in the territory of Afghanistan. Earlier, in Soviet times, Afghanistan claimed for 9 km^3 of water a year. Currently, there are press statements on demands for water in the Amu Darya and its tributaries from 7 to 10 km^3 a year. Moreover, when calculating the available water resources to be allocated between the CA countries in the Master Plan for the Amu Darya River basin, the supposed water withdrawal by Afghanistan in the amount of 2.10 km^3/year was deducted from the total available water resources. Today, this amount has increased by 900 million km^3 a year against that mentioned in the Master Plan and equals 3 km^3. According to our forecasts made upon request of the World Bank in 2002 (Victor A. Dukhovny and Vadim Sokolov, 2002[35]),the potential irrigation growth and, consequently, water use can be 7 km^3 or **4 km^3** more than the current level in this part of the basin.

Thus, the future of regional water supply by 2040-2045 causes serious concerns. In the near future we will lack 17.3 km^3 or 20 km^3 of water a year for direct use in the Aral Sea basin relative to normal year. For dry years, similar to 2008, water deficit would exceed as much as 25-40 km³. This is well illustrated in Figure 9.2.

Figure 9.2. Comparison of water demand and water availability in ASB, Mm³



Source: Authors (2019)

Future water outlook in key basins of Kazakhstan outside the Aral Sea basin

The growing tendency of water intake by China from the Irtysh and the Ili river basins is observed due to rapid population growth, especially upon adoption of the decision by the Government of China on the development of its northern territories and population migration from Central regions to Xinjiang Uyghur Autonomous Region (XUAR), along with industry, oilfields and irrigation development. At present, the irrigated area of XUAR makes 6.5 Mha, including 4.2 Mha in the Ili and Irtysh river basins and this tends to further increase. The China's Government aims at accelerating the development of the Western China, where the construction of two channels was completed three years ago. Water has already been transferred via these channels from the upper reaches of the Irtysh River (Black Irtysh in China) to the plants of Karamay oil basin and for irrigated agriculture.

The **Irtysh River** originates in China, runs through the border with Kazakhstan and Russia and flows into the Ob' River. Currently, the area of irrigated lands in the Irtysh River basin in China makes about 570,000 ha and tends to further increase. The total water withdrawal from the Irtysh River on Chinese territory taking into account the Irtysh-Karamay-Urumqi channel may increase from 3.2 km³ to 7.0 km³ a year. Thus, almost the entire runoff of the Black Irtysh River which equals 7.8 km³/year will be used on Chinese territory. The increased water withdrawal from the Black Irtysh River in China with more than 3 km³ causes new realities of water supply in the Irtysh river basin for Kazakhstan and Russia. If necessary measures are not taken, we will come across with the following possible consequences due to lowering runoff in the Black Irtysh:

- fall of Zaysan Lake level; separation of Bukhtarma reservoir from lake Zaysan, with reduced regulatory capacity;
- deterioration in fisheries, environmental conditions in the basin and flooding flood plain;
- significant reduction in electricity generation at Irtysh HPS cascade;
- deterioration in navigation along the Irtysh river on the territories of Kazakhstan and Russia (Omsk oblast').

Relevant calculations were made for developing appropriate measures to tackle the problems. The total annual runoff of the Irtysh River amounts to 33.5 km^3/year – with 7.8 km^3 flowing from China to Kazakhstan and the rest 25.7 km^3 originating in Kazakhstan. Currently, China utilizes 3.2 km^3/year out of this volume. Under the agreement between Kazakhstan and Russia, Kazakhstan releases on a mandatory basis 8.8 km^3/year of Irtysh river runoff.

By 2030, if China withdraws almost the entire runoff of the Black Irtysh River (7.0-7.8 km^3/ year), Kazakhstan will freely dispose the Irtysh River in the amount of: 33.5 -7.8 - 8.8 = 16.9 km^3. In other words, given the possible extensive water withdrawal by China, there will be enough water for Kazakhstan to cover its own needs.

At present, the Irtysh river basin has available water resources that are composed of natural runoff of Ulba and Uba rivers. The average annual value is estimated at 5.6 km^3/year. It is envisaged to build the phase II of Shulbinsky reservoir for full runoff regulation of these two rivers and to cover water deficit in the region. Besides, it will help to compensate electricity lost at Bukhtarma HPS.

Moreover, it is envisaged to use the Irtysh waters to cover the needs of water- deficient basins of central Kazakhstan and Astana city (the capital of RK). Part of the Irtysh waters will be transferred in the amount of 1.0 km^3/year in phase I, with gradual increase by 2030 of water supply to 2.5 km^3/year in the Nura and Yesil river basins.

It is envisaged to reduce runoff losses through introduction of water-saving technologies, thorough cleaning and reuse of industrial wastewater, reduced irrigation of low-productive farmlands, reconstruction of irrigation systems.

Construction of Krasnogorsk barrage at the Irtysh River (Omsk, Russian Federation) in order to support the necessary river water levels is ongoing.

Ili River. The total annual river runoff of Balkhash-Alakol river basin, including the Ili River makes 27.8 km^3/year, of which 11.4 km^3/year flows from China. The Ili River (known as 'Ile' river in Kazakhstan) has its source in the central Tien Shan in China at 3 540 m at the confluence of the Kunges and Tekes rivers. The length is 1,439 km, of which 815 km (56.6%) belongs to Kazakh territory, where it is considered as one of the largest rivers. The river ends its route flowing into Lake Balkhash, providing a strong desalination effect.

By present, China utilizes 3.0 km^3/year out of this runoff. Given the development of irrigated agriculture, this figure is expected to grow up to 5.0 - 7.0 km^3/year by 2030.

Thus, Kazakhstan will remain with: 27.8 - 5.0 (7.0) = 22.8 (20.8) km^3/year. To maintain the Ili river delta systems and conserve Lake Balkhash, approx. 14.6-14.8 km^3 of water/year is required. While, for industry and irrigation needs, the following amount of water will be left: 22.8 (20.8) - 14.8 = 8.0 (6.0) km^3, which is enough to irrigate 400,000 hectares, including the industry needs for Almaty and Taldykurgan oblasts (with introduction of water-saving technologies and using an optimum cropping pattern).

The main consumer of Ili river runoff should be Lake Balkhash (the Aral Sea tragedy cannot be repeated) and deltaic ecosystems of Ili's lower reaches. In this context, it was proposed to develop a special law of the Republic of Kazakhstan on Balkhash.

For other 7 river basins in Kazakhstan, detailed calculation of future water use by 2040 was made, considering flow transfers. In particular, preservation of Lake Balkhash should be taken into account in the Balkhsh-Alakol basin. As to the Irtysh Ribe basin, it is recommended to put into operation phase II of Shulbinsky reservoir. Multiyear regulation should be arranged finally in the Yesil River basin. In the Ural River basin, it is necessary to put in order water delivery from the Russian Federation through the Russian-Kazakhstan Commission. The same is necessary for the Chu-Talas basin. Water supply in the Naryn-SarySu basin is provided by the Irtysh-Karaganda canal also.

Table 9.4. Water demands of economic sectors in Kazakhstan in the future (up to 2040) by water source, outside ASB, Mm³

Basin	Total	of which					
		surface water	sea and lake water	ground-water	mining waters (use)	waste-water	collector-drainage water
				2020			
Balkhash-Alakol	4239.06	3581.61	166.97	375.71	0.35	61.33	53.1
Yertis	4163.34	3934.53	0	224.06	4.75	0	0
Yesil	433.24	375.41	0	52.71	1.53	3.6	0
Zhayik-Caspian	2435.27	1007.3	1240.14	168.55	19.28	0	0
Nura-SarySu	500.76	364.87	0	81.47	47.86	6.56	
Tobol-Torgay	264.32	220.54	0	36.83	6.95	0	0
Shu-Talas	1885.8	1790.24	0	93.79	1.85	0	0
Total	**13921.79**	**11274.5**	**1407.11**	**1033.12**	**82.57**	**71.49**	**53.1**
				2030			
Balkhash-Alakol	4287.8	3530.2	177.9	436.57	0.38	81.79	61
Yertis	4522.11	4254.75	0	262.38	4.98	0	0
Yesil	576.21	501.03	0	65.25	1.73	8.19	0
Zhayik-Caspian	2858.9	1293.11	1348.74	195.74	21.4	0	0
Nura-SarySu	609.88	463.86	0	82.69	52.09	11.25	0
Tobol-Torgay	2358.61	306.53	0	44.8	7.28	0	0
Shu-Talas	358.61	306.53	0	44.8	7.28	0	0
Total	**15572.12**	**10656.01**	**1526.64**	**1132.23**	**95.14**	**101.23**	**61**
				2040			
Balkhash-Alakol	4412.61	3531.31	190.39	516.38	0.42	105.12	69
Yertis	4822.77	4514.45	0	303.14	5.18	0	0
Yesil	818.56	724.8	0	81.31	1.99	10.46	0
Zhayik-Caspian	3180.78	1493.07	1423.13	240.84	23.74	0	0
Nura-SarySu	686.19	526.86	0	88.99	57.26	13.08	0
Tobol-Torgay	431.72	369.94	0	53.85	7.93	0	0
Shu-Talas	1980.62	1827.66	0	139.6	2.34	0	11.02
Total	**16333.25**	**12988.09**	**1613.52**	**1424.11**	**98.86**	**128.66**	**80.02**

Source: Ibatullin, 2019.

10 RECOMMENDATIONS FOR THE FUTURE: Measures for sustainable water security in Central Asia

Degree of implementation of recommendations from the “Fundamental Provisions of Water Management Strategy in the Aral Sea Basin” (1998) and the 2001 Diagnostic Report

The analysis of implementation of “Fundamental Provisions of Water Management Strategy in the Aral Sea Basin” of 1998 shows that by present no significant positive progress can be observed in the solution of problems identified in 1998. Over 20 years, multiple dialogues, conferences, and workshops were held with the involvement of donors, international institutions and agencies. However, many actions proposed in 1998 are still relevant.

For instance, a set of measures for the reduction of unproductive water losses in order to achieve the agreed unit water consumption targets has not been implemented yet. As to water conservation in irrigated agriculture over the last 20 years, no regional projects were implemented in this area. Each state in the region implements its own national projects and programs on the improvement of irrigation efficiency. At the same time, a positive tendency can be noted - almost all five Central Asian states have been implementing significant reforms in agriculture.

Issues related to the development and implementation of a mechanism for economic water relations have not been resolved so far. This hampers interstate cooperation to a certain extent.

Under umbrella of IFAS, no mutually agreed regional projects and programs were implemented over the last 16 years. Moreover, to date, no systematic hydro-ecological monitoring has been maintained in Prearalie. We still have no regular information on state-of-affairs in this crisis zone.

In this context, more concrete and effective actions are needed to achieve progress.

Measures for sustainable water security in CA

To ensure water security, the following key positions should be taken into consideration.

Improvement of water management at all levels

Sustainable water security is based on a coherent system of water management at all levels.

For effective functioning of the ***upper (interstate and main-canal) level***, it is necessary to address the shortcomings mentioned in Chapter “Performance Review of Water Management System in the Aral Sea Basin”, namely, inaccuracy of annual flow forecasts and absence of long-term forecasts; deviations from the agreed water distribution plans; poor water accounting; idle discharges; lack of harmonization between energy water releases and irrigation needs. Besides, weaknesses described in chapters “Water Management at the Interstate Level” and “International Assistance and Aral Sea Basin Programs” should be addressed as well. Those weaknesses include, in particular, the need to search for policy, economic, institutional, level and financial solutions for mutually beneficial and equitable water use in the region.

For better ***water management at national level***, the governments should consider and overcome such shortcomings that are related to:

- massive growth of individual water consumers – the need to develop forms of cooperation or integrate them into clusters or corporations;
- transfer of much of the former on-farm irrigation network to the inter-farm one (at WUA level). This calls for searching an effective form of WUA development as a valid, financially viable and functional organization;
- lack of clear mechanisms for coordination of different water hierarchical levels in order to reduce water losses at the interfaces of hierarchies (due to non-coordination of water demand and supply and poor information mechanism of coordination) – transfer to better fulfilled plans of water supply and water use is required;
- poor monitoring of water delivery and disposal that led to decreased reliability of water accounting - the water accounting system should be implemented at all water hierarchical levels, with supervision from the side of water users;
- weakness of water charging mechanisms, where water charges were introduced, or absence of any incentive in water saving, where no water charges are applied – it is necessary to introduce incrementing tariff for irrigation water delivery.

Improvement of water accounting and forecasts and SCADA system at hydraulic structures

Difficulties arise in planning and fulfilling the plans of flow distribution along the Amu Darya and the Syr Darya due to:

- poor quality of flow forecasts for the river’s main course as a whole and the lack of flow forecasts for many tributaries of both the Amu Darya (especially Panj) and the Syr Darya;
- late delivery of forecasts: final forecast is ready by mid of April;
- under-accounting of the time-lag of flow, which is especially important for the Amu Darya basin, where this time-lag is 10-15 days;
- under-accounting of open channel losses, as well as of in-stream regulation;
- unsatisfactory accounting of inflow and re-use of collector-drainage water, especially deviations in case of dry year.

A big project of the World Bank on the improvement of the regional monitoring system ($29 million) was implemented by region’s Hydrometeorological services without involvement of and coordination with regional and national water organizations and, therefore, its results had no positive effects on water management. It should be noted that all these factors contribute to higher deviations from established plans, particularly during the non-growing season.

All above listed problems should be solved, first of all, through the improvement of quality of flow accounting and monitoring. Herewith, it is necessary to organize water measurements also at outlets from river and at mouths of all collecting drains that have more than 5 m^3/s of discharge.

Since 2001, SIC ICWC in partnership with BWO Syr Darya and with the support of SDC and USAID have implemented the system for automated water monitoring and control at hydraulic structures (SCADA) in upper reaches and partially middle reaches of the Syr Darya basin. As a result of implementation of this system at 23 structures, the accuracy of water accounting was improved. After the Summit of the Heads of CA States in Turkmenbashi in August 2018, it has been decided to renew this work in the Syr Darya basin and start such work in the Amu Darya basin. This would make it possible to reduce unproductive water losses in open river channel that have increased by **2-3 km^3** along the Syr Darya and by **6-8 km^3** along the Amu Darya since gaining independence. Project passports were prepared for an amount of **$10,688,000** for the Syr Darya and $**10,492,980** for the Amu Darya. Such project proposals were repeatedly submitted to the World Bank and ADB.

Water conservation is a key priority for sustainable future

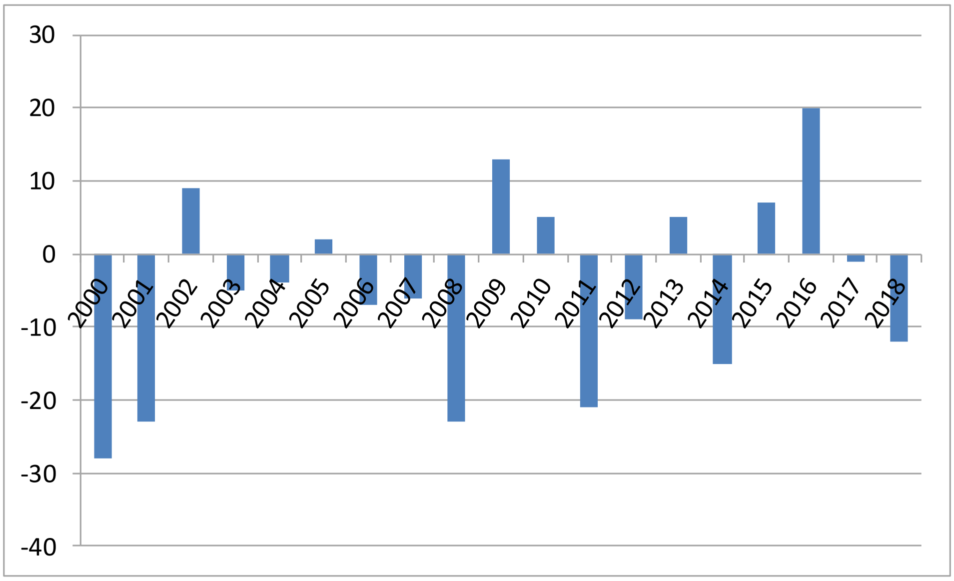
Water conservation is the major direction for regional survival, especially in the context of growing water deficit and decreasing water resources per capita as mentioned in point 44 of the 1998 Fundamental Provisions of the Water Management Strategy. Unit water use in irrigation has decreased as compared to 1990 by 2,000 cubic meters per hectare: from 14,000 to 11,900 cubic meters. The main cause of such a decrease was the pressure laid by hydropower, which reduced winter water releases, and also changes in cropping patters in favor for less water-intensive crops as laid again in the Fundamental provisions. In recent decade, while reaching the target of 11,500 cubic meters per hectare as set for 2010, water inputs remain unchanged: within 11,000 cubic meters per hectare, dropping to 9,000 cubic meters only in dry years. Hence, one can see that compared to earlier reached in the Soviet period indicators for the new irrigation zone in Golodnaya Steppe (8,500-10,000 cubic meters per hectare), the region has possibilities for water saving through technological methods (coating of canals, rehabilitation and reconstruction of ditch and pipe networks, adoption of new irrigation technique, including drip irrigation and sprinkling) and also by improving the water use and management system at the national level, with the involvement of water users and water-management organizations.

Implementation of IWRM in the Fergana Valley that allowed reducing unit water withdrawals by additional 10% through revision of application rates shows that upscaling of IWRM may lead to a decrease in water inputs by **4-5 km^3**.

Application of satellite images is a new direction for better water management

A great recent achievement of ICWC was the application of the **remote sensing-based monitoring** of water and land use, with the technical and financial support from Germany, and development of a special tool for monitoring of water efficiency in Central Asia – WUEMoCA, which covers the whole Aral Sea basin. Using this tool, dynamics of changes in crop acreage and irrigated areas is determined at district and provincial level from 2000 to 2018. The comparative analysis of WUEMoCA data over 2000-2018 shows that, judging from differences between irrigated crop area and net irrigated area in Uzbekistan, both irrigated area exceeds cropped area (minus sign), i.e. some land is not used, and cropped area is higher than irrigated area, indicating to a substantial area of double-season crops. On average over 2000-2018, this indicator is only - 5% in Uzbekistan that indicates to smaller portion of unused irrigated land. However, there are wide variations by year, showing underuse in dry years and excessive cropping in wet years (see Figure 10.1).

Figure 10.1. Dynamics of irrigated land use in Uzbekistan, based on processed RS-data by WUEMoCA



Source: SIC's estimate based on RS-data processing (http://wuemoca.net)

Wide variation can be noted by province. For example, this deviation is from + 34 % to -2% in the Andizhan province, +25% to -9 % in the Fergana province (mainly, **cropped area is higher than irrigated area**), whereas this indicator varies from +25% to -30% in the Khorezm province and even from -20% to -84% in Karakalpakstan, i.e. steady **non-use of irrigated land** is observed.

This software tool allows also estimating the degree of available water supply and water use efficiency by comparing RS-data and ground data over 2014-2018. The data indicate to substantial reserves for the use of available irrigated land and to unsustainable and insufficient provision of some land with water. Wide variations and considerable reserves are found in water use efficiency, which changes from 0.40 to 0.75.

In general, the usage of LANDSAT satellite images having higher resolution instead of MODIS images in WUEMoCA and the development of new functionalities of this tool in part of usage of spectral data for remote online assessment of crop conditions represents a new field for scientific and technological progress.

Revising irrigation norms and schedules

SIC ICWC together with European and Canadian organizations has been trying for more than decade to arrange a transfer to modern irrigation standards based on FAO methodologies that help to adjust irrigation depths depending on current climatic parameters. This work was done as part of the IWRM-Fergana Project on an area of 130,000 ha in the South-Fergana Canal system and proved the possibility of steady reduction of water withdrawal from 2004 to 2010 as shown above on the efficiency of implementation of IWRM in "Water conservation". Generally, such revision of irrigation norms in the region as a whole will reduce water withdrawal by as minimum as **4-5 km^3**.

Energy deficit and its coverage. Development outlook: new hydropower structures and addressing idle discharges

According to PEER Project's analysis, by 2050, the Vakhsh hydropower cascade (existing composition of structures, given its further development – Roghun, etc.) will be capable to produce annually the energy to meet not only domestic demand of Tajikistan within the Amu Darya basin, but also to partially meet demand of Tajikistan as a whole. Given that the electricity demand is partially met by TPPs, there would be even energy surplus in the amount of 1-2 billion kilowatt-hours, which can be exported. The analysis of seasonal energy balances indicates to energy deficit from October to March and its surplus from April to September. Energy deficit is estimated at 1-4 billion kilowatt-hours. The problem of seasonal energy deficit may be solved: by increasing capacities of energy generation; by regulating seasonal flows of energy (export-import).

The potential of prospective HPS' set in the Master Plans of river basins and projects is estimated at approx. 40,950 MW. Most projects are planned in Tajikistan. The total capacity of projected HPS' in Tajikistan is estimated at 72% of the total hydropower capacity in all projects planned in the basin.

According to the data of the Kyrgyz Ministry of Energy and Industry, putting into operation of the Upper Naryn HPS cascade and Kambarata-1 will give additional 6 billion kWh a year, thus covering winter peaks of energy consumption in Kyrgyzstan and giving possibility to increase energy export. Since Kambarata hydropower stations would mainly allow meeting Kyrgyzstan's electricity demand in summer, other riparian countries would face the risk of probable reduction of water releases from Toktogul HPS to 1.0 – 1.5 billion m^3. Moreover, for meeting of summer irrigation demands of the downstream countries, Kyrgyzstan could raise demands for energy supplies against the current ones of 2.2 billion kWh.

Development of Panj's hydropower potential. The Master Plan of the integrated use of the Panj River (Tajikistan, 1996) proposes development of the Panj's hydropotential through the construction of a cascade of 13 hydroschemes, with the total installed capacity of 17.7 million kW and the energy generation of 81.9 billion kWh. The proposed large hydroschemes include the Dashtijum hydroscheme (capacity of HPS - 4000 MW, reservoir capacity – 17.6 km^3) and the Rushan hydroscheme (capacity of HPS - 3000 MW, reservoir capacity – 5.5 km^3).

Table 10.1. Performance indicators of planned HPS' along the Panj River

No.	Name	Installed capacity, thous.kW	Generation, billion kWh	Potential head, m	Full reservoir level, m	Useful volume, km^3
1	Barshor	300	1.6	100	2510	1.25
2	Anderob	650	3.3	200	2410	0.1
3	Pish	320	1.7	150	2225	0.03
4	Khorog	250	1.3	100	2135	0.01
5	Rushan	3000	14.8	150	2060	5.5
6	Yazgulem	850	4.2	100	1665	0.02
7	Granitnye vorota	2100	10.5	300	1665	0.03
8	Shirgovat	1900	9.7	200	1355	0.04
9	Khostav	1200	6.1	300	1170	0.04
10	Dashtijum	4000	15.6	300	1055	17.6
11	Djumar	2000	8.2	200	690	1.3
12	Moscowskaya	800	3.4	200	600	0.04
13	Kokchi	350	1.5	30	430	0.2
	Total	**17720**	**81.9**			**26.16**

Source: Scheme of complex use of water resources in the Panj River (1996)

According to the Master Plan, the Dashtijum hydroscheme was chosen among priority structures for construction, based on performance indicators, the possibility of constructing a high-head dam at a coarse section of river valley and the possibility to catch a portion of water from Sarez Lake in case of forced water discharge from the lake and, as a result, fill the reservoir of this hydroscheme. At the same time, it should be noted that, in terms of transport access, the Dashtijum site is located far from railway line and motorways.

There are also other factors that could tip the scale towards another hydroscheme - the Rushan hydroscheme. In this hydroscheme the total head of 395 m is created by a dam (102 m) and derivation (293 m), while for Dashtijum HPS a high-head dam, 320 m, will be needed. Initial cost estimations for the Dashtijum hydroscheme are more attractive than those for the Rushan hydroscheme; the cost of construction of 1 m^3 of useful capacity of the former is $0.6 in prices of the Soviet period. However, as experience of construction of large HPS in Tajikistan and in the world shows, actual costs obviously exceed the initial cost estimate. Thus, the economic attractiveness can change the balance in favor of the Rushan hydroscheme, taking into account the following circumstances:

- availability of a motorway near the site of Rushan hydroscheme;
- small difference between average annual discharge of the Panj River at the Rushan site and the Dashtijum site – 529 m^3/s and 767 m^3/s, respectively;
- substantially lower height of the dam at the Rushan site as compared to the Dashtijum one;
- well longer duration of construction of Dashtijum, including the preparatory period.

The option on the Rushan hydroscheme as the head structure of Panj cascade can also be more preferable for consideration of the interests of riparian countries. As it is well-known, hydrograph of the Panj River influences the runoff of the Amu Darya that is favorable for meeting irrigation needs at Kerki section. Construction of the Rushan hydroscheme as the main seasonal regulator of the Panj's flow and the head structure of the Panj HPS cascade, which will ensure cascade-based regulation of downstream HPS', will allow matching water demands of different users and natural flow of the Panj River. In this case, if an agreement between the riparian counties on construction and regulation terms is reached. The hydropower potential of the Panj River without three upper HPS' and Dashtijum can be used in the amount of 59 billion kWh or 73%, while minimizing negative effects for downstream countries and producing well-lower cost of 1 kWh as compared to the option of Dashtijum.

The hydropower development strategies of the CA countries set as the main objective that the domestic energy needs should be met in full and the potential of energy export should be increased. It is planned to ensure better balancing of demand and supply through the following measures: decrease electricity demand through investments in energy efficiency, tariff policy (reasonable increase of tariffs); increase electricity generation by modernizing existing hydropower stations and constructing new ones; regulate energy import and export through agreements between the countries.

It is planned to increase energy generation in the Republic of Tajikistan mainly through commencement of new hydropower stations with large reservoirs of multiyear regulation. The domestic annual electricity demand in Tajikistan is estimated by the PEER USAID-SIC ICWC Project (within the Amu Darya basin) at 15.9 billion kWh on average over 2020-2050. By 2050, the domestic demand may increase up to 17.4 billion kWh. Currently, Roghun HPS is under construction at the Vakhsh River. It is to be completed by 2025.

The optimal irrigation-energy development in the Naryn River basin is planned to be achieved by putting into operation new hydropower stations upstream of the Toktogul hydroscheme (cascade of Kambarata HPS', etc.) that are free from irrigation limitations and are operated as seasonal energy compensators. Water-energy modeling demonstrates the effectiveness of such measures for the Syr Darya basin as a whole; however, only in case if the required energy-irrigation regime of water releases that provides additional water from multiyear storage in dry years is followed downstream of Toktogul HPS (operated under multiyear flow regulation regime).

Irrigation water deficit and its coverage through multiyear regulation

The non-regulated natural flow of the Naryn River meets the irrigation demand of 6.0 km^3 in 95 cases of 100. Thus, the natural flow of the river is supportive of irrigated agriculture's demand. Also for this reason, the benefits of Uzbekistan and Kazakhstan from regulation of flow by the Toktogul reservoir in non-dry years are not significant. In case of energy-oriented regulation of flow by the Toktogul hydroscheme, re-regulation by downstream reservoirs is required. The set of irrigation-oriented regulators (Rezaksai, Kenkulsai, Koksaray and other reservoirs) may partially lessen future water deficit in irrigated agriculture. If the Toktogul hydroscheme is operated in energy-oriented regime, irrigated agriculture will suffer from water deficit, and irrigation compensators will not help to eliminate such deficit.

The most reasonable option is to follow the combined irrigation and energy-oriented regulation of flow in the Naryn and the Syr Darya rivers, which compensates energy damage in dry years. The best solution for the Syr Darya basin would be the joint operation of the Kambarata 1 and Toktogul and the irrigation compensators. In this case, the region will get the maximal effect, where deficits in both hydropower (taking into account compensation) and irrigated agriculture are minimal.

Construction of large reservoir hydroschemes in Tajikistan along the Vakhsh, Zarafshan and particularly Panj rivers for their operation in energy oriented regime and, given the lack of sufficient capacities for seasonal flow regulation in Uzbekistan, may lead to 30-40% growth of water deficit in irrigated agriculture in some months of the growing season. A proposal was given above on the selection of potential hydroschemes for construction in order to keep flow hydrograph of the Panj River unchanged as much as possible, based on irrigation capacity of the river. **The current capacities of reservoirs along the Amu Darya do not allow multiyear regulation** as free regulation storage is limited by 4.2 km^3. Upon completion of construction of the Roghun reservoir, such possibility will occur if flow forecasts are accurate and appropriate operation rules for cascades of multiyear regulation are developed. The same conditions need to be met for utilization of the multiyear regulation potential of the Naryn cascade, which is available and will be increased as Kambarata HPS is put into operation. Moreover, it will be more difficult to coordinate and ensure multiyear regulation upon completion of the Upper Naryn and Kambarata cascades along the Naryn River and the whole Vakhsh cascade along the Amu Darya.

The maximum effect of multiyear regulation can be reached under accumulation by large reservoir hydroschemes of flood peaks in the long-term series of years and coordinated use of this storage to guarantee water supply for irrigation and hydroenergy.

As the PEER Project’s calculations show, to increase energy generation by the cascade of Vakhsh HPS’ (without losing heads at HPS in dry periods) and guarantee water for irrigated agriculture, multiyear regulation of the Vakhsh River is needed in the Amy Darya basin. Only this way, after putting into operation of the Roghun Hydroscheme (full design storage of the Roghun reservoir - 13.3 km^3, useful storage - 8.6 km^3), the maximum effect can be reached from all reservoirs in the basin and the degree of flow regulation can be increased.

The countries need to jointly revise the outdated Master Plans for integrated use of water resources and hydropotential in Amu Darya, Syr Darya and Zarafshan river basins by coordinating them with all stakeholders in the basins and provide for flow regulation rules by large reservoir hydrosystems of multiyear and seasonal (annual) regulation.

As an important adaptation measure for mitigation of negatives effects of climate change and global challenges, in process of formulation and implementation of basin strategies it is necessary to organize comprehensive studies for the development of “Control rules for reservoir and HPS cascades in river basins”, which should set guaranteed water releases from HPS and hydroenergy flows.

Measures for adaptation to climate change

Along with multiyear regulation and water conservation as the main measures for adaptation to climate change, it is necessary to develop other measures that are flexible enough for any deviations from normal conditions. Such measures include:

- enhancement of the network of weather stations with software for online transmission of information to water users;
- development of extension services, including new approaches to assessment of field crop conditions using RS and adjustment of recommendations in time. SIC's work in this area under the SDC-supported project (Sh. Mukhamedjanov) in four provinces of the Fergana Valley helped to improve land productivity by establishing farmer schools;
- growing of such double-season crops that consume less water but improve soil fertility through production of nitrogen-fixing bacteria (green gram, bean, pea, lupine, etc.);
- certification of fields and detection of reserves for soil fertility through the so-called yield programming methods;
- re-use of collector-drainage water and wastewater;
- extension of crops under cover (in hothouses, under film, etc.).

Development of economic mechanisms

The lack of effective economic incentives for cooperation and water saving is evident at all levels of water hierarchy. **At the interstate level**, an attempt was made to establish a water-energy consortium as a financial mechanism of harmonization of irrigation and hydropower interests. However, this attempt has failed because of positions of hydroscheme owners regarding flow regulation prices. At present, upon the first President of Kazakhstan N. Nazarbaev's initiative, efforts to revive this idea were made. One of possible solutions could be penalties imposed on basin authorities and hydraulic structures that break ICWC-approved schedules of water allocation and water releases from reservoirs or charges for flow regulation if the states consider it acceptable.

There is a range of unimplemented economic mechanisms and tools that could serve as 'good' leverage for more effective interstate cooperation. To this end, the ICWC-set monthly limits of water supply and water releases from reservoirs should be the thresholds, for violation of which liability for damage is imposed. Similarly, limits of permitted discharge of collector-drainage water to rivers and respective penalties for exceeding of these limits should be set.

Another potential economic tool is value of water and its consideration in the inter-state water allocation. In the late 80s, the SANIIRI Institute in its work showed for the Syr Darya River that as water deficit increased in the basin and re-allocation of water for different needs became more costly, the value of one cubic meter of water grew proportionally to growing costs for this purpose through either an increase in degree of flow regulation or a rise in costs of water conservation or use and desalination of saline water. This value can be integrated in size of penalties that each country will pay for exceeding of water limits set for this country. The cost of damage to river deltas through undersupply of water can be added to this value. It is clear that for implementation of those measures, riparian countries should jointly set the above limits, thresholds and unit costs of one cubic meter and sign relevant agreements.

At the national level, water charges, if available, should be increased depending on an amount of water use or if the water withdrawal level is exceeded so that those could be used as an incentive for saving water. In this context, organization of clusters offers a room for raising interests of all actors of a cluster, including farmers and irrigators, in generating profits in the whole chain of production and sale of final product, depending on real contribution of each actor.

It is necessary to revise the water financing system, taking into account principles of public-private partnership that imply long-term contractual partner relationships between public organizations and the private sector in developing, operating and financing water infrastructural projects (construction of big hydraulic structures, main canals, pumping stations, etc.) that currently are funded by the public sector.

As international experience shows, water management costs are partially covered by users and the rest is paid by the state in form of subsidies. Relevant policies are needed for public support of users in form of subsidies, economic and fiscal mechanisms for application of water-conservation technologies, mainly drip irrigation and sprinkling, and for valuing water in final product.

Human resources development

Current challenges and future threats to water security in the CA countries require the formation of a strong human resource potential at all levels in the water sector. This is an essential prerequisite for the introduction and implementation of innovative solutions for effective and rational water management.

The existing system of professional development for upper and medium level cannot meet the demand for professionals who are able to do appropriately design, construction and operation work at water facilities and who have necessary knowledge and skills for making and implementing organizational and managerial decisions.

In this context, new approaches are needed for the system of water education and professional development. Training programs should incorporate new knowledge based on fundamental and applied research, innovative approaches and best practices, bearing in mind prospective development of water and associated sectors.

In education, there is a need for unified requirements to general training of professionals, economic, organizational and managerial competences and to social and ethical behavior; development of new professions and disciplines, taking into account the sector's needs and diversification of training; exchange programs and courses for training and retraining of teachers in new disciplines; a program for cooperation and joint research on land reclamation and water management in Central Asia. Only this way it would be possible to meet potential needs in the water sector in 2035-2040 (Table 10.2).

Table 10.2. Anticipated personnel needs of water sectors in CA countries by 2035-2040

Indicator	Actual 2018	Anticipated needs by 2035-2040*
Number of higher education institutions	CA – 24: KZ – 9; KG – 3; TJ – 8; UZ – 5.	
Teaching staff, including with academic degree	CA - 834/378: KZ – 108/64; KG – 72/33; TJ –229/91; UZ – 425/190.	CA - 1410/760: KZ – 350/170; KG – 150/90; TJ – 450/350; UZ – 560/300.
Graduated, total in CA, including by country (year/pers)	CA – 1045: KZ – 220; KG – 120; TJ – 245; UZ – 460	CA – 2350: KZ – 800; KG – 350; TJ – 600; UZ – 600.
Staffrequirements, thousandpersons		KZ – 45-47; KG – 24-28; TJ – 18-22; TM- 23-28; UZ – 60-70.
Ratio of employed to graduated,%**	KZ – 22; KG – 82; TJ – 64; UZ – 100.	
Growth in professional orientation average by countries, %		Research and design -13 Construction – 42 Operation - 45

Note: * Expert estimations by S. Ibatullin
** Kyrgyzstan and Uzbekistan has laws making provisions for employment of graduates.
Source: Review of the present state of educational and research capacities in CA water sector (2018)

There is an urgent need for development of integrated and permanent water sector professional development system at both national and regional level in CA. In this context, major efforts should be made by national and regional organizations to remove all shortcomings and problems in this area and ensure financial, legal and administrative conditions.

Raising public awareness

Currently there is growing understanding of the importance of formation of social norms and rules with respect to the water management process since water resources become a part of policy tools. Today water may and must be used rationally not only through economic approaches and incentives but also through the human factor. Public consciousness needs to be transformed by reviving respect to water and educating people based on accumulated knowledge about water, experience and customs of water use and past lessons learnt.

The reasons for raising public awareness proceed from the need to achieve water security and sustainable development under conditions of water scarcity and climate change and to nurture a new generation that is more aware about problems and values of water.

The main goal is to form such line of conduct among all members of the society that is oriented to effective, ecological friendly and efficient use of water. Roles, responsibilities and ways of meeting the interests of all stakeholders must be clearly set in this process (system of partnership). Press services of state agencies, environmental NGOs, mass media, TV, social networks (FB, telegram, etc.), Web-resources, printed media, and youth organizations must be involved in public awareness campaigns. The key slogan of such campaigns should be – from awareness to actions.

Revival and enhancement of water research and design

Chapter 5.6 already highlighted key issues related to deterioration of resource and human capacities in water research and design. At present, the task is set to rehabilitate this design and research capacity, build new laboratories, provide the institutes with equipment and high-qualified staff. It is more complicated to improve the water sector and rehabilitate and build capacities than construct new structures and develop new land. In this context, high-class professionals are urgently needed. Rehabilitation of both research and design institutions and their effective interaction will help the Central Asian water management organizations to grasp new areas, such as the partial transfer of the Siberian rivers flow to Central Asia, the development of interconnected water management system in Central Asia, where the interests of hydropower, environment, and irrigated agriculture are addressed based on automation, digitization, and remote sensing. Such program was already prepared three years ago, and unfortunately, was not supported in sectoral development. We hope that water leaders will gain understanding that progress in water management and conservation is indispensable of solid research, engineering and design capacity.

Another significant aspect is to **enhance cooperation between experts in different disciplines in CA and other concerned countries**. It is important to promote platforms for joint interdisciplinary research and knowledge and experience sharing. In support of sustainable development, security and new integration processes, where water plays the strategic role, effective scientific cooperation is needed through joint interdisciplinary research, particularly on the base of SIC ICSD and SIC ICWC. Such initiative was voiced by the President of Uzbekistan at a Summit of the Heads of IFAS founder-states (Turkmenbashi, 24 August 2018). In support of this initiative, SIC ICWC in cooperation with Dutch partners came up with an idea to establish a *Central Asian Expert Platform*, which would unite experts from multiple disciplines in elaborating and analyzing scenarios, strategies and policies for harmonized development of the CA countries in the context of growing challenges to sustainable development, water resources management and security under conditions of geopolitical and demographic changes. The philosophy underlying the Expert Platform would allow breaking narrow sectoral approaches and shifting to new integration processes and would enhance relationships between institutes of strategic research, design, research institutes and scholars, and ministries and departments involved in policy making, planning and decision making.

Mobilization of additional water sources

The current situation in water supply of CA and strategic interests of CA countries, Russia, Europe and even Northern America promote for reanimation of the project of Siberian flow partial re-distribution to the south. Moreover, amount of transferred water should be increased for saving of the Arctic. It is clear that global approach is needed in terms of financing resources from the side of both China (probably, most prepared given its experience in water transfers and investment capabilities) and the European and global community, as well as financing institutions, based on the below considerations:

- Regional water resources, taking into account water conservation reserves and non-expansion of irrigated land, will be exhausted by 2030-2045. The current provision with land resources (0.11 ha on average per capita) is far from sufficient, given the agricultural orientation of the region, and does not allow for additional development of irrigated land in CA and CIS countries and in Afghanistan, where the degree of provision with land is half as much.
- According to experts of the Siberian branch of the Russian Academy of Sciences and supported by forecast of water content in Siberian rivers made by the Russian Hydrometeorological Center, the current runoff of Siberian rivers is subjected to impact of climate change and characterized by increased inflow of Siberian rivers in the amount of about 150-200 km^3 flowing into the Arctic ocean. Given growing runoff is accompanied by waterlogging of the northern part of Siberia, which is the area of future oil fields. Such substantial inflow of warm water to the Arctic is catastrophic for both Europe and Greenland and, hence, for America as it threatens to destruct the ice cap in North Pole and, consequently, affects the Gulf Stream, which is the main heater of North Europe and America.
- Chinese experience in giant south-north water transfers is a good example of how to solve global socio-economic and environmental issues. Given that the region is in the area of Belt and Road Initiative, the use of such experience and Chinese funds for that project, taking into account interests and implications of Europe in partial diversion of Siberian rivers out of the Arctic Ocean, will help to solve a larger comprehensive program of more rational use of huge water masses in the face of growing negative effects of climate change to the benefit of CA countries and the EECCA region and Europe as a whole.
- The CA countries will be able to mobilize water reserves from water conservation and meet future needs approximately by 2035 at the expense of huge investments of about $60 billion. However, by that time, the project of Siberian river flow partly re-distribution will have to be re-developed (since the old version is not valid anymore and the project has to be updated and re-approved; moreover, the project designer – Soyuzgiprovodkhoz Institute – has been virtually liquidated by now). It seems that the CA countries should give due weight to that matter and, first of all, organize a consortium for design of a transfer canal among representatives of all concerned countries and, then, find an organization, which would construct such a colossal structure. The construction of the proposed giant water infrastructure will take 10-15 years, i.e. 2045-2050, when the regional population will exceed 150 million. Without such a project, the region will face acute water competition, given that 800-900 m^3 would be available per person, that is almost a third of the present level.
- The new global view makes it possible to choose a quite new pathway than in the last 20 years towards solution of long-term water and environmental issues and integrate efforts of CA, Europe, China and North America for more equitable re-distribution of natural resources to the benefit of Eurasia and humankind as a whole.

Conclusions

Water has been always the source of life, prosperity and wellbeing in CA and therefore was in the center of any forms of statehood. Although the diversity of interests and challenges that society and state face moved water aside of national and interstate priorities, but growth, demography, natural balance and future sustainable development in the context of natural cataclysms and climate change again move water back on the top of government concerns.

The Central Asian region inherited a huge water-related infrastructure, a wealth of experience, knowledge and technology, and a great desire to ensure well-being of CA nations. However, in the context of globally, geopolitically, economically, politically and technologically changing world, new ways and solutions in the area of water relations and water use must be sought for.

Water development and use in the region is in the focus of all national and regional water organizations that should be guided by considerations of those future factors to overcome the water deficit, which is anticipated by 2035–2040.

The Summit of the Heads of IFAS founder-states in 2018 called the countries to enhance regional cooperation in the field of water conservation and interstate water management and use. In particular, the President of Uzbekistan proposed to adopt a Regional program for rational water use in Central Asia. The Uzbek Ministry of Water Management has developed a draft of the Regional program and presented it to CA countries for discussion.

Experts think that the Regional program of rational water use in the Central Asian region should consider the following:

a) make use of water reserves by:

- reducing losses in river's main courses and at interfaces of water hierarchy;
- improving the water accounting system;
- increasing uniformity of water distribution and raising stability of water supply;
- using return water and wastewater as maximum as possible;
- coordinating and ensuring fulfillment of the agreed water releases while operating large hydropower schemes;
- revising crop water requirements based on new FAO methodology and considering climate change.

b) potentially huge resource reserves can be developed through the improvement of water and land productivity on the base of agricultural extension services, the work of which will be based on yield programming methods supported by remote sensing; water saving; and, crop diversification. Shifting to drought-tolerant crop varieties, consideration of positive effects of climate change and increased focus on reclamation of land can contribute to improved productivity of land.

c) greater focus should be put on the improvement of surface water and groundwater quality for drinking and household needs (revision of existing water supply schemes and projects, exploration and setting of groundwater discharge).

d) particular attention should be given to water pricing and economic mechanisms for encouragement of efficient water use and to enhancement of material incentives among all water users.

e) a new paradigm of interaction enhancing cooperation between the countries calls for increased trust between them, search for joint solutions in and mutual benefits from the construction of new hydraulic structures and the operation of water infrastructure

f) it is necessary to develop mechanisms for more effective interaction between regional and national water agencies, establish clear procedures of interaction and ensure wider public participation in water management both at national and regional level. Here, the role of donors that could become major facilitators in strengthening regional cooperation is particularly important.

g) regular development of the level of specialized education in colleges and universities and organization of permanent training courses for professionals should ensure upgrade of professional knowledge every five years. Particular attention should be paid to fostering future water leaders.

h) it is necessary to fill critical research gaps in water use management, while paying particular attention to compensation of future water deficit, water conservation, and resumption of work on the partial transfer of Siberian river flow to Central Asia.

New forms of relations are needed to provide for:

- enhancement of the system of open access to information and provision of accurate and timely information on water use and forecasts on water and climate, as well as widening of public participation in water management and use;
- continuous dialogue in water management, elaboration of joint procedures for water management and use, and clear mutual obligations between regional and national organizations;
- strengthening of the scientific and analytical base for water development and use;
- organization of the program on water conservation and response to challenges occurring in the context of water, climate, and political changes.

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Overview of the use and management of water resources in Central Asia - A discussion document

The OECD has been working on water issues in Central Asia for over twenty years. The challenges of achieving a regional vision on water management in Central Asia is characterised by risks of competition and conflict over natural resources. With many of the region's water resources transboundary, agricultural productivity, energy security and industrial development are dependent on adequate flow management along the rivers that connect Central Asian countries.

This discussion paper reviews the use and management of water resources in Central Asia over the past twenty years. The paper aims to assess changes in water and land use management in that period and to identify future water challenges, development trends and needs for the long-term sustainable use of water resources and irrigated land. The paper is intended to inform discussion amongst the water community in Central Asia.

This analysis benefitted from substantial inputs and active cooperation from national experts of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The experts of Scientific-Information Center of the Interstate Commission for Water Coordination (SIC ICWC) contributed to country specific and regional analyses. Supervision was provided from the OECD's Green Action Task Force.

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